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COMBINING ABILITY ANALYSIS OF FOUR ECORACES AND C2 BREED OF ERI SILKWORM, *SAMIA RICINI* DONOVAN

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ABSTRACT

Samia ricini is a domesticated non-mulberry and multivoltine in nature. Four strains namely, Borduar Yellow Plain (BYP), Genung Yellow Plain (GYP), Titabar Greenish Blue Plain (TGBP) & Kokrajhar Greenish Blue Plain (KGBP) and C2 breed of eri silkworm, *S. ricini* were selected as superior strains after evaluation. These were subjected to estimate their General combining ability (GCA) in breeds and specific combining ability (SCA) in the hybrids crossed in a 5x5 diallel fashion. The analysis of variance for combining ability of eight yield contributing traits manifested significant GCA variance in all the traits, while significant SCA variances were observed in seven parameters. Significant reciprocal variances were observed in six parameters which were the indication of maternal effects in these traits in eri silkworm. Among the five inbred lines, BYP was found to be the best general combiner exhibited significant effects in six traits followed by TGBP for five traits and C2 breed in four traits. Among the crosses, BYPxTGBP, GYPxTGBP and C2xBYP showed significant SCA effect for several characters have been identified for further trail rearing for higher production of Eri silk.

Keywords : Combining ability analysis, ecoraces, Eri silkworm, reciprocal effect, strains.

Introduction

Eri silkworm, *Samia ricini* Donovan is domesticated multivoltine species. Crossbreeding is one of the tools for exploiting genetic variation. The main purpose of crossing in silkworms is to produce superior crosses (i.e. make use of hybrid vigiour) to improve fitness and fertility traits and to combine different characteristics in which the crossed breeds were valuable (Hanafi and Iraqi, 2001; William and Pollak, 1985). Crossbreeding involves diallel, pure-or line-breeding, line x tester, double and three way crosses to improve economic traits through the use of complementarities traits or economic heterosis (Sarkar *et al*., 1991; Das *et al*., 1997; Dubey *et al.,* 2001; Gangopadhyay and Ravindran, 2006). Likewise, diallel crossing schemes make accessible the assessment of general and specific combining ability effects (Griffing 1956). Combining ability analysis is extensively employed in many plants and animals for the selection of promising parents and hybrids as well as to design and formulate efficient breeding plans (Petkov, 1975; Eisen *et al.,* 1983; Crusio, 1987; Falconer, 1988; Ravindra Singh *et al*., 2003) Presently, more than 2.40 lakh families are engaged in eri culture and eri raw silk production in India to the tune of 7364 MT during 2021-22. The documented literature on analysis of combining abilities and exploitation of hybrid vigour in eri silkworm to increase the productivity is scanty. Nagaraja and Govindan (1994) studied the general and specific combining abilities of five strains of eri silkworms and pointed out the prospects of exploiting heterosis for the productivity related traits like effective rate of rearing, cocoon yield by number and weight. However, further attempts have not been made to exploit the hybrid Vigour and evolution of high yielding breeds in eri culture in spite of having high potential for production. Thus, the present study was undertaken to study the general combining abilities of five inbred strains, specific combining abilities in hybrids and reciprocal effect in the eri silkworm, *Samia ricini*.

Materials and Methods

Four strains namely, Borduar, Genung, Titabar and Kokrajhar and C2 breed of eri silkworm, *Samia ricini* have thirteen strains which were subjected to multiple traits evaluation index (E.I) method of Mano *et al.,* 1993. Based on the average cumulative index value five strains were selected as superior genotypes and were crossed in a 5x5 diallel fashion and 25 crosses were raised. These crosses along with the parents were reared indoor on castor leaves in a randomised block design with three replications each and after III moult, 100 larvae were retained in each replication. Data were recorded for fecundity, hatching, larval weight, effective rate of rearing (ERR), cocoon weight, cocoon shell weight, shell percentage and absolute silk yield in both parents and hybrids. To determine the general and specific combining abilities along with the reciprocal effect of the four inbred strains and C2 breed of eri silkworm, Griffing's method I, Model II (1956) was followed. Themodel for combining ability analysis used is given below:

$$X_{ijkl} = g_i+g_j+s_{ij}+r_{ij}+1/bk\Sigma bk+1/bk\Sigma\ (bv)_{ijk}+1/bc\Sigma\Sigma k1\ ^{eijk}$$

