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HYBRID VIGOUR IN THREE-WAY CROSSES OF MULBERRY SILKWORM *BOMBYX MORI* L.

S. K. DAS, B. GHOSH, S. PATTNAIK[1], N. K. DAS, T. SINGH[2],
S. K. SEN AND G. SUBBA RAO[3]

Silkworm Breeding and Genetics Section,
Central Sericultural Research and Training Institute, Berhampore 742 101

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ABSTRACT

The present experiment was carried out with a view to combine the best characters of the popular evolved multivoltine breed 'G' with bivoltine hybrids for rearing under tropical conditions. The crosses and their parents were reared during three seasons for study of heterosis. Heterosis over mid-and better parents was determined for seven important commercial characters. The degree of heterosis varied considerably for different economic characters in different seasons. Highly significant heterosis was noticed over both parental values for most of the characters during dry summer season. The overall data indicate that two crosses viz., G x (P5xNB18) and G x (NB18xP%) during dry summer and two crosses viz., G x (KPG-BxNB7) and G x (NB7x KPG-B) during autumn and winter seasons can be exploited commercially in the tropical plants.

Key words : *Bombyx mori* L., silkworm, heterosis, three-way crosses.

Silkworm set the earliest and best example in utilization of hybrid vigour [1] like corn [2]. Heterosis studies for some quantitative characters in silkworm were made by several workers [3-11]. Tropical multivoltine silkworms are hardy with short larval period but their silk yield is less with poor quality [12]. On the other hand, bivoltine worms which originated in temperate climate are excellent for many qualitative and quantitative characters but can not survive well especially during summer months. Moreover, its long larval period causes inconvenience to the farmers for management. The present experiment was carried out with a view to combine the best traits of the popular evolved yellow multivoltine breed G with bivoltine F_1 hybrids for rearing under tropical conditions. Bivoltine F_1 hybrid male parents have been selected in our experiment instead of inbred males to produce three-way crosses

[1]Department of Zoology, University of Berhampur, Orissa.
[2]Silkworm Seed Technology Laboratory, Bangalore 560 035.
[3]Central Silk Board, 39, M.G. Road, Bangalore 560 001.

(Multivoltine × Bivoltine F_1) for several reasons such as better tolerance to climatic conditions, shorter larval period and increased yield. The last is of greatest importance in sericulture. Thus, the practical difficulty associated with low productivity of inbred disease susceptible bivoltine line can be overcome by using hybrid males.

MATERIALS AND METHODS

Three way-crosses were made between the popular yellow multivoltine breed G as female and two bivoltine hybrids and their reciprocals viz., P-5 × NB-18, BNB-18 × P- 5, KPG-B × NB-7 and NB-7 × KPG-B as males. The inbred stocks G, P-5, NB-18, KLG-B and NB-7 used in the experiment were maintained by sib-mating for the last 8-10 years. The four types of three-way crosses along with the female parent G and four male hybrid parents were reared at room temperature by feeding four times a day with mulberry leaves of S_1 variety as per normal schedule [13] during three seasons (June-July, 1988, October-November, 1988; and December-January, 1988-89). Four replications were maintained for each of the cross and parents. Data were collected on number of eggs laid, larval period, survival percentage, single cocoon weight, single shell weight, filament length and yield per 100 layings. Heterosis over mid parent (MP) and better parent (BP) was determined as per standard statistical method followed by Tayade [6]. In West Bengal, autumn (October- November) and winter (December-January) seasons are considered as most favourable for silkworm rearing while summer (June-July) season needs hardy silkworm breeds.

RESULTS AND DISCUSSION

Mean rearing performance data on seven economic characters of the four three-way crosses along with the female and male parents in three seasons are presented in Table 1. The heterosis values over mid-parent (MPV) and better parent (BPV) of all the crosses during three seasons are given in Table 2. For assessment, the data are described seasonwise.

