Asian J. Exp. Sci., Vol. 23, No. 1, 2009; 115-122

Selection of Promising Bivoltine Hybrids by MST Analysis

C.K. Ramesh[1]* and G. Subramnaya[2]

[1] P.G. Department of Biotechnology, Sahyadri Science College, Shimoga-577203 (Karnataka); India.

[2] Department of P.G. Studies in Sericulture, Manasagangotri, University of Mysore, Mysore (Karnataka); India.

Abstract : The objectives of the silkworm breeding is realized when the best hybrids for commercial exploitation are identified. The ultimate results in silkworm breeding are judged by the superiority of commercial characters of the parental strains that appear in the F_1 hybrids. In the present experiment an attempt has been made to select superior bivoltine hybrids utilizing the four newly evolved bivoltine races *viz.* MG_{405}, MG_{406}, MG_{408} and MG_{414} and crossing them with three conventional bivoltine races *viz.* KA, NB_4D_2, NB_7 and NB_{18}, to evaluate the rearing performance of different hybrid combinations. The mean values of the hybrids were subjected to MST analysis, and relevant selection index program to identify the promising hybrids. The identified hybrids were short listed. The use of selection index and recommendations of hybrids for commercial exploitation is discussed.

Key words : Bivoltine hybrids, MST, Silkworm, Rearing performance.

Introduction

Hybrid vigor or heterosis is defined as the superiority of any given trait of importance over either of the parents or both. Heterosis in corn and silkworm has received considerable attention because of the marked effect on yield improvement. Systematic and planned hybridization together with improved farming in corn and rearing practices in sericulture has helped a great deal to increase the productivity by many folds.

Unlike many agricultural crops, where commercial cultivars are mostly inbred lines, there are hardly a few examples in silkworm, where the inbred lines are used for commercial exploitation. In fact, the aim of silkworm breeding is not only to synthesize the new genotypes, but also to adjudicate the best hybrids for commercial exploitation. Even though, the parental lines are superior, they do not have much value if the desirable characters are not reflected in the hybrids. Therefore, ultimate results in silkworm breeding are judged by the superiority of the commercial characters of the parental strains that appear in the F_1 hybrids.

Since the dawn of Sericulture, efforts have been made to cross different silkworm varieties to produce the hybrids with an improvement in productivity. Many silkworm breeders in Japan practiced the crossing of different silkworm varieties before the popularization of the knowledge of heterosis to improve the productivity. However, the rearing of F_1 hybrids instead of pure lines was introduced for the first time in Japan by Toyama in 1906 in a systematic manner and this commercial exploitation of hybrid vigour heralded a new era in sericulture, which contributed substantially to the increased silk production. The superiority of the F_1 hybrids over parental races due to high magnitude of heterosis for most of the quantitative traits has been well documented (Osawa and Harada, 1944; Hirobe, 1985). After the advent of

* **Corresponding author :** C.K. Ramesh, P.G. Department of Biotechnology, Sahyadri Science College, Shimoga-577203 (Karnataka); India; Tel. : 0-9901818486; E-mail : *ckramck@yahoo.co.in*

biometrical genetics, several new and highly productive hybrids were produced by employing the methods of Diallel cross technique and Line x tester analysis to understand general and specific combining abilities in addition to estimate the levels of heterosis and over dominance (Chandrashekaraiah 1992; Doddaswamy and Subramanya, 2005; Raghavendra Rao *et al*, 2005; Singh *et al*. 2005; Choudhary and Singh, 2006 and Singh *et al*., 2006).

Materials and Methods

The four evolved bivoltine breeds MG_{405}, MG_{406}, MG_{408} and MG_{414} and four tropical bivoltine races, KA, NB_7, NB_{18} and NB_4D_2 formed the material for the present study. Among the four evolved bivoltine breeds used as lines for the present analysis, MG_{405}, MG_{406} and MG_{414} are characterized by spinning white dumbbell cocoons and MG_{408} spins white oval cocoons. Among the four testers, KA and NB_7 spins white oval cocoons while, NB_{18} and NB_4D_2 spins white dumbbell cocoons

The experiment was initiated by crossing female lines with each of the male testers. For each of the lines, testers and their sixteen hybrids, three replicates were maintained. Following standard rearing methods the data has been recorded for the ten economic traits such as fecundity, hatching percentage, larval duration, cocoon yield by number / 10,000 larvae brushed, cocoon yield by weight / 10,000 larvae brushed, single cocoon weight, single shell weight, cocoon shell percentage, pupation rate and filament length.

Maize Selection Tool (MST) developed by International maize and wheat improvement centre (CIMMYT) was employed to select promising hybrid combinations based on superior index values.

