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Selection of Sustainable Bivoltine Foundation Crosses to Be Used As Male Components with Multivoltines under West Bengal Conditions

N. Suresh Kumar, A. K. Saha and B. B. Bindroo

Central Sericultural Research and Training Institute, Berhampore, 742 101, India

Corresponding author: nairsuresh_in@yahoo.com

Abstract:
The objective of this breeding study was to develop and identify superior bivoltine breeds possessing the desired targeted traits on productivity along with higher survival under the varied and fluctuation climatic conditions of West Bengal. Initially bivoltine breeds collected from different parts of the country were screened under the ambient conditions of West Bengal. The breeds with high survival with moderate productivity traits were selected as potential parents for this study. By utilising these parental breeds foundation crosses (both ovals and dumbbells) were made and subjected for evaluation under the ambient conditions of West Bengal. Based on the overall performance few oval and dumbbell foundation crosses were identified.

Keywords: *Bombyx mori*, bivoltine silkworm, foundation cross

1.0. Introduction:
The success of silkworm breeding depends on the initial selection of parents, their judicious utilization in appropriate and desirable combinations and choice of mating systems to generate ample genetic variability for facilitating enough scope for selection. The genetic worth of the initial parents to be utilized in the breeding programme allows the breeder to critically analyze the most suitable and effective genoptype before choosing as a breeding resource material. Therefore, it is of paramount importance that utmost care has to be taken by the breeder in verifying and analyzing the genetic worth of the initial parents to be utilized as potential resource material by employing various selection methods (Suresh Kumar *et al.,* 2006; Lakshmi and Chandrashekariah, 2007 and Harjeet Singh and Suresh Kumar, 2008).

It is essential to measure the degree of phenotypic manifestation for the characters of economic importance under both similar and variable environmental conditions in order to understand the genetic endowment pertaining to adaptability and productivity of the breeding material. Generally, such information is often not available to the breeder who is handicapped in selecting the initial parents from the local races without evaluation. As a result, they were able to fix certain gene blocks rapidly with correlated response in the adverse direction in many cases. Therefore, the problem of balancing and fixing the desirable traits for local environments is a challenge for the breeder (Nirmal Kumar and Yamamoto, 1994).

Silkworm breeding is conducted to bring together all desirable genes in appropriate combinations to improve the genetic potentiality for maximizing the cocoons yield and productivity per unit area and population. The genetic variability expresses in different genetic material paves the way to amalgamate many desirable genes into a single breed through conventional breeding methods. The desirable level of success depends on the selection of initial breeding resource materials, their effective utilization in different combinations to the genetic expression of the character under consideration (Mano, 1992).

Though, India has a number of indigenous races, it suffers for want of new silkworm races in competing with other sericulturally advanced countries such as China and Japan where significant progress has been achieved in synthesizing highly productive and resistant silkworm races suitable to their native climatic conditions through hybridization (Yokoyama, 1956).

Eastern India is generally characterized by luxuriant growth of mulberry for its highly fertile soil and rainfall. But, rearing of productive silkworm breeds and hybrids are restricted due to highly variable climatic situation, which causes poor larval growth, moulting disorder and severe mortality of silkworm caused by diseases and ultimately leading to low cocoon yield. High temperature coupled with high humidity act as the major limiting factor for rearing silkworm particularly during the seasons falling between May and September when huge leaf biomass is available. In this region, fluctuating climate restricts rearing of highly productive good quality bivoltine breeds because of poor survival and as a result, stakeholders are compelled to rear hardy multivoltine silkworm strain (Nistari) with extremely poor productivity and quality, thus leaf conversion efficiency into good quality cocoons becomes very poor. Besides, because of high temperature and humidity as well as rainfall, most of the rearers are compelled to rear indigenous multivoltine strain, Nistari.

Low temperature with low humidity during December and January severely affects the performance of P1 rearing. Besides, due to low production of mulberry leaf in low temperature regions, which affects the growth of silkworm resulting in poor performance of bivoltine P1 rearing. Though, February-March season is suitable for raising bivoltine as a P1 but subsequent commercial rearing for multivoltine x bivoltine is unpredictable due to prevalence of high temperature during late age rearing. Therefore, the silkworm egg producers have to depend on other parts of the country for bivoltine cocoons as P1 material. In West Bengal the bivoltine single parent rearing was found to be difficult during unfavourable season due to the prevalence of high temperature and high humidity. Therefore, this institute has identified a foundation cross, SK6 x SK7 to be used as a male component with Nistari. Initial field studies during unfavourable season indicated that the performance of this foundation cross was better than the single parent. Based on the seed crop and commercial crop results it can be concluded that the multi x bi hybrids can be successfully raised and commercialized in the Eastern India. Further bivoltine seed crop stabilization, which is bottleneck for the development of sericulture in the region, can also be solved by the introduction of foundation crosses. Therefore, it is highly pertinent to identify more number of bivoltine foundation crosses which can withstand the highly variable and fluctuating climatic conditions of this region. Keeping these aspects in mind, an attempt has been made in this study to identify sustainable foundation crosses to be used as male parents with multivoltine breeds.

2. 0. Materials and Methods:

The main objective of the study was to select suitable bioltine foundation crosses to be used as male parents with multivoltine breed which can withstand the varying and fluctuating climatic conditions of West Bengal. Considerable variation exists among the bivoltine silkworm breeds at different rearing conditions, which opens an avenue for selection of suitable bivoltine breeds for tropical conditions of West Bengal.

2.1 Materials:

The following breeds were screened under high temperature conditions to select suitable breeding resource materials.

1) Gen3, 2) BHR2, 3) BHR3, 4) SK3C, 5) 14) SK4C, 6) D6PN 7) SK6, 8) SK7, 9) KSO1,10) Dun21, 12) Dun22, 13) KPGA , 14) CSN 15) NB18, 16) P5 and 17) NB4D2

2.2 Methods:

Silkworm rearing was conducted following the standard method under natural conditions and also at recommended temperature and humidity conditions Plastic collapsible mountages were used for mounting the ripened larvae. After 48 hours of mounting, when the larvae formed hammock, the mountages were turned upside down. Cocoon harvesting was carried out on the 7th day of spinning. The cocoons were deflossed and the defective ones were sorted out. Assessment was carried out on the subsequent day. The survival rate was calculated as the number of live pupae to the number of larvae treated.

2.3 Parameters studied:

Various quantitative traits such as fecundity, yield/10000 larvae by number, yield/10000 larvae by weight, cocoon weight, cocoon shell weight and cocoon shell percentage were calculated.

