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STUDIES ON FOUNDATION HYBRIDS IN SILKWORM *BOMBYX MORI* L.

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Improvement in foundation crosses over its pure parental strains in Chinese and Japanese type bivoltine silkworm was studied. Results indicate that larval duration was shorter in foundation crosses. Significant positive hybrid vigour was found in foundation crosses with regard to yield by number and by weight. There are specific advantages in rearing the foundation crosses than rearing the pure strains at the seed cocoon growers level.

INTRODUCTION

The exploitation of heterosis in silkworm has been known for more than half century (Yokoyama, 1957). It has played a pivotal role in phenomenal increase in global silk production. Heterosis in silkworm has been studied by many workers (Hirobe, 1969; Growen, 1952; Yokoyama, 1957; Harada, 1961; Gamo, 1976a & b). In India, heterosis is being exploited by raising F1 hybrids involing females of local multivoltine strains and exotic bivoltine races to considerable extend whereas bivoltine hybrids to a lesser extent.

The hybrid era in Indian sericulture commenced in 1922 in Karnataka where crosses between indigenous Pure Mysore and Japanese races were popularized. Large scale bivoltine hybrid rearings were introduced in the field during 1973-74. During 1975 the improved cross breed PM x NB4D2 was introduced and since then there has been a considerable improvement in cocoon yield, silk content and silk recovery.

Currently, the seed farmers raise the pure bivoltine strains for the commercial hybrid seed production and often they encounter the problem of low productivity or cocoon crop losses. Rearing of foundation hybrids at seed rearers is advantageous and in sericulturally advanced countries like Japan, double hybrids were introduced long back. The rearing of double hybrids facilitates a gain in egg productivity without reducing the cocoon shell percentage (Gamo,1976a). Keeping in view the advantage of foundation hybrids, the present investigation was made to estimate the improvement in foundation crosses over its pure parental strains in both Chinese and Japanese type bivoltine varieties.

MATERIALS AND METHODS

Four bivoltine breeds CC1 and CA2 (Chinese type) and NB18 and NB4D2 (Japanese type) of the silkworm breeding laboratory of CSR&TI, Mysore were utilised in the present study.Foundation crosses were produced between Chinese x Chinese and Japanese x Japanese types and four foundation hybrids were prepared. They are CC1 x CA2, CA2 x CC1 (C Type), NB18 x NB4D2 and NB4D2 x NB18 (J type). The parents and foundation hybrids were reared simultaneously during three trials October - November 1995, January - February 1996 at CSR&TI, Mysore. Three replications were reared in each combination and pure lines and an equal number of 300 larvae were conducted by randomised block design adopting the standard new technique of rearing (Krishnaswamy, 1971& 1978). Heterosis over mid parent/better parent value for each character was calculated by the following formula:

$$\text{Heterosis \%} = \frac{\text{F1 - mid parental/better parental value}}{\text{mid parental/better parental value}} \times 100$$

For estimation of cocoon characters, a random sample of 100 cocoons was selected, and for the filament length 50 cocoons were randomly taken and reeled separately for each batch. Observations were made of fecundity, hatching percent, larval duration, survival rate, yield by weight/10000 larvae, single cocoon weight, single shell weight, cocoon shell ratio and filament length. The results were statistically analysed.

RESULTS

The mean results of three rearing trials along with Anova with regard to seven economic characters are presented in Table I and II. Heterosis values were calculated and presented in Table III and IV.

Fecundity and Hatching percent : There was not much difference between the parents and their foundation crosses and its reciprocals regarding the number of eggs per laying and hatching percentage.

Larval duration : The larval duration was shorter in Chinese type combinations. However, both in the C type and J type foundation, is shorter by 2.5% and 2.4% in C and J type crosses, respectively. Both type of cocoons have shown positive heterosis for larval duration.

Table I : Anova of the seven economic characters in Chineses type parents and their foundation crosses.

Race/Cross/ Treatment	Larval Durat-ion (Hrs)	Yield/10000 larvae brushed		Cocoon Wt. (gms)	Shell Wt. (gms)	Cocoon Shell ratio (%)	Filament length (mts)
		Pupation No.	Wt. (kg)				
CC1	647	7718	14.955	1.90	0.430	22.7	1230
CA2	650	7466	14.211	1.91	0.420	22.2	1197
CC1 x CA2	630	8503	17.059	1.94	0.440	22.9	1305
CA2 x CC1	630	8691	17.293	2.00	0.450	22.4	1295
Between seasons	**	**	**	**	**	**	**
Between parents	NS	NS	NS	NS	NS	NS	NS
Between hybrid	NS	NS	NS	*	NS	NS	NS
Parents x hybrids	**	**	**	**	*	NS	**
Race x season	**	NS	NS	*	NS	NS	NS
CD AT 5%							
Races	5	695	1.525	0.06	-	-	52
Season	4	602	1.321	0.05	0.06	0.56	45
S.E.							
Races	2	236	0.519	0.02	-	-	18
Seasons	2	205	0.449	0.02	0.018	0.19	15

Table II : Anova of the seven economic characters in Japanese type parents and foundation crosses.