SUMMER CROP (June-July) :

These two months are considered as the summer season and very unfavourable for mulberry silkworm rearing in West Bengal due to very high temperatures (26°-36°C) and high relative humidity (80-96%). The farmers of West Bengal give maximum emphasis to the survival percentage and yield per 100 dfls in evaluating silkworm rearing during this season. The survival percentage of all the three-way crosses and female parent are almost equal and ranged from 70.28 (G) to 77.62 [G × (NB18 × P5)], but among male hybrid parents it was nearly two fold less

ranging only between 30.40 (NB7 × KPG-B) and 49.94 (NB18 × P5). Moreover, high molting percentage was noticed in pupal stage among the surviving males. The maximum yield per 100 dfls was 53.55 in G × (NB18 × P5) where as in female parent G, it was 32.23 and among male parents 3 to 4 times less than the three-way crosses (Table 1). The number of eggs per laying, which showed a bit improvement among all the three-way crosses, ranged from 398 [G × (NB7×KPG-B)] to 439 [G ×(P5×NB18)]. In the female parent (G) it was 389 and among male parents it ranged from 420 (P5 KPG-B). Positive and significant heterotic effects were noticed in most of the characters of all the three-way crosses (Table 2). For no. of eggs per laying, no positive heterotic effect over MP and BP was noticed except in G × (P5×NB18). The desirable negative heterotic effect for larval period was recorded only over MP. For survival percentage, significant positive effects over MP were noticed in all the three-way crosses which ranged from 24.58 [G × (P5×NB18)] to 40.97 [G × (NB7×KPG-B)]. Over BP, heterotic effects for the same character were also positive although insignificant. The heterotic effects over MPV and BPV for SCW, SSW, filament length and yield per 100 dfls were found highly positive and significant in all the three-way crosses except in G × (NB7×KPG-B) over BPV (Table 2). However, the highest heterotic effects were noticed in G × (NB18×P5) over MPV and BPV, which were 33.45 and 27.65 for SCW, 50.55 and 47.79 for SSW and 51.81 and 50.26 for filament length, respectively, followed by G × (P5×NB18) for the same characters. The maximum heterotic effect (105.34) was found over MPV for yield per 100 dlfs in G × (KPG-B×NB7) followed by G × (NB18×P5) (98.06). But for per *per'se* performance, highest yield per 100 dlfs was recorded in G × (NB × P5) (53.55 kg), followed by G × (P5 × NB18) (49.88 Kg).

AUTUMN SEASON (October-November) :

These two months are known as autumn season, and are favourable for all kinds of mulberry silkworm rearing in West Bengal. The highest survival percentage (94.44), SCW (1.736) and SSW (0.309) were observed in G × (NB7×KPG-B) and fecudity (417) and yield per 100 dfls (59.28 kg.) in G × (KPG-B×NB7) (Table 1). Positive and significant heterotic effects over BPV were noticed over both parental values except for number of eggs per laying and a few values (Table 2). For number of eggs per laying, all the heterotic effects were negative and some of them were significant also. Desirable negative larval periods were noticed in all the three-way crosses over MPV. For survival percentage all the heterotic effects were positive over BPV in except in except G × (P5×NB18) and G × (NB18×P5) crosses. The highest and significant heterosis observed in G × (KPG-B×NB7) over both parental values for survival percentage of 22.21 and 20.49 was. For SCW, most of the heterotic effects were positive and significant and maximum value was recorded in G × (NB7×KPG-B)

Table 1. Mean values of different characters of mulberry in three-way crosses and parents