3.0. Results and discussion:

3.1. Performance of parental breeds:

The performance of the bivoltine breeds under optimal temperature (25 ±1°C) and humidity (70 ± 5 %) conditions is presented in Table 1. The fecundity of the 17 breeds considered for the study at 25 ±1°C and 70 ± 5 % RH ranged from 521 to 576 with the lowest of 521 recorded for

KPGA and the highest of 576 recorded for Dun21. The yield/10,000 larvae by number at 25 ±1°C and 70 ± 5 % RH ranged from 8865 to 9154 with the lowest of 8865 recorded for NB4D2 and the highest of 9154 recorded for SK6. The yied/10,000 larvae by weight at 25 ±1°C and 70 ± 5 % RH ranged from 13.490 to 15.798 kg with the lowest of 13.490 kg recorded for NB4D2 and the highest of 15.798 kg recorded for P5. The cocoon weight at 25 ±1°C and 70 ± 5 % RH ranged from 1.522 to 1.764 g with the lowest of 1.522 g recorded for NB4D2 and the highest of 1.764 g recorded for P5. The cocoon shell weight at 25 ±1°C and 70 ± 5 % RH ranged from 0.311 to 0.427 g with the lowest of 0.311 g recorded for BHR3 and the highest of 0.427 g recorded for P5. The cocoon shell percentage at 25 ±1°C and 70 ± 5 % RH ranged from 20.4 to 24.3 % with the lowest of 20.4 % recorded for BHR3 and the highest of 24.3% recorded for Dun21.

The performance of the bivoltine breeds under ambient temperature (32 ±1°C) and humidity (85 ±5 %) conditions is presented in Table 2. The fecundity of the 17 breeds considered for the study at 32 ±1°C and 85 ± 5 % RH ranged from 387 to 530 with the lowest of 387 recorded for P5 and the highest of 530 recorded for CSN. The yield/10,000 larvae by number at 32 ±1°C and 85 ± 5 % RH ranged from 7430 to 9002 with the lowest of 7430 recorded for BHR3 and the highest of 9002 recorded for SK6. The yied/10,000 larvae by weight at 32 ±1°C and 85 ± 5 % RH ranged from 8.450 to 14.230 kg with the lowest of 8.450 kg recorded for KSO1 and the highest of 14.230 kg recorded for D6PN. The cocoon weight at 32 ±1°C and 85 ± 5 % RH ranged from 1.265 to 1.547 g with the lowest of 1.265 g recorded for SK3C and the highest of 1.547 g recorded for SK7. The cocoon shell weight at 32 ±1°C and 85 ± 5 % RH ranged from 0.221 to 0.320 g with the lowest of 0.221 g recorded for SK4C and the highest of 0.320 g recorded for SK7. The cocoon shell percentage at 32 ±1°C and 85 ± 5 % RH ranged from 17.4 to 23.9 % with the lowest of 17.4 % recorded for SK4C and the highest of 23.9% recorded for P5.

3.2 Evaluation Index:

The evaluation index values obtained for the breeds under 25±1°C and 70±5 % RH conditions are presented in the Table 3. The index value for fecundity ranged from 36 to 71 with the lowest of 36 recorded for KPGA and the highest of 71 recorded for Dun21. The index value for yield/10000 larvae by number ranged from 40 to 70 with lowest of 40 recorded for SK3C and P5 and the highest of 70 recorded for SK6. The index value for yield/10000 larvae by weight ranged from 42 to 76 with the lowest of 42 recorded for BHR3 and the highest of 76 recorded for P5. The index value for cocoon weight ranged from 43 to 79 and the lowest of 43 recorded for BHR3 and SK6 and the highest of 79 recorded for P5. The index value for cocoon shell weight ranged from 41 to 73 with the lowest of 41 recorded for BHR3 and the highest of 73 recorded for P5. The index value for cocoon shell percentage ranged from 41 to 67 with the lowest of 41 recorded for SK3C and the highest of 67 recorded for P5 and Dun21. The cumulative index values for all the traits ranged from 42 to 67 with the lowest of 42 recorded for SK3C and the highest of 67 recorded for P5.

The evaluation index values obtained for the breeds under 32±1°C and 85±5 % RH conditions are presented in the Table 4. The index value for fecundity ranged from 36 to 67 with the lowest of 36 recorded for P5 and the highest of 67 recorded for CSN. The index value for yield/10000 larvae by number ranged from 32 to 63 with lowest of 32 recorded for BHR3 and the highest of 63 recorded for SK6. The index value for yield/10000 larvae by weight ranged from 30 to 68 with the lowest of 30 recorded for KSO1 and the highest of 68 recorded for D6PN. The index value for cocoon weight ranged from 40 to 76 and the lowest of 40 recorded for BHR2 and BHR3 and the highest of 76 recorded for SK7. The index value for cocoon shell weight ranged from 30 to 68 with the lowest of 30 recorded for SK4C and the highest of 68 recorded for SK7. The index value for cocoon shell percentage ranged from 32 to 71 with the lowest of 32 recorded for SK4C and the highest of 71 recorded for P5. The cumulative index values for all the traits ranged from 44 to 61 with the lowest of 44 recorded for BHR2, SK4C and NB4D2 and the highest of 61 recorded for SK7.

3.3. Performance of oval foundation crosses:

The performance of the oval foundation crosses under optimal temperature (25 ±1°C) and humidity (70 ± 5 %) conditions is presented in Table 5. The fecundity of the 19 foundation crosses considered for the study at 25 ±1°C and 70 ± 5 % RH ranged from 440 to 579 with the lowest of 440 recorded for KPGA x BHR3 and the highest of 579 recorded for KSO-1 x SK3C. The yield/10,000 larvae by number at 25 ±1°C and 70 ± 5 % RH ranged from 8667 to 9200 with the lowest of 8667 recorded for KPGA x Gen3 and the highest of 9200 recorded for KSO-1 x MC4(E) . The yield/10,000 larvae by weight at 25 ±1°C and 70 ± 5 % RH ranged from 12.465 to 15.589 kg with the lowest of 12.465 kg recorded for KPGA x CSN and the highest of 15.589 kg recorded for Gen3 x BHR3. The cocoon weight at 25 ±1°C and 70 ± 5 % RH ranged from 1.418 to 1.569 g with the lowest of 1.418 g recorded for BHR2 x Gen3 and the highest of 1.569 g recorded for KSO-1 x SK3C. The cocoon shell weight at 25 ±1°C and 70 ± 5 % RH ranged from 0.270 to 0.288 g with the lowest of 0.270 g recorded for MC4(E) x CSN and the highest of 0.288 g recorded for KSO-1 x MC4(E). The cocoon shell percentage at 25 ±1°C and 70 ± 5 % RH ranged from 21.3 to 22.7 % with the lowest of 21.3 % recorded for KPGA x MC4(E), BHR2 x SK3C, KSO-1 x SK3C and MC4(E) x CSN and the highest of 22.7 % recorded for KSO-1 x MC4(E).