MST Selection Index Software (Version 1.0)

Barreto *et al*. (1991) developed the software at the Maize training unit of the International Maize and Wheat Improvement Centre (CIMMYT), Central America. This software has two parts, namely data entry and data analysis. The software selects a specific number of genotype based on two selection parameters defined by the user, selection objective and intensity. The selection objective varies between -3.0 and + 3.0, whereas, the intensity ranges from 0 to 10. In operational terms the program computes a variable called index, which mathematically incorporates all the characteristics indicated by the user in a single numerical value. The index variable represents the Euclidian distance of the set of variables to the objective desired by the user. The lower the value of the index, the closer the genotype and to the user's objective thus it is superior based on the desired characteristics. This program recognizes the data file based on this index variable to produce a listing of genotypes requested by the user, according to selection criteria established by him, that make up the superior fraction. This software lists the superior materials with values corresponding to the selection variables in the output device defined by the user. This program calculates the original mean of the population and the mean of the selected fraction to obtain the selection differential in real and standardized units. The program also produces descriptive statistics (mean, standard deviation, coefficient of variation, minimum, maximum) for the variables selected, and a correlation matrix.

Results

The mean values of eight important economic traits such as fecundity hatching percentage, larval duration, single cocoon weight, single shell weight, shell percentage, pupation rate and filament length in the sixteen new hybrids were considered for the evaluation by MST analysis (Tables 1,2 and 3). Since the aim of the present research program is to identify the hybrid combinations with high viability without much sacrificing the

Table 1 : Mean Values of Economic Characters of the Lines

Lines	Fecundity	Hatching percentage	Larval Duration (h.)	Coon yield by No. 10,000 Larvae	Cocoon yield by weight/10,000 larvae	Single cocoon Weight (g.)	Single Shell eight (g.)	Shell Percentage	Pupation rate	Filament Length (m.)
MG_{405}	460.30	94.41	573.3	9256	15.76	1.723 ‘	0.313	18.22	91.43	926.66
MG_{406}	559.33	94.57	575.26	9276	15.73	1.73	0.324	18.7	92.18	924.66
MG_{408}	557.33	95.29	572.66	9360.6	15.97	1.723	0.321	18.67	93.21	932.66
MG_{414}	562.30	94.69	575	9336.6	15.96	1.75	0.325	18.62	92.9	941.66

Table 2 : Mean Values of Economic Characters of the Testers

Testers	Fecundity	Hatching percentage	Larval Duration (h.)	Coon yield by No. 10,000 Larvae	Cocoon yield by eight/10,000 larvae	Single cocoon Weight (g.)	Single Shell Weight (g.)	Shell Percentage	Pupation rate	Filament Length (m.)
KA	560.00	92.55	592.00	8748.60	15.71	1.82	0.363	19.90	86.60	960.33
NB7	551.66	92.21	586.80	8858.00	15.11	1.78	0.366	20.59	85.63	981.33
NB_{16}	562.60	93.22	593.30	8778.60	15.79	1.85	0.376	20.27	85.83	953.33
NB_4D_2	567.60	93.58	605.10	8991.30	16.74	1.90	0.390	20.58	87.28	1014.60

Table 3 : Mean Values of Economic Characters of the New Bivoltine Hybrids and the Control

Testers	Fecundity	Hatching percentage	Larval Duration (h.)	Coon yield by No. 10,000 Larvae	Cocoon yield by eight/10,000 larvae	Single cocoon Weight (g.)	Single Shell Weight (g.)	Shell Percentage	Pupation rate	Filament Length (m.)
MG_{405} x KA	559.3	96.80	565.0	9500.3	18.04	1.94	0.398	20.54	94.21	1074
MG_{405} x NB_7	556.6	96.35	562.0	9469.3	16.94	1.80	0.338	18.83	93.10	957
MG_{405} x NB_{18}	559.6	95.53	564.3	9380.0	17.44	1.91	0.382	20.01	93.78	1001
MG_{405}xNB_4D_2	561.0	96.57	565.3	9420.3	17.17	1.85	0.361	19.53	93.81	982
MG_{406} x KA	562.6	96.28	555.3	9554.6	17.89	1.92	0.381	19.82	94.82	1009
MG_{406} X NB_7	550.1	97.58	562.3	9360.6	17.53	1.94	0.388	20.35	94.67	10006
MG_{406}XNB_{18}	554.6	95.19	564.3	9402.0	18.67	2.09	0.407	19.50	93.65	1156
MG_{406} x NB_4D_2	560.6	95.53	565.0	9358.6	18.59	2.05	0.405	19.79	92.81	1159
MG_{408} x KA	562.6	97.13	556.0	9433.3	17.73	1.90	0.397	20.95	93.16	1050
MG_{408} x NB_7	560.0	94.71	554.6	9466.0	16.34	1.78	0.348	19.60	93.20	991
MG_{408} x NB_{18}	510.0	97.82	558.0	9490.3	17.74	1.90	0.373	21.04	94.01	1147
MG_{408} x NB_4D_2	586.6	97.02	555.0	9772.0	18.46	1.92	0.390	20.28	95.57	1084
MG_{414} x KA	570.3	97.91	553.6	9692.6	19.18	2.05	0.417	20.98	95.50	1192
MG_{414} x NB_7	555.3	96.27	557.0	9406.6	18.62	2.05	0.401	19.59	93.89	1182
MG_{414} x NB_{18}	585.0	97.44	564.6	9502.6	18.10	1.96	0.394	19.95	93.91	1107
MG_{414}XNB_4D_2	567.6	96.63	556.6	9621.3	19.11	2.06	0.406	20.11	94.61	1207
Control										
NB_{18}xNB_7	554.0	95.10	574.0	9128.6	17.45	1.90	0.374	20.14	87.76	1038
KA xNB_4D_2	569.5	94.46	573	9046.0	17.91	1.94	0.393	20.25	89.90	1122