Where,

g_i and $g_j$are GCA quantities of the i^{th} female parent and j^{th} male parent respectively.

s_{ij} and r_{ij} are the SCA quantities for the cross (i x j) and reciprocal effects respectively.

For each cross (i x j), the quantity (g_i + g_j + s_{ij}) was computed and the null hypothesis was tested from zero value, assuming no genotypic differences among F_1s.

Eri cocoons being unreliable, whole cocoon shells are utilized in spinning of silk threads after taking out the pupa and as such weight of whole green cocoon is not considered as an important parameter in respect of silk yield. Absolute Silk Yield (ASY) in grams which is considered as important parameter was calculated as follows,

ASY= *Single cocoon shell weight (g) x ERR(%)*

Results and Discussion

The mean data pertaining to the eight quantitative traits of 12 inbred strains and C2 breed of eri silkworm showed superiority in certain traits only is presented in Table 1. The highest mean of fecundity, hatching%, larval weight, ERR%, cocoon weight, shell weight, shell ratio and absolute silk yield% were exhibited by C2 breed followed by BYP strain. KGBP showed lowest mean of fecundity, ERR%, shell ratio, ASY% and GYP showed lowest larval weight, cocoon weight and shell weight. All the strains are showing significant difference ($P< 0.05$) in all the parameters.

Table 1 : Mean performance of eight traits of 12 strains and C2 breed of eri silkworm

Ecorace/ Strain	Fecundity Nos.	Hat. (%)	Larval wt (g)	ERR (%)	Cocoon wt (g)	Shell wt (g)	Shell Ratio (%)	ASY%
BYP	365.20	89.39	7.68	91.96	3.43	0.49	14.00	110.57
B GBP	348.80	84.38	7.46	77.88	3.28	0.43	12.72	77.14
B YZ	313.20	89.65	7.11	77.64	3.16	0.44	13.92	65.29
B GBZ	338.20	84.52	7.54	75.44	3.09	0.45	13.67	66.86
T YP	323.80	85.09	7.60	80.32	3.27	0.43	13.14	77.44
T GBP	360.60	86.87	7.51	89.00	3.34	0.48	13.79	106.17
TYS	323.40	78.56	7.20	73.03	2.98	0.40	12.30	54.83
T GBS	343.00	87.00	7.35	76.04	3.15	0.45	13.43	67.19
G YP	361.80	88.14	7.41	87.78	3.22	0.46	13.77	91.64
G GBP	339.60	84.82	7.27	75.81	2.96	0.40	13.51	66.59
KYP	311.60	73.74	7.11	67.64	3.12	0.43	13.04	45.71
K GBP	355.00	87.07	7.45	86.35	3.26	0.47	13.54	91.21
C2 breed	371.40	90.95	7.78	87	3.51	0.51	14.44	106.81
Mean	**342.75**	**85.40**	**7.42**	**77.45**	**3.21**	**0.45**	**13.51**	**79.03**
CDat 5%	**19.22**	**4.51**	**0.20**	**4.04**	**0.15**	**0.04**	**0.75**	**16.56**

The average evaluation index values revealed that none of the genotypes is superior in all the characters. The C2 breed recorded highest average evaluation index value of 64.29 and individual evaluation index value of >50 in all the eight parameters registering highest value in six characters is rated as the best breed followed by BYP with an average evaluation index value of 62.60 and individual evaluation index value of >50 in all the eight characters registering highest value in two characters. Similarly, TGBP, GYP and KGBP also exhibited individual evaluation index value of >50 in all the eight characters and average evaluation index value of 59.25, 54.46 and 54.98 respectively (Figure-1). These superior genotypes are selected for diallel cross.