The performance of the oval foundation crosses under ambient temperature (32 ±1°C) and humidity (85 ±5 %) conditions is presented in Table 6. The fecundity of the 19 foundation crosses considered for the study at 32 ±1°C and 85 ± 5 % RH ranged from 440 to 579 with the lowest of 440 recorded for KPGA x BHR3 and the highest of 579 recorded for KSO-1 x SK3C. The yield/10,000 larvae by number at 32 ±1°C and 85 ± 5 % RH ranged from 3067 to 8150 with the lowest of 3067 recorded for KPGA x BHR3 and the highest of 8150 recorded for BHR2 x Gen3. The yied/10,000 larvae by weight at 32 ±1°C and 85 ± 5 % RH ranged from 3.488 to 10.633 kg with the lowest of 3.488 kg recorded for KPGA x Gen3 and the highest of 10.633 kg recorded for BHR2 x Gen3. The cocoon weight at 32 ±1°C and 85 ± 5 % RH ranged from 1.167 to 1.478 g with the lowest of 1.167 g recorded for BHR2 x KSO-1 and the highest of 1.478 g recorded for Gen3 x MC4(E) and KSO-1 x BHR3. The cocoon shell weight at 32 ±1°C and 85 ± 5 % RH ranged from 0.195 to 0.289 g with the lowest of 0.195 g recorded for BHR2 x KSO-1 and the highest of 0.289 g recorded for KPGA x Gen3. The cocoon shell percentage at 32 ±1°C and 85 ± 5 % RH ranged from 14.5 to 21.4 % with the lowest of 14.5 % recorded for BHR2 x KPGA and the highest of 21.4% recorded for KPGA x Gen3.

Table 1: Performance of bivoltine breeds under optimal temperature (25 ±1°c) and humidity (70 ±5 %) conditions

Sl. No.	Breed	Fecundity	Yield/10000 larvae		Cocoon weight (g)	Cocoon Shell weight (g)	Cocoon Shell Percentage
			By No.	By Wt (kg)			
1	BHR2	535	9023	13.910	1.542	0.321	20.8
2	BHR3	545	9043	13.780	1.525	0.311	20.4
3	SK3C	524	8956	13.810	1.543	0.316	20.5
4	KPGA	521	9012	13.925	1.546	0.320	20.7
5	SK4C	532	9016	13.942	1.547	0.322	20.8
6	SK6	554	9154	13.950	1.525	0.318	20.9
7	SK7	543	9136	14.905	1.543	0.319	20.7
8	D6PN	538	9053	13.992	1.546	0.322	20.8
9	KSO1	546	9034	13.935	1.543	0.335	21.7
10	CSN	523	8987	14.065	1.565	0.335	21.4
11	MC4(E)	528	9087	14.012	1.542	0.327	21.2
12	P5	568	8956	15.798	1.764	0.427	24.2
13	Dun21	576	9012	15.220	1.689	0.410	24.3
14	Dun22	565	8965	15.014	1.675	0.404	24.1
15	Chinese Peanut	548	9015	14.126	1.567	0.368	23.5
16	NB18	554	9065	14.255	1.573	0.373	23.7
17	NB4D2	528	8865	13.490	1.522	0.327	21.5

Table 2: Performance of bivoltine breeds under ambient temperature (32 ±1°C) and humidity (85 ±5 %) conditions

Sl. No.	Breed	Fecundity	Yield/10000 larvae		Cocoon weight (g)	Cocoon Shell weight(g)	Cocoon Shell Percentage
			By No.	By Wt (kg)			
1	BHR2	430	7970	10.090	1.266	0.260	20.5
2	BHR3	517	7430	9.400	1.266	0.259	20.5
3	SK3C	512	7568	10.568	1.265	0.257	20.3
4	KPGA	480	7687	11.258	1.289	0.265	20.6
5	SK4C	417	9187	12.580	1.273	0.221	17.4
6	SK6	496	9020	13.030	1.445	0.295	20.4
7	SK7	415	8970	13.880	1.547	0.320	20.7
8	D6PN	455	9085	14.230	1.465	0.276	18.8
9	KSO1	431	8640	8.450	1.317	0.262	19.9
10	CSN	530	8435	11.400	1.396	0.246	17.6
11	MC4(E)	486	8238	11.180	1.364	0.271	19.9
12	P5	387	8370	10.700	1.278	0.306	23.9
13	Dun21	404	7790	10.520	1.351	0.311	23.0
14	Dun22	414	7910	10.590	1.340	0.308	23.0
15	Chinese Peanut	410	9020	13.120	1.365	0.275	20.1
16	NB18	499	9012	12.730	1.341	0.272	20.3
17	NB4D2	397	8420	10.930	1.297	0.248	19.1

Table 3: Evaluation index of bivoltine breeds under optimal temperature (25 ±1°c) and humidity (70 ±5 %) conditions

Sl. No.	Breed	Fecundity	Yield/10000 larvae		Cocoon weight	Cocoon Shell weight	Cocoon Shell %	Average Index
			By No.	By Wt				
1	BHR2	45	50	44	45	44	43	45
2	BHR3	51	53	42	43	41	40	45
3	SK3C	38	40	43	45	42	41	42
4	KPGA	36	48	45	46	43	42	43
5	SK4C	43	49	45	46	44	43	45
6	SK6	57	70	45	43	43	43	50
7	SK7	50	67	61	45	43	42	51
8	D6PN	47	55	46	46	44	43	47
9	KSO1	52	52	45	45	47	49	48
10	CSN	38	45	47	49	47	47	45
11	MC4(E)	41	60	46	45	45	46	47
12	P5	66	40	76	79	73	67	67
13	Dun21	71	48	66	67	68	67	65
14	Dun22	64	41	63	65	66	66	61
15	Chinese Peanut	53	49	48	49	57	62	53
16	NB18	57	56	50	50	58	63	56
17	NB4D2	45	50	44	45	44	43	45

Table 4: Evaluation index of bivoltine breeds under ambient temperature (32 ±1°c) and humidity (85 ±5 %) conditions

Sl. No.	Breed	Fecundity	Yield/10000 larvae		Cocoon weight	Cocoon Shell weight	Cocoon Shell %	Average Index
			By No.	By Wt				
1	BHR2	45	43	41	40	45	51	44
2	BHR3	64	32	37	40	44	51	45
3	SK3C	51	49	49	49	49	50	50
4	KPGA	56	37	49	43	47	51	47
5	SK4C	42	61	57	41	30	32	44
6	SK6	60	63	60	63	58	50	59
7	SK7	42	62	66	76	68	52	61
8	D6PN	51	62	68	65	51	41	56
9	KSO1	46	56	30	46	45	47	45
10	CSN	67	52	50	57	39	34	50
11	MC4(E)	57	48	48	52	49	47	50
12	P5	36	51	45	41	63	71	51
13	Dun21	40	39	44	51	64	66	51
14	Dun22	42	42	44	49	63	66	51
15	Chinese Peanut	41	54	61	53	51	48	51
16	NB18	60	61	58	49	49	50	55
17	NB4D2	38	52	47	44	40	43	44

Table 5. Performance of oval foundation crosses under optimal temperature (25 ±1°c) and humidity (70 ±5 %) conditions

