EVALUATION OF SOME DOUBLE CROSS HYBRIDS OF THE SILKWORM *BOMBYX MORI* L.

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INTRODUCTION

Heterosis or hybrid vigour is the phenomenon in which the crosses of two different varieties or lines produce a hybrid that is superior in growth, size, yield or general vigour (Falconer, 1981). The present commercial varieties of the silkworm are produced by the single cross, three-way cross or double cross. As a result of silkworm breeders' efforts, the recent varieties have a high percentage of cocoon shell and raw silk that is negatively correlated with egg productivity of parental lines. To improve the egg productivity, double crossed hybrids have been widely utilized for the commercial egg production (GAMO, 1976 and HIRATA, 1985). The primary objective of rearing double cross hybrids is to get the desired quantitative and qualitative traits into one combination (DATTA and BASAVARAJA, 1998). In the present study, an attempt has been made to evaluate some double cross hybrids under the Egyptian conditions and to determine the most promising hybrids by using two methods, the Subordinate Function Index method (GOWER, 1971) and Evaluation Index method (MANO *et al.*, 1992).

MATERIAL AND METHODS

Five F_1 hybrids imported from different countries during Spring 2006 were crossed to obtain double cross hybrids. These hybrids are HQIX.XJIUF and HBBX.DT which imported from China and coded as A and B, respectively. Hybrids of $C_1X.X_2$ and Bp35X M_2 which imported from Bulgaria and coded as C and D. Japon X Cin imported from Turkey and coded F.

Cross systems were made by using hybrid A as a female parent with hybrids B, C and D as a male parent, and used as male parent with female of hybrids of B, C, D and F. Female of hybrid D crossed with male of B, C and F, also male of D mated with the female of hybrid B. F hybrid as a female was crossed with male of

B and C. Male of F mated with B as female. Hybrid C was crossed as a female parent with hybrids of B and F. So, sixteen double cross hybrids were obtained.

Silkworm rearing was carried out according to KRINSHSWAMY 1978. Three replicates from each hybrid were reared during Autumn season of 2006 (September-October) under the laboratory normal conditions at 24.65°C and 72.23 % RH. Three hundred larvae were retained after third moult per each replicate. Data were accrued for nine economic traits namely cocoon weight (CW), cocoon shell weight (CSW), pupal weight (PW), cocoon shell ratio (CSR), silk productivity (SP), fifth instar duration(FID), total larval duration (LD), pupation ratio (PR) and double cocoon percentage (DCP).The weights of cocoon, cocoon shell and pupa were recorded by gram, while cocoon shell ratio, pupation ratio and double cocoon as percentage, fifth instar duration and total larval duration recoded by day and silk productivity by centigram/day.

Cocoon shell ratio for each entry was calculated according to TANAKA (1964) as follows:

Silk productivity was estimated by using formula of

$$Cocoon\ shell\ ratio\ (\%) = \frac{cocoon\ shell\ weight}{fresh\ cocoon\ weight}\ x100$$

CHATTOPADHYAY *et al.*, (1995).

$$Silk\ productivity\ (cg/day) = \frac{Cocoon\ shell\ weight\ (cg)}{fifth\ instar\ duration\ (day)}$$

Where cg: Centigram

Double cocoon percentage and pupation ratio were calculated according to the following formulae of LEA (1996):

$$Double\ cocoon\ percentage\ (\%) = \frac{Number\ of\ pupae\ made\ double\ cocoon}{Total\ number\ of\ pupae\ harvested}$$

$$Pupation\ ratio\ (\%) = \frac{Number\ of\ health\ pupae}{Corrected\ basic\ number\ of\ examined}$$

The Subordinate Function values character wise were calculated by using formula of (GOWER, 1971) as follows:

$X_U = (X_i\ X_{min}) / (X_{max}\ X_{min})$

Where: X_U = Subordinate Function, X_i = Measurement of character of a tested genotype, Xmin = the minimum value of the character among all the tested genotypes, X_{max} = the maximum value of the character from all the tested genotypes.

The highest cumulative Subordinate Function values assigned first rank and subsequent ranks are assigned in the descending order.

Also, evaluation index was calculated using the following formula according to MANO *et al.*, (1993):

$$Evaluation\,index\,(EI) = \frac{(A-B)}{C}\,X10 + 50$$

Where:

A= Value obtain for a particular trait of the particular hybrid.

B= Mean value of the particular trait of all the considered hybrids.

C= Standard deviation (n-1) of a particular trait of all the considered hybrids.

10 = standard unit, 50 = Fixed value

In order to judge superiority of hybrid genotypes impartially, a common evaluation index is necessary to be adopted giving equal emphasis to all the commercial economic traits. The average of evaluation index value fixed to select a hybrid genotype is over 50. Only the hybrids with an evaluation index value higher than 50 have been considered of great economic importance.