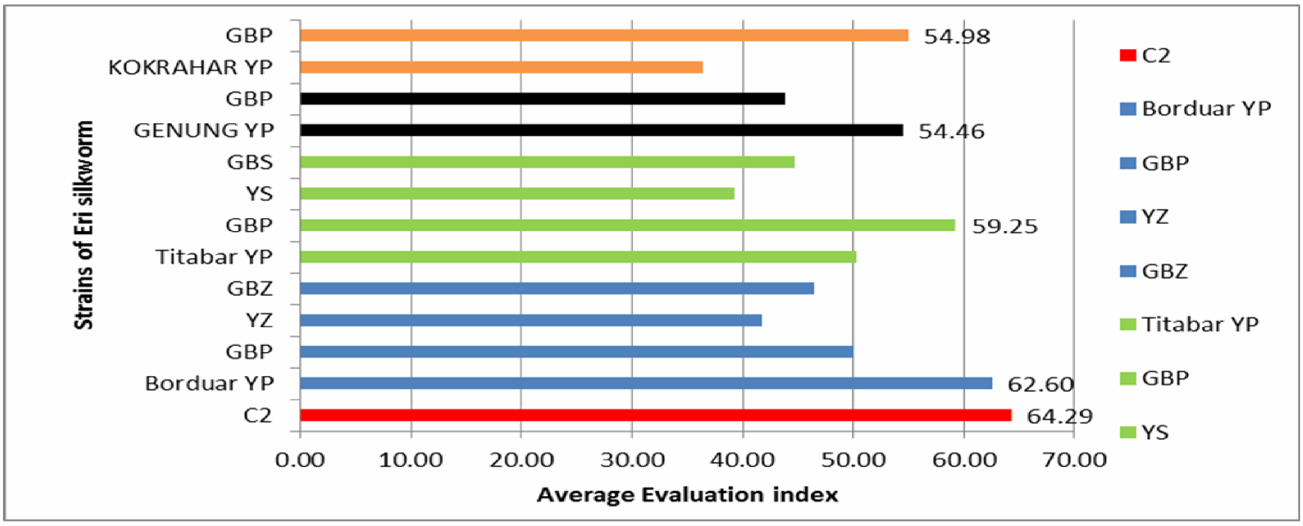

Fig. 1: Evaluation index has been calculated for 08 characters

The analysis of variance for combining ability of eight characters showed significant GCA variance in all the characters, while significant SCA variance were observed in seven parameters except ERR% (Table-2).

Significant reciprocal variances were observed in six characters which were the indication of maternal effects in these traits of eri silkworm. Significant of both GCA and SCA variances in most of the traits implied that both additive and non-additive components are important for the expression of these traits. (Subba Rao and Sahai, 1989; Eid *et al.*, 2005) reported the existence of significant variances for both GCA and SCA variances for cocoon weight, shell weight, shell percentage and larval duration thereby indicating the importance of both additive and non-additive gene action for these traits. The higher magnitude of the additive genetic variance in most of the traits suggested the additive gene action in controlling these traits.

The general combining ability effects of five inbred lines revealed that BYP exhibited positive significant effects on fecundity (5.207*), larval weight (0.133**), Cocoon weight (0.087*), shell weight (0.023**), shell ratio (0.322**) and absolute silk yield (11.466**) followed by TGBP for five traits i.e. fecundity, larval weight, cocoon weight, shell weight and absolute silk yield demonstrating the predominant role of additive gene action for the expression of these traits. C2 breed exhibited significant GCA effects for four traits viz., fecundity, larval weight, shell weight and shell percentage (Table-3).