Sl. No.	Oval Foundation cross	Fecundity	Yield/10000 larvae by No.	Yield/10000 larvae by wt (kg.)	Cocoon weight (g)	Cocoon shell weight (g)	Cocoon shell percentage (%)
1	**KPGA x MC4(E)**	**452**	**8700**	**12.502**	**1.456**	**0.271**	21.3
2	KPGA x Gen3	445	8667	13.488	1.488	0.279	22.0
3	KPGA x BHR3	440	9067	13.942	1.467	0.277	21.8
4	KPGA x CSN	526	8967	12.465	1.500	0.282	22.2
5	**BHR2 x Gen3**	**533**	**9150**	**14.158**	**1.418**	**0.276**	21.7
6	**BHR2 x KPGA**	**540**	**8767**	**13.687**	**1.430**	**0.275**	21.7
7	BHR2 x KSO-1	557	8833	13.333	1.467	0.275	21.7
8	**BHR2 x MC4(E)**	**462**	**8967**	**14.235**	**1.505**	**0.281**	22.1
9	**BHR2 x SK3C**	**486**	**9100**	**13.772**	**1.538**	**0.271**	21.3
10	SK3C x Gen3	464	9167	14.003	1.499	0.276	21.7
11	**SK3C x MC4(E)**	**463**	**8968**	**13.185**	**1.467**	**0.272**	21.4
12	SK3C x BHR3	485	8788	14.752	1.487	0.278	21.9
13	Gen3 x MC4(E)	484	8767	14.908	1.515	0.277	21.8
14	Gen3 x BHR3	529	8900	15.589	1.516	0.278	21.9
15	KSO-1 x MC4(E)	537	9200	14.141	1.561	0.288	22.7
16	**KSO-1 x BHR3**	**472**	**9000**	**14.594**	**1.532**	**0.285**	22.4
17	KSO-1 x SK3C	579	8867	14.019	1.569	0.271	21.3
18	**MC4(E) x BHR3**	**484**	**8955**	**13.755**	**1.496**	**0.285**	22.4
19	MC4(E) x CSN	459	8898	13.306	1.488	0.270	21.3

Table 6. Performance of oval foundation crosses under ambient temperature (32 ±1°c) and humidity (85 ±5 %) conditions

Sl. No.	Oval Foundation cross	Fecundity	Yield/10000 larvae by No.	Yield/10000 larvae by wt (kg.)	Cocoon weight (g)	Cocoon shell weight (g)	Cocoon shell percentage (%)
1	**KPGA x MC4(E)**	**452**	**7700**	**9.502**	**1.365**	**0.251**	18.4
2	KPGA x Gen3	445	3467	3.488	1.353	0.289	21.4
3	KPGA x BHR3	440	3067	3.942	1.364	0.247	18.1
4	KPGA x CSN	526	4067	4.465	1.295	0.209	16.1
5	**BHR2 x Gen3**	**533**	**8150**	**10.275**	**1.342**	**0.266**	19.8
6	**BHR2 x KPGA**	**540**	**7767**	**10.633**	**1.418**	**0.205**	14.5
7	BHR2 x KSO-1	557	4733	4.333	1.167	0.195	16.7
8	**BHR2 x MC4(E)**	**462**	**7967**	**8.235**	**1.235**	**0.21**	17.0
9	**BHR2 x SK3C**	**486**	**8100**	**8.772**	**1.308**	**0.203**	15.5
10	SK3C x Gen3	464	4167	5.003	1.412	0.286	20.3
11	**SK3C x MC4(E)**	**463**	**7500**	**9.185**	**1.343**	**0.242**	18.0
12	SK3C x BHR3	485	4533	5.752	1.414	0.248	17.5
13	Gen3 x MC4(E)	484	3767	4.908	1.478	0.279	18.9
14	Gen3 x BHR3	529	4900	5.589	1.437	0.271	18.9
15	KSO-1 x MC4(E)	537	3400	4.141	1.456	0.259	17.8
16	**KSO-1 x BHR3**	**472**	**8000**	**10.594**	**1.478**	**0.257**	17.4
17	KSO-1 x SK3C	579	3567	5.019	1.431	0.251	17.5
18	**MC4(E) x BHR3**	**484**	**7955**	**8.755**	**1.418**	**0.225**	15.9
19	MC4(E) x CSN	459	3567	4.306	1.422	0.25	17.6

Table 7: Performance of dumbbell foundation cross under optimal temperature (25 ±1°c) and humidity (70 ±5 %) conditions

Sl. No.	Dumbbell Foundation cross	Fecundity (No.)	Yield/ 10000 larvae (No.)	Yield/ 10000 larvae (wt.) (Kg.)	Cocoon Weight. (g)	Cocoon Shell Weight. (g)	Cocoon Shell %
1	NB18 XSK-6	544	8853	12.026	1.573	0.302	19.2
2	NB18 XSK-7	432	9000	13.998	1.657	0.325	19.6
3	NB18 x CHINESE(PN)	481	8833	13.425	1.43	0.312	21.8
4	NB18 XP-5	461	8925	14.282	1.597	0.318	19.9
5	CHINESE(PN) X P5	494	9167	13.351	1.597	0.318	19.9
6	D6(P)N X NB4D2	534	8933	13.986	1.53	0.308	20.1
7	D6(P)N X NB18	550	8968	14.158	1.482	0.305	20.6
8	D6(P)N XSK-6	540	9567	14.912	1.506	0.305	20.3
9	D6(P)N XCHI(PN)	422	9067	13.173	1.509	0.309	20.5
10	SK6 XSK-7	542	9267	13.472	1.495	0.311	20.8
11	SK-7 XCHI(PN)	450	9235	13.389	1.521	0.312	20.5
12	SK-7 XP-5	468	9067	14.933	1.528	0.304	19.9
13	DUN-21 XDUN-22	586	8956	13.488	1.6	0.315	19.7
14	DUN-21 XSK4C	551	8767	13.752	1.564	0.309	19.8
15	DUN-21 XNB4D2	497	9233	14.746	1.576	0.296	18.8
16	DUN-22 XD6(P)N	434	9059	13.042	1.587	0.311	19.6
17	DUN-22 XSK4C	507	9200	13.451	1.544	0.304	19.7
18	DUN-22 XNB4D2	499	8933	14.295	1.496	0.305	20.4
19	DUN-22 XNB18	468	8900	14.088	1.571	0.308	19.6

20	DUN-22 XSK-6	445	9200	13.759	1.582	0.302	19.1
21	DUN-22 XSK-7	406	9125	13.832	1.581	0.31	19.6
22	NB4D2 XNB18	448	8867	13.203	1.491	0.308	20.7
23	NB4D2 XSK-6	533	8968	13.077	1.542	0.305	19.8
24	NB4D2 XSK-7	557	8700	13.248	1.552	0.301	19.4
25	NB4D2 XCHI(PN)	471	8775	14.716	1.486	0.298	20.1

Table 8: Performance of dumbbell foundation cross under ambient temperature (32 ±1°c) and humidity (85 ±5 %) conditions