RESULTS AND DISCUSSION

The mean performance of the sixteen double cross hybrids for nine traits is presented in Table 1, it clarify that none of the sixteen hybrids acquired the best performance for all traits under study. Hybrid DXB is good for all traits except for total larval duration, pupation ratio and double cocoon percentage. While, hybrid of DXA earned the lowest values for all characters under study except cocoon shell ratio, pupation ratio and double cocoon percentage. Similar results were obtained by BABU *et al.*(2002) who found that the performance of the eighteen different hybrid genotypes exhibited superiority in different individual characters and no single hybrid combination excelled in all the ten analyzed characters put together.

Evaluation Index value of nine characters for sixteen double cross hybrids is recorded in Table 2, it shows that there are nine hybrids earned average of Evaluation Index above 50 index value. Hybrid CXA earned best values of

Evaluation Index for all traits (best value of Evaluation Index of fifth instar duration, total larval duration and double cocoon percentage that less than 50 index value) under study, also it has best average of Evaluation Index (51.788). Hybrid DXB acquired better values for all traits except pupation ratio, it has highest average of Evaluation Index (59.102). These results are in agreement with those found by GHAZY (2005) who studied twenty two four-way hybrids, of *B. mori* and stated that there were only three hybrids earned a best value for all traits together. Also, SINGH (2001) reported that among eight three-way hybrids, only five hybrids have average of Evaluation Index higher than 50 the Evaluation Index value.

In the Subordinate Function method, the cumulative index ranged from a maximum of 7.784 for hybrid DXB to minimum of 4.878 for DXA. So, hybrid of DXB is assigned first rank while the subsequent ranks for remaining tested hybrids were assigned in descending order (Table, 3). Similar results were obtained by BABU *et al.*, (2002) who estimated the Subordinate Function in eighteen bivoltine hybrids, data showed that the cumulative values ranged from 8.2432 up to the minimum of 1.7806; the hybrid with the highest Subordinate Function value is assigned first rank.

The present data showed the hybrid of DXB with the highest value of average of Evaluation Index (59.102) and ranked the first among sixteen double cross hybrids. Also, the same hybrid scored the highest Subordinate Function value (7.784). Generally, the relative ranks assigned for all tested hybrids are in conformity with all the hybrids scoring average of Evaluation Index above 50 except hybrids of CXA, BXF and BXA, which assigned the 5^{th}, 7^{th} and 9^{th} ranks (Table, 4). These results confirm the applicability of Subordinate Function Index method for multiple trait analysis of silkworm hybrids and subsequent determining the promising hybrids, beside its comparability with the Evaluation Index is widely applied. These results are in agreement with those of BABU *et al.*, (2002). Also, MUKHERJEE (1998) stated that in general the heterotic manifestation is higher in case of three-way and double crosses for almost all the characters.

SUMMARY

Five F1 hybrids of *Bombyx mori* L. imported from different countries during Spring 2006 were crossed to obtain double cross hybrids. Sixteen double crosses were obtained; hybrids have been evaluated using two methods; Evaluation Index and Subordinate Function Index for nine economic characters. Hybrid of DXB acquired

TABLE (I)

Mean performance of double cross hybrids of silkworm *Bombyx mori* L.

C / H	CW (g)	CSW (g)	PW (g)	CSR (%)	FID (Day)	TLD (day)	S P (cg/day)	P R (%)	DCP %
AXB	1.061	0.210	0.854	19.968	7.000	28.000	2.997	93.258	1.176
AXC	0.975	0.207	0.808	21.213	8.000	29.000	2.591	86.792	2.675
AXD	1.061	0.198	0.854	18.793	7.000	29.000	2.830	95.172	3.378
BXA	0.948	0.210	0.771	21.762	9.000	31.000	2.335	94.970	1.440
BXF	1.101	0.219	0.907	20.210	8.000	30.000	2.741	96.007	1.235
CXA	1.275	0.244	1.049	20.679	8.000	27.000	3.046	92.954	1.104
CXB	1.231	0.253	0.987	20.658	9.000	25.000	2.814	94.771	5.521
CXF	1.236	0.234	0.999	19.023	8.000	30.000	2.925	83.900	2.073
BXD	1.223	0.241	0.977	19.837	8.000	30.000	3.018	84.162	1.691
DXA	0.762	0.168	0.630	22.141	9.000	31.000	1.865	94.583	0.437
DXB	1.377	0.332	1.111	24.253	7.000	29.000	4.744	84.162	1.071
DXC	1.286	0.240	1.001	18.889	9.000	31.000	2.669	92.403	0.567
DXF	1.065	0.175	0.849	16.646	8.000	28.000	2.192	93.697	3.734
FXA	1.210	0.233	0.990	19.299	8.600	30.660	2.708	90.714	1.772
FXB	1.071	0.212	0.877	19.924	8.000	30.000	2.651	81.882	3.187
FXC	1.071	0.208	0.889	19.494	9.000	29.000	2.313	81.379	3.543
Average	1.122	0.224	0.910	20.174	8.163	29.229	2.777	90.050	2.163
SD	0.154	0.037	0.119	1.701	0.727	1.631	0.618	5.332	1.391

Where SD: Standard deviation, H: hybrid , C: Character

TABLE (II)

Evaluation Index value of double cross hybrids of silkworm *Bombyx mori* L.