Hence, BYP was found to be the best general combiner exhibiting significant GCA effects for all the economic traits. The results are in agreement in case of mulberry silkworm, *B. mori* with that of Satenahalli *et al.* (1989); Subba Rao and Sahai (1989) and Eid *et al.* (2005). Breeds with significant GCA effects for several traits can be effectively utilized in development of promising breeds of eri silkworm. Mingguan (1982) has reported that GCA effects were helpful to identify parents for utilizing in breeding programme and in F_1 hybrids for commercial exploitation. In the present study, the ratio of GCA/SCA was observed more than one indicating the predominant role of additive gene action.

Specific combining ability (SCA) variances involve both dominance and other interactions which together constitute the non additive type of gene action. SCA consists of non-additive effects, dominant effects and other interactions and it is not heritable. The analysis of SCA effects is useful to identify specific crosses with desirable traits (Acquaah, 2007). SCA effect in ten hybrids (Table-4) showed that the cross BYP x TGBP exhibited significant SCA effect for six traitsviz., fecundity, hatching, cocoon weight, shell weight, shell percentage and absolute silk yield followed by C2xBYP which recorded significant SCA effects in three traits viz., cocoon weight, shell weight and shell percentage.

The hybrid C2 X K GBP exhibited significant SCA effects for two traits viz., shell weight and Absolute silk yield. The hybrids significant SCA effects for yield contributing possessing characters involved at least one parent having high GCA effect. Specific combining ability analysis is a useful tool for the identification of superior hybrids to exploit hybrid vigour for increasing silk production and it involves both dominance and other interactions which together constitute the non- additive type of gene action which could be optimized in upgrading the genetic potential of the crop by adopting reciprocal recurrent selection. Predominant role of non-additive gene action for cocoon weight and cocoon shell weight has been studied in mulberry silkworm, *Bombyx mori* (Bhargava *et al.*, 1992; 1995).

Among ten reciprocal crosses, GYP X TGBP showed significant reciprocal effects for six traits viz., hatching, larval weight, cocoon weight, shell weight, shell percentage and absolute silk yield followed by GYP X C2 for two traits viz., fecundity and cocoon weight. In mulberry silkworms, the reciprocal effects were pronounced in the hybrids involving parents of wider genetic distance (Benchamin *et al.*, 1988; Mal Reddy *et al.*, 2003; Ravindra Singh *et al.*, 2006). The observation of significant reciprocal effects in some of the hybrids may be due to the wider genetic distance of the parents involved in the hybrids. The differences in reciprocal effects were caused mainly due to sex linkage and maternal effects.

The results obtained from this study indicate that the Eri silkworm inbreds like BYP, TGBP and C2 breed possessing significant GCA effects for several characters may be utilized in future breeding programmes for the development of promising eri silkworm breeds and the promising hybrids viz., B YPxT GBP and C2xBYP exhibiting high and significant SCA and GYP x TGBP possessing significant reciprocal effects for several economic traits may be exploited on commercial scale for the production of Eri silk.

Table 2 : Analysis of variance for combining ability in a 5x5 diallel cross

Source	df	Fecundity (Nos.)	Hat. (%)	Larval wt. (g)	ERR (%)	Cocoon wt. (g)	Sh. wt. (g)	Shell ratio (%)	ASY%
GCA	4	4587.82**	221.99**	2.338**	226.44*	0.74**	0.04**	9.56**	7053.29**
SCA	10	968.542**	200.59**	0.799**	188.97	0.224**	0.018**	14.12**	3473.44**
REC.	10	2515.65**	298.65	0.623	2158.65**	1.425**	0.005**	5.89**	2615.36**
ERROR	38	2490.98	254.07	0.623	1458.97	0.176	0.006	5.52	1823.29**
GCA/ SCA Ratio		4.73	1.10	2.92	1.19	3.343	2.5	0.67	2.03

* and ** denote significantly different at 5% and 1% level.

