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Studies on the Utilization of Bivoltine Foundation Cross Males in the Preparation of Cross Breed Eggs of the Silkworm, *Bombyx mori* L.

K.L.Rajanna[1,*] and G.Vemananda Reddy[2]

Silkworm Seed Technology Laboratory, Kodathi, Carmelarm post, Bangalore-560035, India.
[1]Egg Production Technology Division, Silkworm Seed Technology Laboratory, Central Silk Board, Carmelaram Post, Kodathi, Bangalore-560035, India
[2]Reproductive Physiology Division, Silkworm Seed Technology Laboratory, Central Silk Board, Carmelaram Post, Kodathi, Bangalore-560035, India

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In order to study the feasibility of utilizing bivoltine foundation cross (FC2) males of the silkworm as male components with Pure Mysore (PM), six foundation crosses viz,CSR2 x CSR27, CSR27 x CSR2, CSR27 x CSR50, CSR50 x CSR27, CSR2 x CSR50 and CSR50 x CSR2 along with CSR2 pure breed were assessed for performance of parental crop,grainage, rearing and reeling performance. The foundation crosses exhibited better performance than CSR2 as a parental crop and male component which resulted in higher egg recovery. Though there was not much difference between PM crossed with FC2 and CSR2 males pertaining to important bioassay parameters, PM x CSR2 exhibited superiority in reeling traits particularly with reelability and raw silk %. This study reveals that FC2 seed cocoons can be utilized during exigency when there is a dearth for CSR2 seed cocoons but not regularly.

Key words: *Bombyx mor*i L, Foundation cross, Male parent, Cross breed eggs

Introduction

In India, more than 90% of the mulberry silk production is from polyvoltine x bivoltine hybrid, particularly PM x CSR2 and Nistari x NB4D2. Sericulture farmers in south India have achieved a quantum jump in cocoon yield about 15 Kg/100 Disease free layings (Dfls) and the reelability has improved by 10% with PM x CSR2. Many times, during unfavorable seasons CSR2 cocoon crops failed or crops with poor pupation of 40-50% affected the recovery of cross breed eggs. Apart from this, due to failure of CSR2 crops, the price of seed cocoons goes exorbitantly high resulted in high cost of production during cross breed egg production. Foundation crosses(FC2) are easy to rear with better pupation rate, the yields are on par or better than CSR2,male moths are more vigorous and it is highly imperative to use FC2 male parent in cross breed egg production.(Kamble *et al*.,2007; Dandin *et al*., 2008). Extensive studies have been made on the utilization of various bivoltine hybrid males in the preparation of cross breed eggs with Pure Mysore females (Krishnaswami, 1987; Jolly, 1987; Thangavelu, 1988; Benchamin *et al*., 1988; Rajanna *et al*., 1999) and with Nistari females (Subba Rao *et al*., 1988, 1989; Das *et al*., 1994; Rajanna *et al*., 1998; Moorthy *et al*., 2011). In view of the above, an attempt has been made to study the feasibility of using new foundation crosses as male parents in the preparation of cross breed eggs and to generate the information on crop stability, grainage and reeling performance.

Materials and Methods

The present study was carried out at Silkworm Seed Technology Laboratory, Bangalore. The experiment was conducted by utilizing three CSR bivoltine breeds viz., CSR2, CSR27 and CSR50 and polyvoltine breed Pure Mysore. Raised the seed cocoons of CSR2, CSR27 and CSR50 and prepared six possible foundation crosses i.e. CSR2 x

*To whom the correspondence addressed
Silkworm Seed Technology Laboratory, Central Silk Board, Carmelaram Post, Kodathi, Bangalore-560035, India.
Tel: 091-080-28440492, Fax: 091-080-28440494;
E-mail: sstlbng@yahoo.com
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Table 1. Rearing performance of CSR2 breed and foundation crosses

Combination/ Race	Fecundity	Yield / 10000 larvae By no.	By weight (kg)	Pupation rate (%)	Cocoon weight (g)	Shell weight (g)	Shell ratio (%)
CSR2 x CSR27	504 ± 32	9263 ± 191	16.150 ± 0.851	90.75 ± 1.52	1.774 ± 0.117	0.407 ± 0.049	22.90 ± 1.61
CSR27 x CSR2	514 ± 21	9127 ± 699	15.043 ± 1.586	90.09 ± 5.39	1.697 ± 0.039	0.393 ± 0.020	23.14 ± 0.70
CSR27 x CSR50	477 ± 55	8880 ± 514	14.806±2.208	87.21 ± 4.46	1.704 ± 0.194	0.404 ± 0.055	23.64 ± 0.59
CSR50 x CSR27	464 ± 6	9363 ± 193	15.360 ± 0.471	91.75 ± 1.32	1.671 ± 0.057	0.378 ± 0.006	22.62 ± 0.99
CSR2 x CSR50	470 ± 7	9567 ± 417	15.750 ± 2.396	89.65 ± 4.76	1.700 ± 0.151	0.378 ± 0.051	22.18 ± 1.06
CSR50 x CSR2	477 ± 19	9160 ± 67	13.698 ± 0.671	89.26 ± 4.00	1.544 ± 0.061	0.337 ± 0.015	21.80 ± 0.45
CSR2 (control)	534 ± 61	9340 ± 356	14.681 ± 1.482	88.56 ± 4.73	1.595 ± 0.108	0.352 ± 0.035	22.01 ± 0.93
CD at 5%	14	78	0.171	0.58	0.021	0.006	0.48