Table 4 : Standardized Selection Parameters Analysis in Sensitivity (MST)

Variable	Target	Intensity	Desired target
Fecundity	0.00	3.00	561
Hatching percentage	0.00	3.00	96.55
Larval duration	-0.50	5.00	557
Single Cocoon Weight	0.50	4.00	1.992
Single Shell Weight	0.50	4.00	0.398
Shell Percentage	1.00	8.00	20.665
Pupation rate	1.00	9.00	94.84
Filament Length	0.50	4.00	1124

productivity, different selection intensities were applied to various economic traits. Table 4 provides the details of the standardized selection parameters applied to various economic traits. High intensity of selection (9.00) was applied to pupation rate followed by shell percentage (8.00) shorter larval duration (5.00). For the traits, single cocoon weight, single shell weight and filament length equal selection intensity (4.00) was given due to their positive correlations. Fecundity and hatching percentage were a selection intensity of 3.00 values each. Based on the superior index values obtained by sensitivity analysis of MST, the following ten hybrids were short-listed in the order of merit among a total of sixteen hybrid combinations studied. MG_{414} X NB_4D_2 (3.80), MG408 x NB_4D_2 (4.63), MG_{405} x KA (4.75), MG_{406} x KA (5.43), MG $_{406}$ x NB_7 (5.56), MG_{414} x KA (5.86), MG_{408} x NB_{18} (5.93), MG_{414} x NB_{18} (6.19), MG $_{414}$ x NB_7 (6.8), MG_{408} x KA (7.01). The mean values of these hybrids for various economic traits are presented in Table 5.

Discussion

The introduction of commercial hybrids has increased the productivity to several folds in agriculture, horticulture, animal husbandry, fisheries and poultry. In sericulture, heterosis has become an important tool in the utilization of hybrids of silkworm for commercial exploitation and is one of the best illustrations of the practical utilization of applied genetics next to maize. In fact, the utility of F_1 hybrids ever since Toyama's 1906, for commercial exploitation has heralded a new era in most of the Sericultural countries including India.

The superiority of the hybrids over the parental strains due to variable magnitude of heterosis for several quantitative characters is well documented. (Osawa and Harada, 1944, Hirobe 1985, Gamo, 1976). In order to adjudicate the promising hybrid combinations, several methods have been developed in order to evaluate their quantitative characters.

Selection of potential breeds with desirable combination of genes contributing to their overall superior performance for commercially important traits could be achieved precisely by adopting a common index giving adequate weightage to all the traits manifested. Such a strategy in the development of selection index depends on the proper understanding of correlation between various economic traits through statistical methods.

Application of selection indices in various plants and animals including silkworms has lead to the identification of superior varieties/hybrids (Mano *et al*., 1992 and Nirmal Kumar, 1995; Lakshmi and Chandrashekaraiah 2007; Nirupam and Singh, 2007). Attempts have also been made for establishing an evaluation method and indexing based on one or two economic traits alone. Of the several selection indices developed, MST analysis utilized in the

Table 5 : Merit Wise Listing of 10 Selected Entries in the Sensitivity Analysis (MST)