C / H	CW	CSW	PW	CSR	FID	TLD	SP	PR	DCP	Average
AXB	46.027	46.17	45.347	48.789	34.019	42.468	53.553	56.016	42.909	46.144
AXC	40.469	45.503	41.447	56.107	47.766	48.598	46.986	43.89	53.681	47.161
AXD	46.027	43.034	45.324	41.876	34.019	48.598	50.844	59.606	58.738	47.563
BXA	38.698	46.255	38.372	59.34	61.513	60.858	42.831	59.226	44.806	50.211
BXF	48.637	48.716	49.795	50.209	47.766	54.728	49.415	61.171	43.327	50.418
CXA	59.921	55.229	61.702	52.967	47.766	36.338	54.339	55.445	42.389	51.788
CXB	57.053	57.801	56.498	52.844	61.513	24.078	50.591	58.854	74.145	54.820
CXF	57.408	52.659	57.483	43.228	47.766	54.728	52.396	38.465	49.351	50.387
BXD	56.576	54.639	55.647	48.015	47.766	54.728	53.893	38.956	46.61	50.759
DXA	26.629	34.946	26.492	61.566	61.513	60.858	35.231	58.501	37.591	44.814
DXB	66.547	78.892	66.95	73.983	34.019	48.598	81.827	38.956	42.148	59.102
DXC	60.663	54.321	57.687	42.442	61.513	60.858	48.252	54.412	38.528	53.186
DXF	46.275	36.956	44.915	29.25	47.766	42.468	40.524	56.84	61.298	45.144
FXA	55.682	52.349	56.773	44.854	56.014	58.774	48.874	51.245	47.191	52.417
FXB	46.683	46.785	47.3	48.53	47.766	54.728	47.955	34.679	57.364	47.977
FXC	46.706	45.746	48.268	46.001	61.513	48.598	42.489	33.737	59.924	48.109

Where H: hybrid , C: Character

TABLE (III)

Subordinate Function values of double cross hybrids of silkworm *Bombyx mori* L.

H \ C	CW	CSW	PW	CSR	FID	TLD	SP	PR	DCP	Cumulative index
AXB	0.771	0.633	0.001	0.823	0.778	0.903	0.632	0.971	0.213	5.724
AXC	0.001	0.624	0.001	0.875	0.889	0.936	0.546	0.904	0.485	5.259
AXD	0.771	0.596	0.001	0.775	0.778	0.936	0.597	0.991	0.612	6.056
BXA	0.001	0.633	0.001	0.897	1.000	1.000	0.492	0.989	0.261	5.273
BXF	0.800	0.660	0.001	0.833	0.889	0.968	0.578	1.000	0.224	5.951
CXA	0.926	0.735	0.944	0.853	0.889	0.871	0.642	0.968	0.200	7.028
CXB	0.894	0.762	0.001	0.852	1.000	0.807	0.593	0.987	1.000	6.896
CXF	0.898	0.705	0.001	0.784	0.889	0.968	0.617	0.874	0.375	6.110
BXD	0.888	0.726	0.001	0.818	0.889	0.968	0.636	0.877	0.306	6.109
DXA	0.001	0.506	0.001	0.913	1.000	1.000	0.393	0.985	0.079	4.878
DXB	1.000	1.000	1.000	1.000	0.778	0.936	1.000	0.877	0.194	7.784
DXC	0.934	0.723	0.901	0.779	1.000	1.000	0.563	0.963	0.103	6.965
DXF	0.773	0.527	0.001	0.686	0.889	0.903	0.462	0.976	0.676	5.894
FXA	0.879	0.702	0.001	0.796	0.956	0.989	0.571	0.945	0.321	6.158
FXB	0.778	0.639	0.001	0.822	0.889	0.968	0.559	0.853	0.577	6.084
FXC	0.778	0.627	0.001	0.804	1.000	0.936	0.488	0.848	0.642	6.121

Where H: hybrid , C: Character

the highest values of average of Evaluation Index (59.102) and Subordinate Function value (7.784). Generally, rearing of double cross hybrids is better during the autumn season. Also, double cross hybrids gives the breeders a good chance for developing the lines by accumulative most important characters together in the same line.

TABLE (IV)

Ranking of double cross hybrids of silkworm *Bombyx mori* L.

Serial Number	Hybrid	Average Evaluation Index	Cumulative Subordinate Function
1	DXB	59.102	7.784
2	CXB	54.820	6.896
3	DXC	53.186	6.965
4	FXA	52.417	6.158
5	CXA	51.788	7.028
6	BXD	50.759	6.109
7	BXF	50.418	5.951
8	CXF	50.387	6.110
9	BXA	50.211	5.273
10	FXC	48.109	6.121
11	FXB	47.977	6.084
12	AXD	47.563	6.056
13	AXC	47.161	5.259
14	AXB	46.144	5.724
15	DXF	45.144	5.894
16	DXA	44.814	4.878

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