CSR27, CSR27 x CSR2, CSR27 x CSR50, CSR50 x CSR27, CSR2 x CSR50 and CSR50 x CSR2. Foundation crosses are characterized by plain larvae, white oval cocoons and it is a cross between two lines among CSR2, CSR27 and CSR50.A total of 6 foundation crosses and CSR2 breed were reared during three seasons. Three replications of 500 worms each were maintained after third moult and standard rearing technologies were followed as suggested by Krishnaswami (1978) and recorded fecundity, Yield/10000 larvae by number and weight, pupation rate, cocoon weight, shell weight and shell ratio. The females of indigenous Pure Mysore were crossed with males of six foundation crosses and CSR2 and prepared a total of seven cross breed combinations. During egg production, recorded the important contributing parameters (in percentage) such as pairing, unlaid moth, poor laying, total rejection, good laying and unfertilized eggs, Bioassay studies of six three way crosses and PM x CSR2 (control) were conducted and recorded six important economic characters such as fecundity, Yield/10000 larvae by number and weight, cocoon weight, shell weight and shell ratio. The resultant cocoons (300 cocoons each / replication) were subjected for reeling test and recorded five silk contributing parameters such as filament length, denier, renditta, raw silk percentage and reelability. The results were statistically analyzed and compared with that of PM x CSR2.

Results and Discussion

The rearing performance of six foundation crosses and CSR2 breed is presented in Table 1. The fecundity which ranged from 464 - 534 showed significant difference between foundation crosses and CSR2. Maximum fecundity was recorded in CSR2 and minimum in CSR50 x CSR27. The yield / 10000 larvae by number was exhibited significant variability ranging from 8880(CSR27 x CSR50) to 9567(CSR2 x CSR50). In case of cocoon yield / 10000 larvae by weight also exhibited significant difference between combinations which ranged from 13.698 kg (CSR 50 x CSR2 to 16.150 kg (CSR2 x CSR27). The pupation rate was significantly higher in all the foundation crosses than in CSR2 with an exception to CSR27 x CSR50. Five foundation crosses have recorded significantly higher cocoon weight and shell weight than the control with an exception to CSR50 x CSR2. However, shell ratio was significantly higher in four crosses (except CSR2 x CSR50 and CSR50 x CSR2). The superiority of foundation crosses with high pupation rate without affecting any productive traits is in corroboration with the findings of other investigators (Kamble *et al*., 2007; Dandin *et al*., 2008).

It was also observed that the rearing of CSR2 in the harsh summer season resulted in frequent crop failures or crops with poor pupation. The problem faced during rearing of pure races like CSR2 can be solved as the foundation crosses are easy to rear and show better growth. (S.B. Dandin *et al*., 2008)

The performance of foundation crosses and CSR2 as male components in the cross breed egg production is given in Table 2. The pairing% showed significant variation between PM x FC2 and PM x CSR2 crosses and ranging from 39.12% (PM x CSR2) to 40.18% PM(CSR2 x CSR27). Similarly good laying recovery also followed the same pattern i.e., maximum of 33.79% in PM (CSR2 x CSR27) and minimum in PM x CSR2 (29.23%).The percentage of un-laid moths (2.82~5.27%), poor laying (3.57~5.23%), un-fertilized eggs (1.52~2.50%) and total rejection (6.39~10.24%) were significantly lower with pure Mysore crossed with foundation crosses exhibits superiority in grainage performance (except in PM (CSR27 x CSR50). These results clearly indicate that males of foundation crosses are more vigorous and active, which can be used for three times in production of quality cross breed eggs with high egg recovery.

Table 2. Performance of male component of CSR2 and CSR foundation crosses in cross breed egg production

Combination / Race	Pairing (%)	Un laid moths (%)	Poor laying (%)	Total rejection (%)	Good laying (%)	Un-fertilized eggs (%)
PM (CSR2 x CSR27)	40.18±1.75	2.82±0.26	3.57±0.37	6.39±0.56	33.79±1.42	1.98±0.14
PM (CSR27 x CSR2)	39.70±1.16	3.73±0.29	4.02±0.25	7.75±0.45	31.95±0.85	1.52±0.20
PM(CSR27 x CSR50)	39.26±1.54	5.30±027	4.94±0.15	10.24±0.32	28.02±1.52	1.81±0.27
PM (CSR50 x CSR27)	39.85±0.93	4.26±0.31	3.32±0.45	7.53±0.49	32.32±0.92	1.73±0.18
PM (CSR2 x CSR50	39.50±1.32	4.07±0.33	4.90±0.26	8.97±0.50	30.53±1.06	2.07±0.28
PM (CSR50 x CSR2)	40.06±1.26	4.37±0.22	5.23±0.49	9.72±0.57	30.40±1.47	2.02±0.38
PM x CSR2 (control)	39.12±1.54	5.27±0.11	4.62±0.23	9.89±0.30	29.23±1.53	2.50±0.19
CD at 5%	NS	0.25	0.24	0.36	1.14	0.09