Table 3 : General combining ability effects in a 5 x 5 diallel cross of Eri silkworm

Parents	Fecundity (Nos.)	Hat. (%)	Larval wt. (g)	ERR (%)	Cocoon wt. (g)	Shell wt. (g)	Shell ratio (%)	ASY%
C2 breed	5.264*	1.073	0.088*	-1.111	0.024	0.015**	0.371**	1.923
BYP	5.207*	1.042	0.133**	2.167	0.087*	0.023**	0.322**	11.466**
T GBP	5.152*	0.03	0.137*	1.611	0.092*	0.014**	0.043	6.245**
GYP	-2.737	0.901	-0.075	-1.833	-0.053	-0.016	-0.275	-6.284
K GBP	-12.885	-3.045	-0.283	-0.833	-0.149	-0.036	-0.461	-13.35

* and ** denote significantly different at 5% and 1% level.

Table 4 : SCA effects in 5x5 diallel crosses of Eri silkworm

Treatments	FEC (no.)	HAT%	LW(gm)	ERR%	C. Wt (gm)	SW (gm)	SR%	ASY
C2 X BYP	0.934	0.209	0.022	-4	0.058**	0.008*	0.031*	2.995
C2 X T GBP	-4.843	0.956	-0.046	3	-0.095	-0.025	-0.364	-4.143
C2 X G YP	1.769	-0.002	0.191**	-0.667	0.09**	0	-0.393	-6.133
C2 X K GBP	2.14	-1.162	-0.167	-1	-0.052	0.017**	0.078	7.281**
BYP XTGBP	5.935*	1.645*	-0.059	-2.833	0.043*	0.031**	0.772**	12.171**
BYP X GYP	-7.396	0.726	-0.138	3.167	-0.099	-0.017	-0.063	-4.489
BYP X KGBP	0.527	-2.58	0.175**	-0.833	-0.003	-0.022	-0.678	-10.677
TGBP X GYP	3.601	-3.534	0.031	-2.333	0.003	0.002	0.078	-0.401
TGBP XKGBP	-4.693	0.932	0.075*	-4.667	0.049*	-0.009	-0.487	-7.627
GYP X KGBP	2.026	2.81**	-0.083	-1.667	0.006	0.014	0.378	11.022**

* and ** denote significantly different at 5% and 1% level, ASY denotes absolute silk yield.

Table 5 : Reciprocal effects in a 5 X 5 diallel cross of eri silkworm hybrid

Treatments	FEC (nos)	HAT %	LW(gm)	ERR%	C. Wt (gm)	SW (gm)	SR%	ASY
BYP X C2	-4.5	2.78**	-0.168	0.361	-0.062	-0.005	0.172	-11.62
T GBPX B YP	-3.498	1.83*	-0.138	2.139	-0.055	-0.008	-0.073	-8
TGBPX C2YP	1.667	-2.818	0.05	0.25	-0.04	-0.003	0.12	4.73*
G YP X C2	3.833*	-4.258	-0.108	-2.306	0.067**	0.008	0.013	-2.052
K GBP X C2	4.167	0.068	-0.06	1.694	0.202**	-0.018	-0.4	3.013
G YP X B YP	-8.388	-0.348	0.125**	-0.75	-0.018	0	0.04	2.298
K GBPX B YP	1.833	-1.427	-0.04	-1.75	-0.055	-0.005	0.062	-2.762
G YPX T GBP	2.11	4.67**	0.11**	0.306	0.072**	0.025*	0.04**	4.555*
KGBPXTGBP	-2.665	-2.23	0.203**	-2.694	0.005	0.005	0.095	-10.58
K GBPX G YP	-6.498	-2.695	-0.247	2.75	-0.087	-0.012	-0.002	-9.487

* and ** denote significantly different at 5% and 1% level, ASY denotes absolute silk yield.

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