Race/Combination	Fecund (no)	Lar Pd (Days)	Survival % Orig	Survival % Trans	S.C.W. (g)	S.S.W. (g)	Fil.Len (m)	Yld/100 Dfls (kg)
JUNE-JULY								
G × (P5×NB18)	439	20	73.76	59.19	1.722	0.293	861	49.88
G × (NB18×P5)	432	20	77.62	61.77	1.764	0.293	952	53.55
G × (KPG-B×NB7)	425	20	73.35	58.92	1.670	0.280	838	48.10
G × (NB7×KPG-B)	398	20	70.97	57.40	1.585	0.275	814	39.88
G	389	20	70.28	56.97	1.382	0.191	620	32.23
P5×NB18	420	26	48.13	43.93	1.309	0.203	601	21.00
NB18×P5	499	26	49.94	44.96	1.262	0.198	633	21.85
KPG-B×NB7	452	26	35.35	36.48	1.257	0.207	625	14.63
NB7×KPG-B	538	26	30.40	33.46	1.243	0.201	619	13.75
OCT-NOV								
G × (P5×NB18)	404	22	91.97	73.54	1.657	0.294	1045	54.93
G × (NB18×P5)	386	22	86.98	68.85	1.611	0.274	978	49.83
G × (KPG-B×NB7)	417	22	92.06	73.64	1.644	0.307	1028	59.28
G × (NB7×KPG-B)	391	22	94.44	76.36	1.736	0.309	918	50.83
NB18×P5	499	26	49.94	44.96	1.262	0.198	633	21.85
KPG-B×NB7	452	26	35.35	36.48	1.257	0.207	625	14.63
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G × (NB7×KPG-B)	391	22	94.44	76.36	1.736	0.309	918	50.83
G	372	22	76.41	60.94	1.120	0.159	611	24.33
P5×NB18	571	26	93.85	75.64	1.582	0.301	1071	59.70
NB18×P5	510	26	93.79	75.57	1.691	0.337	1074	48.90
KPG-B×NB7	467	26	74.26	59.51	1.452	0.284	1108	44.48
NB7×KPG-B	526	26	86.29	68.27	1.482	0.296	1023	43.02
DECEMBER-JANUARY								
G × (P5×NB18)	486	23	86.95	68.82	1.970	0.339	1062	74.23
G × (NB18×P5)	449	23	86.73	68.64	2.009	0.356	1145	72.80
G × (KPG-B×NB7)	457	23	88.54	70.21	1.897	0.320	1019	69.43
G × (NB7×KPG-B)	463	23	85.68	67.76	1.888	0.359	968	71.65

(Table contd.)

G × (NB7×KPG-B)	463	23	85.68	67.76	1.888	0.359	968	71.65
G	478	23	75.91	60.61	1.604	0.232	689	54.73
NB18xP5	440	25	99.16	84.73	1.769	0.340	1058	70.83
KPG-B×NB7	415	25	98.31	82.53	1.563	0.309	1039	66.05
NB7×KPG-B	467	25	96.61	79.39	1.605	0.327	1041	73.63
CD at 5%								
Race/comb.	36	(#)	-	6.21	0.057	0.015	59	6.03
Race × season	63	(#)	-	10.76	0.099	0.026	102	10.44

(#) ANOVA for data on larval period is not done as their error variance is zero; Fecund : No. of eggs per laying; Lar Pd : Larval period; S.C.W.; Single cocoon weight: S.S.W.; Single shell weight; Fil Len : Filament length; Yld/100 dfls : Yield per 100 disease free layings; Orig : Original; Trans : Transformed.

(33.46 and 17.14 over MPV and BPV respectively). The highest positive and significant heterotic effects were observed in G × (KPG-B×NB7) for SSw (39.3) and yield per 100 dlfs (72.31) and for filament length in G × (P5× NB18) (24.21) over MPV.

WINTER CROP (December-January) :

These two months are considered as the winter season in West Bengal and favourable for rearing all kinds of mulberry silkworm. The mean performance of all the three-way crosses and their parents was very good during this season (Table 1), which caused the heterotic effects to be negative or insignificant over both parental values in most of the crosses for number of eggs per laying, survival percentage and larval period (Table 2). For SCW, positive and significant heterotic effects over MPV and BPV were found in all the crosses which ranged from 17.68 to 20.17 and 13.57 to 18.25 respectively. For SSW, the heterotic effects were positive and significant over MPV and ranged from 17.08 [G × (P5×NB18)] to 28.50 [G × NB7×KPG-B) (0.95). Filament length exhibited highly significant and positive heterotic effect over MPV in all crosses ranging from 11.98 [G × (NB7×KPG-B0]to 31.12 [G× (NB18× P5)]. The yield per 100 dfls revealed positive heterotic effects over both parental values except G × (NB7XKPG-B) (–.68) over BPV. The highest value over MPV (32.10) and over BPV (28.75) was found in G × (P5 × 18).