Table 3. Rearing and Reeling performance of PM x foundation crosses and PM x CSR2

Combination	Fecundity (No.)	Yield / 10000 larvae By no.	Yield / 10000 larvae By weight (kg)	Cocoon weight (g)	Shell weight (g)	Shell ratio (%)	Filament length (m)	Denier	Renditta	Raw silk (%)	Reelability (%)
PM (CSR2 x CSR27)	521 ±12	9403 ±151	14.460 ±0.888	1.573 ±0.113	0.286 ±0.028	18.21 ±0.94	721 ±94	2.37 ±0.26	8.36 ±0.39	29.16 ±2.03	86.42 ±2.44
PM (CSR27 x CSR2)	504 ±20	8741 ±128	13.115 ±2.653	1.620 ±0.156	0.297 ±0.041	18.27 ±0.94	767 ±127	2.30 ±0.27	8.34 ±0.31	28.21 ±2.26	84.87 ±5.00
PM(CSR27 x CSR50)	494 ±8	8966 ±438	14.166 ±1.723	1.576 ±0.141	0.290 ±0.039	18.27 ±1.25	772 ±99	2.40 ±0.19	7.87 ±0.32	29.71 ±2.62	84.80 ±1.97
PM (CSR50 x CSR27)	522 ±18	9562 ±105	15.278 ±1.327	1.625 ±0.144	0.295 ±0.039	18.11 ±0.93	718 ±69	2.55 ±0.17	7.89 ±0.37	30.49 ±1.83	89.54 ±2.45
PM (CSR2 x CSR50)	508 ±10	9553 ±305	15.601 ±1.223	1.592 ±0.130	0.292 ±0.039	18.33 ±1.33	733 ±106	2.43 ±0.33	8.24 ±0.53	29.69 ±4.31	86.59 ±4.50
PM (CSR50 x CSR2)	519 ±14	9255 ±447	14.676 ±1.054	1.604 ±0.127	0.285 ±0.037	17.73 ±1.17	686 ±113	2.75 ±0.26	7.86 ±0.75	31.03 ±2.80	86.02 ±3.94
PM x CSR2 (control)	509 ±16	9296 ±362	14.393 ±0.917	1.588 ±0.075	0.287 ±0.028	18.08 ±0.99	715 ±61	2.52 ±0.23	8.09 ±0.58	31.33 ±1.04	88.27 ±2.21
CD at 5%	9	66	0.140	NS	NS	NS	NS	0.22	0.29	1.62	2.79

Rearing and Reeling performance of PM x foundation crosses and PM x CSR2 is presented in Table 3. The mean values computed for fecundity ranging from 494 to 521 and was significantly higher in PM (CSR2 x CSR27), PM (CSR50 x CSR27) and PM (CSR50 x CSR2) compared to PM (CSR27 x CSR50). The effective rate of rearing was higher (94-95%) in PM (CSR50 x CSR27), PM (CSR2 x CSR50) and PM (CSR2 x CSR27), moderate (92-93%) in PM (CSR50 x CSR2) and PM x CSR2 and lower in PM (CSR 27 x CSR2) and PM (CSR27 x CSR50) crosses. No significant difference was noticed with respect to cocoon weight, shell weight and shell ratio among the different crosses to that of control. Data of the reelability showed significant variability ranging from 84.80% to 89.54% and higher (89.54%) in PM (CSR50 x CSR27) followed by PM x CSR2 (88.27%).The mean values of raw silk% revealed significant variation ranging from 28.21 to 31.33% and it was higher in PM x CSR2 (31.33%) than other crosses except the PM (CSR50 x CSR2) which recorded 31.03%.

The important observation made from the results that the reelability (88.27%) and raw silk (31.33%) were found better with PM x CSR2 indicating the superiority in reeling performance. These results are supporting with the existing situation prevailing in the field where the procurement of PM x FC2 cocoons are not preferred by the reelers and also the production of PM x FC2 eggs is in decreasing trend with the seed producers.Eventhough, rearing performance of foundation crosses is superior with tolerance to silkworm diseases and assured with good pupation rate and better grainage performance with good laying recovery. The seed cocoons of foundation crosses can be used for the production of cross breed eggs only in exigency particularly in summer season to fill up the gap during non-availability of CSR2 seed cocoons but not regularly.

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