Race/Cross/ Treatment	Larval Durat-ion (Hrs)	Yield/10000 larvae brushed		Cocoon Wt. (gms)	Shell Wt. (gms)	Cocoon Shell ratio (%)	Filament length (mts)
		Pupation No.	Wt. (kg)				
NB18	656	7425	15.118	2.011	0.433	21.6	1092
NB4D2	654	7321	14.651	1.964	0.422	21.5	1062
NB18 x NB4D2	639	8166	16.381	2.022	0.439	21.7	1165
NB4D2 x NB18	641	8133	17.239	2.058	0.437	21.3	1167
Between seasons	**	**	**	**	**	NS	**
Between parents	NS	NS	NS	NS	NS	NS	NS
Between hybrid	NS	NS	NS	NS	NS	NS	NS
Parents x hybrids	**	**	**	*	NS	NS	**
Race x season	**	NS	NS	NS	NS	NS	NS
CD AT 5%							
Races	5	472	0.887	0.058	-	-	52
Season	4	409	8.768	0.058	0.0162	-	45
S.E.							
Races	2	160	0.302	0.020	-	-	18
Seasons	2	139	0.261	0.017	0.0055	-	15

* = Significant at 5% level; ** = Significant at 1% level.

Larval weight : The growth of the 5th age larva was better in the foundation hybrids in both C and J type crosses. There was an improvement of 1.7% and 1.8% in larval growth in C and J type crosses, respectively. The heterosis for larval weight was more in C type crosses (7.1 to 7.9%) than J type crosses (3.2 to 3.9%).

Survival rate : The survival rate was superior in the foundation crosses than their parents. There was an improvement of 13.2% in C type and 10.4% in J type crosses. CA2 x CC1 was the best 86.8% survival compared to other three crosses. There was no significant difference among the C and J type crosses. C type recorded 4.2% high survival than J type crosses. The heterosis ranges from 10 to 14% in different crosses. Higher heterosis was recorded in CA2 x CC1 (12.5 to 14.3%) followed by CC1 x CA2 (10.2% to 12.0%).

Yield/10,000 larvae by weight: Significant differences were seen between the F.C's and their parents. Among the different combinations CA2 x CC1 gave the maximum yield per 10,000 larvae by weight (17.284 kg). Chinese type F.C's performed better and the improvement noticed was 17.8%, where in J type foundation crosses there was an improvement of 12.9%. Heterosis observed was 8.3% to 18.6%. Higher heterosis values were recorded in the cross CA2 x CC1.

Cocoon weight, shell weight and Cocoon shell ratio : There was no significant difference in cocoon weight in all the combinations. The shell weight was better in case of foundation crosses than parents in both the type of crosses. C type foundation crosses were better by 3.5% and J type foundation crosses were better by 2.8% in shell weight than their parents. There was not much difference in case of cocoon shell ratio. Marginal heterotic values were observed with regard to shell weight (0.7 to 3.5%). C type crosses showed more heterosis than J type crosses.

Table III : Heterosis value in Chinese type foundation crosses for ten economic characters.

Race/ Cross	Fecundity	Hatching (%)	Larval duration (Hrs)	Weight of matured 10 larvae (gms)	Yield/10000 larvae brushed		Single cocoon Wt. (gms)	Single shell Wt. (gms)	Cocoon shell ratio (%)	Filament length (mts)
					Pupation No.	Wt. (kg)				
CC1	645	93.3	647	47.3	7715	14.951	1.938	0.430	22.1	1229
CA2	592	91.0	650	46.6	7462	14.199	1.900	0.420	22.1	1196
MPV	618	92.2	648	46.9	7588	14.575	1.919	0.425	22.1	1212
CC1 x CA2	616	95.6	630	50.7	8499	17.047	1.936	0.440	22.7	1304
GOBP (%)	-4.5	2.49	2.60	7.10	10.16	14.02	-0.10	2.32	2.71	6.10
GOMP (%)	-0.3	8.73	2.78	7.92	12.01	16.96	0.89	3.53	2.71	7.60
CA2 x CC1	624	95.9	630	50.7	8676	17.284	1.996	0.440	22.0	1294
GOBP (%)	-3.2	2.87	2.60	7.14	12.46	15.60	2.99	2.32	-0.4	5.29
GOMP (%)	0.97	4.12	2.78	7.96	14.34	18.59	4.01	-3.53	-0.4	6.80

MPV = Mid parent value; GOBP = Gain over better pairent; GOMP = Gain over mid parent.