Sl. No.	Dumbbell Foundation cross	Fecundity (No.)	Yield/ 10000 larvae (No.)	Yield/ 10000 larvae (wt. (Kg.)	Cocoon Weight. (g)	Cocoon Shell Weight. (g)	Cocoon Shell %
1	**NB18 XSK-6**	**544**	**7853**	**11.026**	**1.354**	**0.268**	19.8
2	**NB18 XSK-7**	**432**	**8000**	**10.998**	**1.368**	**0.284**	20.8
3	NB18 XCHINESE(PN)	481	4333	5.425	1.42	0.25	17.6
4	**NB18 XP-5**	**461**	**8125**	**9.282**	**1.479**	**0.275**	18.6
5	**CHINESE(PN)X P5**	**494**	**9167**	**11.351**	**1.33**	**0.245**	18.4
6	D6(P)N X NB4D2	534	4933	4.986	1.392	0.257	18.5
7	**D6(P)N X NB18**	**550**	**7968**	**9.158**	**1.405**	**0.28**	19.9
8	**D6(P)N XSK-6**	**540**	**8567**	**12.912**	**1.41**	**0.258**	18.3
9	**D6(P)N XCHI(PN)**	**422**	**8067**	**11.173**	**1.426**	**0.237**	16.6
10	SK6 XSK-7	542	4267	4.472	1.251	0.194	15.5
11	**SK-7 XCHI(PN)**	**450**	**8235**	**9.389**	**1.332**	**0.217**	16.3
12	SK-7 XP-5	468	4067	4.933	1.41	0.235	16.7
13	**DUN-21 XDUN-22**	**586**	**7956**	**9.488**	**1.355**	**0.239**	17.6
14	DUN-21 XSK4C	551	3767	4.752	1.365	0.236	17.3
15	DUN-21 XNB4D2	497	4533	4.746	1.453	0.287	19.8
16	**DUN-22 XD6(P)N**	**434**	**8059**	**9.042**	**1.328**	**0.237**	17.8
17	DUN-22 XSK4C	507	4200	5.451	1.401	0.248	17.7
18	DUN-22 XNB4D2	499	4433	6.295	1.465	0.299	20.4
19	**DUN-22 XNB18**	**468**	**7500**	**10.088**	**1.458**	**0.282**	19.3
20	**DUN-22 XSK-6**	**445**	**7400**	**10.759**	**1.491**	**0.267**	17.9
21	DUN-22 XSK-7	406	4200	4.832	1.368	0.215	15.7
22	NB4D2 XNB18	448	4867	4.203	1.353	0.24	17.7
23	NB4D2 XSK-6	533	3500	5.077	1.364	0.269	19.7
24	NB4D2 XSK-7	557	4700	5.248	1.412	0.26	18.4
25	**NB4D2 XCHI(PN)**	**471**	**7775**	**8.716**	**1.432**	**0.266**	18.6

Table 9. Evaluation index of oval foundation crosses under optimal temperature (25 ±1°c) and humidity (70 ±5 %) conditions

Sl. No.	Oval Foundation cross	Fecundity	Yield/ 10000 larvae by No.	Yield/ 10000 larvae by wt	Cocoon weight	Cocoon shell weight	Cocoon shell (%)	Avg. Index
1	**KPGA x MC4(E)**	39	35	42	40	38	37	38
2	KPGA x Gen3	38	33	50	48	54	54	46
3	KPGA x BHR3	36	59	53	43	50	49	48
4	KPGA x CSN	58	52	42	51	59	59	54
5	**BHR2 x Gen3**	60	64	54	30	48	47	50
6	**BHR2 x KPGA**	61	39	47	33	46	47	46

7	BHR2 x KSO-1	65	43	49	43	46	47	49
8	**BHR2 x MC4(E)**	42	52	56	53	57	57	53
9	**BHR2 x SK3C**	48	61	52	61	38	37	49
10	SK3C x Gen3	42	65	54	51	48	47	51
11	**SK3C x MC4(E)**	42	52	47	43	40	39	44
12	SK3C x BHR3	48	41	60	48	52	52	50
13	Gen3 x MC4(E)	47	39	61	55	50	49	50
14	Gen3 x BHR3	59	48	66	56	52	52	55
15	KSO-1 x MC4(E)	61	67	55	67	71	72	66
16	**KSO-1 x BHR3**	44	54	58	60	65	64	58
17	KSO-1 x SK3C	71	46	54	69	38	37	52
18	**MC4(E) x BHR3**	47	51	52	50	65	64	55
19	MC4(E) x CSN	41	48	48	48	36	37	43

Table 10. Evaluation index of oval foundation crosses under ambient temperature (32 ±1°c) and humidity (85 ±5 %) conditions

Sl. No.	Oval Foundation cross	Fecundity	Yield/ 10000 larvae by No.	Yield/ 10000 larvae by wt	Cocoon weight	Cocoon shell weight	Cocoon shell (%)	Avg. Index
1	KPGA x MC4(E)	39	60	61	49	52	54	53
2	KPGA x Gen3	38	39	37	47	66	72	50
3	KPGA x BHR3	36	37	39	49	51	52	44
4	KPGA x CSN	58	42	41	40	37	40	43
5	BHR2 x Gen3	60	63	64	46	58	62	59
6	BHR2 x KPGA	61	61	66	55	36	30	52
7	BHR2 x KSO-1	65	46	41	24	33	44	42
8	BHR2 x MC4(E)	42	62	56	32	38	45	46
9	BHR2 x SK3C	48	62	58	42	35	36	47
10	SK3C x Gen3	42	43	43	55	65	66	52
11	SK3C x MC4(E)	42	59	60	46	49	52	51
12	SK3C x BHR3	48	45	46	55	51	48	49
13	Gen3 x MC4(E)	47	41	43	63	62	57	52
14	Gen3 x BHR3	59	47	46	58	59	57	54
15	KSO-1 x MC4(E)	61	39	40	60	55	50	51
16	KSO-1 x BHR3	44	62	66	63	54	48	56
17	KSO-1 x SK3C	71	40	43	57	52	48	52
18	MC4(E) x BHR3	47	62	58	55	43	39	51
19	MC4(E) x CSN	41	40	41	56	52	49	46

Table 11. Evaluation index of dumbbell foundation crosses under optimal temperature (25 ±1°c) and humidity (70 ±5 %) conditions