During summer season the analysis revealed high degree of heterosis in all the three-way crosses (Table 1 and 2). This difference in the performance of the crosses from season to season may be explained to be due to environmental effect which is known to modify additive and dominance effects of genes as reported by earlier authors [4-5, 14-15].

Table 2. Heterosis in three-way crosses

Race/ Combination		ECUND	LAR PD	Survival %	S.C.W.	S.S.W.	Fil.Len	YLD/100 Dfls
JUNE-JULY								
G × (P5×NB18)	MP	8.51	-13.04	24.58**	27.96**	48.38**	41.03**	87.41**
	BP	4.47	0.00	4.95	24.61**	43.91**	38.81**	54.77**
G × (NB18×P5)	MP	-.73	-13.04	29.13**	33.45	50.55**	51.81**	98.06**
	BP	-13.48*	0.00	10.44	27.65**	47.79**	50.26**	66.18**
G × (KPG-B×NB7)	MP	1.19	13.04	38.88**	26.56**	40.62**	34.63**	105.34**
	BP	-5.92	0.00	4.36	20.86**	35.10**	34.12**	49.26**
G × (NB7×KPG-B)	MP	-14.11*	-13.04	40.97**	20.78**	40.31**	31.33**	73.46**
	BP	-26.06**	0.00	0.98	14.71**	36.82**	31.20**	23.74
OCT-NOV								
G × (P5×NB18)	MP	-14.35	-8.33	8.03	2.68**	27.82**	24.21**	30.73**
	BP	-29.32**	0.00	-2.01	4.76	-2.41	-2.47	-8.00
G × (NB18×P5)	MP	-12.48*	-8.33	2.21	14.64**	10.75**	16.06**	36.09**
	BP	-24.36**	0.00	-7.26	-4.73	-18.56**	-8.94	1.89
G ×(KPG-B×NB7)	MP	-0.60	-8.33	22.21**	27.86**	39.03**	19.59**	72.31**
	BP	-10.76	0.00	20.49**	13.23**	8.38	-7.24	33.28**
G × (NB7×KPG-B)	MP	-12.79*	-8.33	16.09**	33.46**	36.05**	12.40**	50.93**
	BP	-25.58**	0.00	9.45	17.14**	4.48	-10.22*	18.14
DECEMBER-JANUARY								
G × (P5×NB18)	MP	9.50	-6.12	3.92	20.17**	17.08**	22.80**	32.10**
	BP	1.68	0.00	-4.90	17.61**	-2.17	2.02	28.75**
G × (NB18×P5)	MP	-2.23	-4.17	-0.92	19.12**	24.42**	31.12**	15.97*
	BP	-6.07	0.00	-12.53*	13.57**	4.71	8.25	2.79
G × (KPG-B×NB7)	MP	2.52	-4.17	1.64	19.77**	18.30**	17.91**	14.97
	BP	-4.24	0.00	-9.94	18.25**	3.64	-1.97	5.11
G × (NB7× KPG-B)	MP	-1.98	-4.17	-0.67	17.68**	28.50**	11.98*	11.65
	BP	-3.04	0.00	-11.31*	17.63**	9.95*	-94	-2.68

* ** Significant at 5% and 1%; MP : Mid parent value and BP : Better parent value.

From the *per se* performance as well as heterosis values, two crosses viz., G × (P5× NB18) and G × (NB18 × P5) for summer and two crosses viz., G × (KPG-B×NB7) and G × (NB7× KPG-B) for autumn and winter may be selected for commercial exploitation.

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