Table IV : Heterosis value in Japanese type foundation crosses for ten economic characters.

Race/ Cross	Fecundity	Hatching (%)	Larval duration (Hrs)	Weight of matured 10 larvae (gms)	Yield/10000 larvae brushed		Single cocoon Wt. (gms)	Single shell Wt. (gms)	Cocoon shell ratio (%)	Filament length (mts)
					Pupation No.	Wt. (kg)				
NB18	631	94.7	656	48.5	7422	15.120	2.006	0.430	21.4	1092
NB4D2	656	94.8	654	49.2	7351	14.647	1.960	0.423	21.6	1062
MPV	643	94.7	655	48.8	7386	14.883	1.983	0.426	21.5	1077
NB18 x NB4D2	578	95.7	635	48.7	8166	16.378	2.020	0.435	21.5	1167
GOBP (%)	-11.89	0.84	2.90	-1.01	10.02	8.32	0.70	2.1	-0.5	6.87
GOMP (%)	-10.11	0.99	3.00	-0.29	10.56	10.04	1.86	0.7	0.0	8.35
NB4D2 x NB18	632	94.8	641	50.8	8172	17.236	2.056	0.440	21.4	1165
GOBP (%)	-3.66	-0.08	2.00	3.21	10.10	13.99	2.49	2.32	-0.92	6.68
GOMP (%)	-1.71	0.02	2.10	3.97	10.64	15.81	3.68	3.29	-0.47	8.17

MPV = Mid parent value; GOBP = Gain over better pairent; GOMP = Gain over mid parent.

Filament length and denier : Significant differences were observed for filament length between parents and F. C's. There was an improvement of 7.2% and 8.3% in C and J type crosses respectively over their parents. CC1 x CA2 has recorded maximum filament length of 1304 mts. The size of the filament did not vary significantly among C and J type crosses.

DISCUSSION

The hybrid vigour can be defined as the extra vigour, exceeding that of both the parental stocks, which is frequently shown by hybrids from the crossing of species, breeds, strains of inbred lines. In India, utilization of hybrid vigour came rather late (1920's). Large scale bivoltine hybrid rearing were introduced in the field during 1973-74. Under tropical conditions, farmers are getting an average cocoon yield in the range of 30-37 kg/100 dfls (Jolly, 1984). But there are some inherent problems that are coming in the way of productivity enhancement. There is considerable gap in productivity between laboratory and field level.

The present investigation aims mainly to improve the crop stability and enhance the production levels of parental pure strains which are more vulnerable to fluctuating climate and varied management levels. This results in frequent failure of cocoon crops and often discourage the seed cocoon growers. As is evident from the present investigation, this problem could be overcome by rearing the foundation crosses which register considerable heterosis particularly with reference to survival percentage, instead of raising pure strains at seed farmers level. Anova of the results indicate significant results were observed between parents and hybrids for all the economic characters except shell ratio.

Expression of hybrid vigour was different in different crosses in relation to survival, cocoon yield, cocoon shell weight, larval duration and filament length. Gamo (1993) showed that the characters such as survival rate has very low heritability (0.20) and this could be improved only through hybrid vigour. The level of heterosis present in a cross can be influenced by environmental factors. Lerner (1954) proposed the concept of genetic homeostasis in which heterozygote is expected to be less influenced by environmental effects than homozygote.

Results indicate that the larval duration was shorter in F.C's than parents and it has a specific advantage for seed rearers with regard to crop losses due to disease problems in final stages. Heterosis was also high for survival and yield characters, thus the foundation crosses were superior to the parents.

Results of the investigation also showed that the winter season was the best for bivoltine rearings in tropical conditions of Karnataka. The heterosis varies according to the season. The concept of genotype environment interaction was studied in greater detail by Yokoyama (1957), Griffing & Siros (1971), Knight (1951) and Orozoco (1976). In silkworm, Harada (1961) found high degree of differences in heterosis for various characters in different seasons. Cocoon weight, shell weight and filament length were also better in F.C's than parents.

The present study revealed that there were specific advantages in rearing the foundation crosses as compared to pure lines. The increased crop stability would help the seed cocoon growers significantly.

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