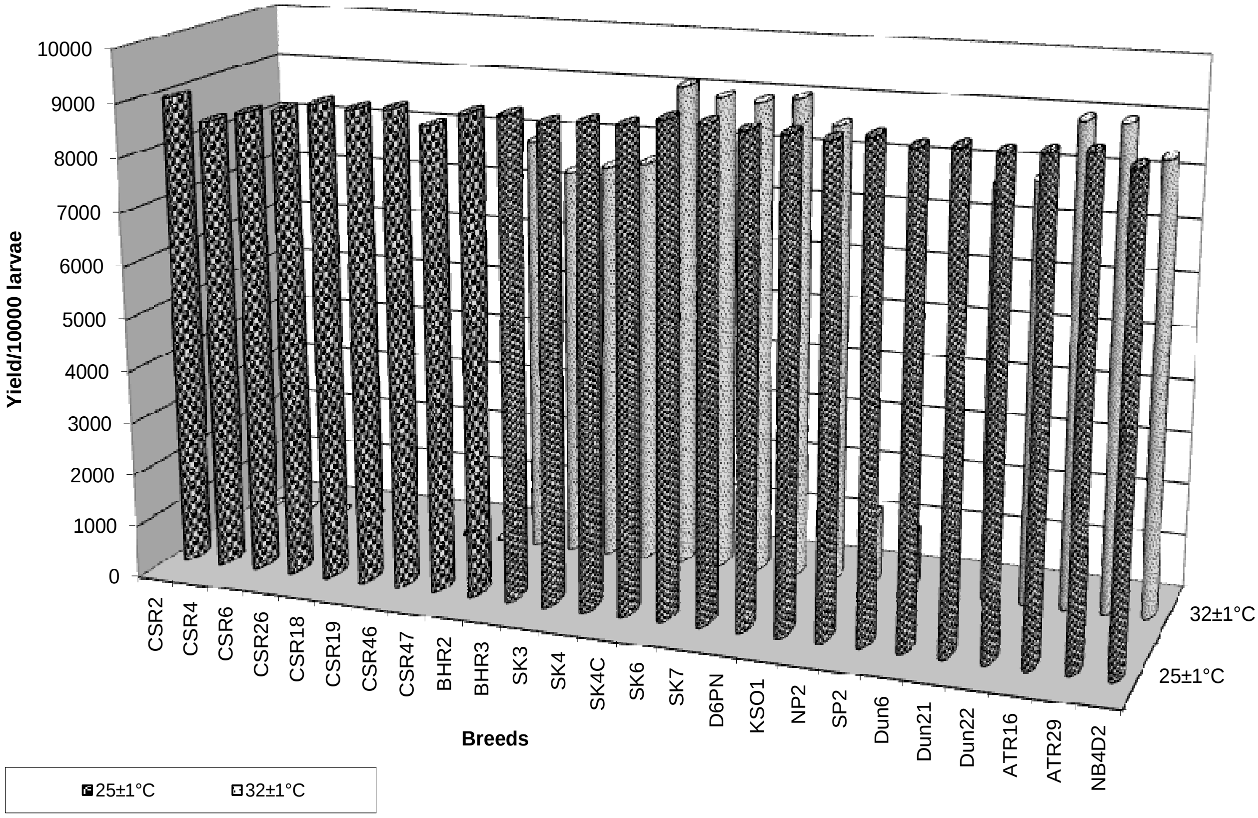
Sl. No	Dumbbell Foundation cross	Fecundity	Yield/ 10000 larvae (No.)	Yield/ 10000 larvae (wt.)	Cocoon Weight	Cocoon Shell Weight	Cocoon Shell %	Avg. Index
1	NB18 XSK-6	61	41	24	56	41	38	43
2	NB18 XSK-7	37	49	54	73	76	44	56
3	NB18 x CHINESE(PN)	48	40	45	27	56	79	49
4	NB18 XP-5	43	45	58	61	66	49	54
5	CHINESE(PN) X P5	50	58	44	61	66	49	54
6	D6(P)N X NB4D2	58	45	54	47	50	52	51
7	D6(P)N X NB18	62	47	56	37	45	60	51
8	D6(P)N XSK-6	60	78	67	42	45	55	58
9	D6(P)N XCHI(PN)	35	52	41	43	51	58	47
10	SK6 XSK-7	60	63	46	40	55	63	54
11	SK-7 XCHI(PN)	41	61	45	45	56	58	51
12	SK-7 XP-5	45	52	68	47	44	49	51
13	DUN-21 XDUN-22	69	47	46	61	61	46	55
14	DUN-21 XSK4C	62	37	50	54	51	47	50
15	DUN-21 XNB4D2	51	61	65	57	31	31	49
16	DUN-22 XD6(P)N	38	52	39	59	55	44	48
17	DUN-22 XSK4C	53	59	45	50	44	46	49
18	DUN-22 XNB4D2	51	45	58	40	45	57	50
19	DUN-22 XNB18	45	44	55	56	50	44	49
20	DUN-22 XSK-6	40	59	50	58	41	36	47
21	DUN-22 XSK-7	32	55	51	58	53	44	49
22	NB4D2 XNB18	41	42	42	39	50	62	46
23	NB4D2 XSK-6	58	47	40	50	45	47	48
24	NB4D2 XSK-7	63	33	42	52	39	41	45
25	NB4D2 XCHI(PN)	46	37	64	38	34	52	45

Table 12. Evaluation index of dumbbell foundation crosses under optimal temperature (32 ±1°c) and humidity (85 ±5 %) conditions

Sl. No.	Dumbbell Foundation cross	Fecundity	Yield/ 10000 larvae (No.)	Yield/ 10000 larvae (wt.)	Cocoon Weight.	Cocoon Shell Weight.	Cocoon Shell %	Avg. Index
1	**NB18 XSK-6**	**61**	**58**	**62**	**43**	**56**	**62**	57
2	**NB18 XSK-7**	**37**	**59**	**62**	**45**	**62**	**69**	56
3	NB18 XCHINESE(PN)	**48**	**40**	**42**	**55**	**48**	**46**	46
4	**NB18 XP-5**	**43**	**60**	**56**	**66**	**59**	**53**	56
5	**CHINESE(PN)X P5**	**50**	**65**	**63**	**38**	**46**	**51**	52
6	D6(P)N X NB4D2	**58**	**43**	**40**	**50**	**51**	**52**	49
7	**D6(P)N X NB18**	**62**	**59**	**55**	**52**	**61**	**62**	59
8	**D6(P)N XSK-6**	**60**	**62**	**69**	**53**	**52**	**51**	58
9	**D6(P)N XCHI(PN)**	**35**	**59**	**62**	**56**	**43**	**38**	49
10	SK6 XSK-7	**60**	**40**	**38**	**24**	**26**	**31**	36
11	**SK-7 XCHI(PN)**	**41**	**60**	**56**	**39**	**35**	**36**	45
12	SK-7 XP-5	**45**	**39**	**40**	**53**	**42**	**39**	43
13	**DUN-21 XDUN-22**	**69**	**59**	**56**	**43**	**44**	**46**	53

14	DUN-21 XSK4C	62	37	39	45	43	44	45
15	DUN-21 XNB4D2	51	41	39	61	64	62	53
16	**DUN-22 XD6(P)N**	38	59	55	38	43	47	47
17	DUN-22 XSK4C	53	39	42	51	48	46	47
18	DUN-22 XNB4D2	51	40	45	63	68	66	56
19	**DUN-22 XNB18**	45	56	58	62	62	58	57
20	**DUN-22 XSK-6**	40	56	61	68	55	48	55
21	DUN-22 XSK-7	32	39	39	45	34	32	37
22	NB4D2 XNB18	41	43	37	43	44	46	42
23	NB4D2 XSK-6	58	36	40	45	56	61	49
24	NB4D2 XSK-7	63	42	41	54	53	51	51
25	**NB4D2 XCHI(PN)**	46	58	53	57	55	53	54

Fig.1 Yield/10000 larvae by number at two different temperature treatment



3.5 Evaluation Index:

The evaluation index values obtained for the Oval foundation crosses under 25±1°C and 70±5 % RH conditions are presented in the Table 9. The index value for fecundity ranged from 36 to 71 with the lowest of 36 recorded for KPGA x BHR3 and the highest of 71 recorded for KSO-1 x SK3C. The index value for yield/10000 larvae by number ranged from 33 to 67 with lowest of 33 recorded for KPGA x Gen3 and the highest of 67 recorded for KSO-1 x MC4(E). The index value for yield/10000 larvae by weight ranged from 42 to 66 with the lowest of 42 recorded for KPGA x MC4(E) and KPGA x CSN and the highest of 66 recorded for Gen3 x BHR3. The index value for cocoon weight ranged from 30 to 69 and the lowest of 30 recorded for BHR2 x Gen3 and the highest of 69 recorded for KSO-1 x SK3C. The index value for cocoon shell weight ranged from 36 to 71 with the lowest of 36 recorded for MC4(E) x CSN and the highest of 71 recorded for KSO-1 x MC4(E). The index value for cocoon shell percentage ranged from 37 to 72 with the lowest of 37 recorded for KPGA x MC4(E), BHR2 x SK3C, KSO-1 x SK3C and MC4(E) x CSN and the highest of 72 recorded for

KSo-1 x SK3C. The cumulative index values for all the traits ranged from 38 to 66 with the lowest of 38 recorded for KPGA x MC4(E) and the highest of 66 recorded for KSO-1 x MC4(E) .

The evaluation index values obtained for the oval foundation crosses under 32±1°C and 85±5 % RH conditions are presented in the Table 10. The index value for fecundity ranged from 36 to 71 with the lowest of 36 recorded for KPGA x BHR3 and the highest of 71 recorded for KSO-1 x SK3C. The index value for yield/10000 larvae by number ranged from 37 to 63 with lowest of 37 recorded for KPGA x BHR3 and the highest of 63 recorded for BHR2 x Gen3. The index value for yield/10000 larvae by weight ranged from 37 to 66 with the lowest of 37 recorded for KPGA x Gen3 and the highest of 66 recorded for KSO-1 x BHR3. The index value for cocoon weight ranged from 24 to 63 and the lowest of 24 recorded for BHR2 x KSO-1 and the highest of 63 recorded for Gen3 x MC4(E). The index value for cocoon shell weight ranged from 33 to 66 with the lowest of 33 recorded for BHR2 x KSO-1 and the highest of 66 recorded for KPGA x Gen3. The index value for cocoon shell percentage ranged from 30 to 72 with the lowest of 30 recorded for BHR2 x KPGA and the highest of 72 recorded for KPGA x Gen3. The cumulative index values for all the traits ranged from 42 to 59 with the lowest of 42 recorded for BHR2 x KSO-1 and the highest of 59 recorded for BHR2 x KSO-1.

The evaluation index values obtained for the dumbbell foundation crosses under 25±1°C and 70±5 % RH conditions are presented in the Table 11. The index value for fecundity ranged from 32 to 69 with the lowest of 32 recorded for Dun22 x SK7 and the highest of 69 recorded for Dun21 x Dun22. The index value for yield/10000 larvae by number ranged from 33 to 78 with lowest of 33 recorded for NB4D2 x SK7 and the highest of 78 recorded for D6(P)N x SK6. The index value for yield/10000 larvae by weight ranged from 24 to 68 with the lowest of 24 recorded for NB18 x SK6 and the highest of 68 recorded for SK7 x P5. The index value for cocoon weight ranged from 27 to 73 and the lowest of 27 recorded for NB18 x Chinese Peanut and the highest of 73 recorded for NB18 x SK7. The index value for cocoon shell weight ranged from 31 to 76 with the lowest of 31 recorded for Dun21 x NB4D2 and the highest of 76 recorded for NB18 x SK7. The index value for cocoon shell percentage ranged from 31 to 79 with the lowest of 31 recorded for Dun21 x NB4D2 and the highest of 79 recorded for NB18 x Chinese Peanut. The cumulative index values for all the traits ranged from 43 to 58 with the lowest of 43 recorded for NB18 x SK6 and the highest of 58 recorded for D6(P)N x SK6 .

The evaluation index values obtained for the dumbbell foundation crosses under 32±1°C and 85±5 % RH conditions are presented in the Table 12. The index value for fecundity ranged from 32 to 69 with the lowest of 32 recorded for Dun22 x SK7 and the highest of 69 recorded for Dun21 x Dun22. The index value for yield/10000 larvae by number ranged from 36 to 65 with lowest of 36 recorded for NB4D2 x SK6 and the highest of 65 recorded for Chinese Peanut x P5. The index value for yield/10000 larvae by weight ranged from 37 to 69 with the lowest of 37 recorded for NB4D2 x NB18 and the highest of 69 recorded for D6(P)N x SK6. The index value for cocoon weight ranged from 24 to 68 and the lowest of 24 recorded for SK6 x SK7 and the highest of 68 recorded for Dun22 x SK6. The index value for cocoon shell weight ranged from 26 to 68 with the lowest of 26 recorded for SK6 x SK7 and the highest of 68 recorded for Dun22 x NB4D2. The index value for cocoon shell percentage ranged from 31 to 69 with the lowest of 31 recorded for SK6 x SK7 and the highest of 69 recorded for NB18 x SK7. The cumulative index values for all the traits ranged from 36 to 59 with the lowest of 36 recorded for SK6 x SK7 and the highest of 59 recorded for D6(P)N x NB18 .

Bivoltine breeds of different geographical origin and possessing important genetic potential on various economic traits in varying magnitude were screened for evaluation, in order to obtain fair and precise assessment of various traits. Seventeen selected breeds which were possessing desired targeted traits on larval duration, fitness, and productivity were subjected for amalgamation, in a selective fashion. Oval breeds were crossed with ovals and dumbbells were with dumbbells as also the breeds of plain larvae with plain and breeds of marked with marked larvae. Priority was given to top performers in the evaluation studies and selective crossing was made keeping the objective and giving representation to different groups.

Foundation crosses, are possessing a significant advantage of inherent genetic plasticity because of two parental resources involved in the genetic architecture and therefore, new breeds evolved were subjected for a concise study, to utilize this advantage. The final aim of the breeder is primarily to evolve a breed which can give rise to stabilized crops and secondly to improve both quantity and quality of silk (Tazima, 1984 and Lakshmanan and Suresh Kumar 2012c). Improvement of breeds necessarily means selection of desirable genes in appropriate combinations, which contribute to the overall genetic worth of the population. With respect to the economic value, the focus should be on all the genes affecting the traits thereby contributing to the viability and productivity. Therefore, selection of hybrid combinations emphasize the need to organize the genetic material in a way that help to improve the manifestation of commercially important traits (Nirmal Kumar, 1995). This can be achieved precisely by adopting a strategy by setting up a common index giving adequate weightage to all the component traits manifested among an array of hybrids. The rationale for judging the utility of multiple trait evaluation index in the present study is based on major metric traits, which are considered to be economically important. However, asymmetry is found in most of the traits as evidenced by indices of the individual component traits that the index value obtained individually for each trait can fail but the overall index values help in adjudicating the performance of the hybrids derived. In view of this, all the major traits have been considered together to obtain the aggregate index value, since exclusion of any one trait can result in negative situation.

According to Allard and Bradshaw (1964), performance of the strain itself in a given environment indicates its superiority. While evaluation, emphasis was given on the phenotypic expression of traits of economic importance under different temperature conditions. However, as the objective of the study was for greater viability and high productivity merits, equal importance was given on these two traits while selection of parents. The significant variations observed in the phenotypic manifestation for the traits analyzed can be attributed to the genetic constitution of the breeds and their degree of expression to which they are exposed during their rearing. Such variations in the manifestation of phenotypic traits of the breeds studied can be ascribed to the influence of environmental conditions. Variable gene frequencies at different loci make them to respond differently. The results are in line with the findings of (Watanabe,1928; Hassanein and Sharawy, 1962; Krishnaswami and Narasimhanna, 1974; Ueda *et a*l., 1975; Rajanna, 1989; Raju, 1990; Maribashetty, 1991; Kalpana, 1992; Nirmal Kumar,1995; Basavaraja, 1996 and Sudhakar Rao *et al.,* (2001).

It is important to measure the phenotypic expression of the major contributing traits of economic importance in the silkworm strains under diversified environmental conditions to understand the genetic endowment pertaining to adaptability and productivity. The balancing of desirable traits during the course of the breeding for varied climatic conditions is a challenging task for the breeder. The choice of parental material is critical and difficult to evaluate all the available silkworm breeds,. However, a few strains of known genetic background, pedigree and specific traits desirable for the new breeding programme have to be taken into consideration while evaluating the breeding material. It is also equally important to understand the traits related to productivity and viability. All the breeds selected for the evaluation are having one or more desirable traits as per the objectives of the present study. In the present study, which envisages to evaluate bivoltine foundation crosses to identify more resistant bivoltine foundation crosses that can give rise to stable cocoon crops with better viability, even though productivity is low compared to the existing productive bivoltine breeds that are currently used in the field. In silkworms, the correlation for some characters is positive and for some it is negative (Gamo and Ichiba, 1971 and Gamo, 1976) . Such a negative correlation is observed for the traits productivity and viability and hence the attempt made was to increase the viability of the developed breeds. Moreover as suggested by Lekuthai and Butrachand (1974) and Strunnikov and Strunnikov (1986), the selection parameters were primarily aimed at improving the viability character such as yield by number without sacrificing much of the productivity traits like cocoon weight, cocoon shell weight and yield by weight. In addition, during later generations of inbreeding, selection was applied to select desired genotypes to improve the traits of commercial importance like viability and productivity as suggested by Mano (1993 and 1994) to improve the yield of bivoltines.

The fluctuations noticed in the pupation rate among the bivoltine breeds and foundation crosses considered for this study can be partially attributed to the influence of environmental factors and the interaction of alleles responsible for the expression of the trait. The fecundity is largely dependent on the genotype of mother moth and environmental conditions prevailing at the time of oviposition.. The phenomenon of cocoon yield is correlated to cocoon weight and because of high temperature stresses it was drastically reduced. It was observed that under optimal conditions it reached to maximum and under stress conditions it was minimum. The overall picture shows that cocoon weight was low in the high temperature treated batches when compared to room temperature batches. Generally as the temperature increases, larval weight decreases. High temperature did not favour the productivity and tends to the withering of mulberry leaves which were fed to the silkworms, thereby reducing the feeding quantum. But high temperature accelerates the growth rate leading to poor cocoon quality (Pillai and Krishnaswami, 1980). This may be due to the fact that high temperature will cause leaf withering leading to low rate of ingestion by the silkworm. During this situation the silkworm larvae cannot eat more time on provided leaf and it leads to decline in the cocoon weight (Gangawar *et al.,* 1993). Further, the analysis of variance indicating significant ($P < 0.001$) differences can be attributed to differential selection response. Similarly, cocoon shell weight which was found to exhibit variation during the process of selection indicating interesting results. The cocoon shell weight which was known as moderately heritable (Tsuchiya and Kurashima, 1959; Gamo and Hirabayashi, 1983) showed positive selection response in both the temperature conditions. Application of selection for the trait not only increased the cocoon shell weight but also concomitant increase for most of the productivity traits as suggested by Kobayashi (1962). With regards to cocoon shell percentage, the results indicated positive selection response. It has been pointed out by many Japanese breeders that the trait is very difficult to increase by selection (Gamo and Hirabayashi, 1983; Mano *et al.,* 1988). However, an attempt made in the present experiment indicates that the response was slow at high temperature and varied response was observed whereas at room temperature, lower values were observed. Thus cocoon shell percentage was significantly improved under optimum conditions than high temperature conditions. These findings are in agreement with Shivakumar *et al.,* (1997).

Silkworm breed which are reared over a series of environments exhibiting less variation are considered stable. One of the objectives of the breeder is to recommend stable breeds to the farmers for rearing under different environmental conditions. Effect of high temperature and high humidity in terms of cocoon crop depends on several factors that operate within and outside the body of the silkworm. In the present study, it was observed that apart from the temperature, humidity also influences the productivity pattern in the silkworm and is in agreement with Krishnaswami (1986) and Sudhakar Rao (2003). It was also reported that the cocoon yield/10000 larvae, cocoon weight, cocoon shell weight and cocoon shell percentage were also low in the high temperature treated batches when compared to the batches reared under optimum rearing conditions which corroborates the findings of the present study. In the present study an attempt was made to identify superior bivoltine foundation crosses by assessment on multiple traits of the developed foundation crosses as an important task in predicting the potential foundation cross combinations. The comprehensive merit of the foundation cross over a range of traits depends on relative superiority of many individual traits. Selection needs to be based on multiple trait analysis comprising of viable, quantitative and qualitative traits. In silkworm, good number of foundation crosses are evaluated and promising ones are selected based on the economic traits (Singh and Subba Rao, 1993). The preset data was analyses with equal weight to all the important traits using multiple trait evaluation index (Mano *et al*., 1993 Lakshmanan and Suresh Kumar 2012a, 2012b and 2012c and Suresh Kumar *et al*., 2012).

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