Hybrid Combination	Index	Fecundity	Hatching percentage	Larval Duration (h.)	Single cocoon weight (g.)	Single Shell weight (g.)	Shell Percentage	Pupation rate	Filament Length (m.)
MG_{414} x NB_4D_2	3.4	561	96.63	566	2.06	0.406	20.11	94.61	1207
$MG_{408}XNB_4D_2$	4.63	568	97.02	555	1.92	0.39	20.28	95.57	1084.3
MG_{405} x KA	4.75	559	96.8	565	1.94	0.398	20.54	94.21	1074
MG_{406} x KA	5.43	562	96.28	555	1.926	0.361	19.82	94.62	1009
MG_{406} x NB_7	5.56	550	97.58	562	1.94	0.388	20.35	94.67	1008.6
MG_{4I4} x KA	5.86	570	97.91	553	2.05	0.417	20.98	95.5	1192.6
MG_{408} x NB_{18}	5.93	570	97.82	558	1.9	0.373	21.04	94.01	1174.6
MG_{414} x NB_{18}	6.19	585	97.44	564	1.96	0.394	19.95	93.91	1107
MG_{414} x NB_7	6.8	553	96.27	557	2.05	0.401	19.59	93.89	1182
MG_{408} x KA	7.01	562	97.13	556	1.9	0.397	20.93	93.1	1050

present research programme has been developed by Barreto *et al*. (1991). The selection index has been evaluated by giving due consideration to the criteria of fixing targets depending on their direct or indirect relationship with various economic characters. Based on the superior index values ten hybrid combinations were short-listed having desirable combination of various characters. The hybrid MG 414 x NB4D2 revealed a lowest index value of 3.8 and highest in the hybrids of MG 408 x KA with an index value of 7.01. The lower the value of the index the closer the genotype to the objective defined and hence it is considered superior. Selection of silkworm hybrids based on superior index values was attempted by Nirmal Kumar (1995); Ramesh Babu *et al*. (2002); Singh *et al*. (2006); Suresh Kumar (2006); Doddaswamy **(**2008), by using multiple trait evaluation index. Kumar *et al*. (1995) and Kalpana (1999) Categorized different silkworm races based on index values by utilizing MST analysis.

Keeping in view, on the basis of foregoing discussion on the performance of new hybrids over the control hybrids, and based on the MST the authors suggest MG_{414} x NB_4D_2, MG_{408} x NB_4D_2, MG_{405} x KA and MG_{406} x KA for commercial exploitation.

References

Barreto H.J., Bolanos J.A. and Cordova H.S. (1991): Selection index programme. *In Software operation guide. International Maize and Wheat improvement centre IMMYT). Central America.* 1-24.

Chandrashekaraiah (1992): Studies on the genetics of quantitative traits in a few multivoltine and bivoltine races of silkworm, *Bombyx mori* L. *Ph.D. Thesis,* University of Mysore, Mysore.

Chatterjee S.N. (1992): Need for new direction in research for improvement of silkworm and silk production. *Base Paper. Nat. Conf Muib. Sen. Res.* 10-11th *Dec. CSR & TlMysore.*

Choudhary N. and Singh R. (2006): Heterosis in relation to combining ability in hybrids between multivoltine and bivoltine breeds of the silkworm, *Bombyx mori* L. *Uttar Pradesh J. Zool.*, **26(1)**, 23-28.

Doddaswamy M.S. (2008): Contribution towards the genetics of cross breeding strategies in the Silkworm *Bombyx mori* L. *Ph.D. Thesis,* University of Mysore, Mysore.

Doddaswamy M.S. and Subramanya G. (2005): Studies on heterosis for some economic traits in few multi-bi and bi-multi hybrids of the silkworm, *Bombyx mori*. In “Advances in tropical sericulture.” Proceedings of the National conference on tropical sericulture for Global Competitiveness. 5th to 7th Nov 2003, CSR & TI, Mysore, pp. 88-92.

Gamo. T. (1976): Recent concept and trends in silkworm breeding. *Farming Japan*, **10(6)**, 11-12.

Hirobe T. (1985): On the recent advancement of silkworm breeding in Japan. Tamagawa Univ. 2-17-19, Gakuen-Cho, Highshikurume-Shi Jpn. 157-167.

Kalpana G.V., Sudhakar Rao P., Kshama Giridhar, Ashan M.M. and R.K. Datta (1999): Identification of promising bivoltine hybrids by maiz selection tool (MST)-A software package. *Uttarpradesh J. Zool*., **19(1)**, 25-29.

Kumar P., Bhutia R. and Ahsan M.M. (1995): Estimates of genetic variability for commercial quantitative traits and selection indices in bivoltine races of mulberry silkworms (*Bombyx mon L.,) md. I Genet.*, **55(2)**,109-116.

Lakshmi H. and Chandrashekaraiah (2007): Identification of breeding research material for the development of Thermo-tolerant breeds of silkworm *Bombyx mori., J. Exp. Zool. India.,* **10(1)**, 55-63.

Mano J., Nirmal Kumar S., Basavaraja H.K., Mal Reddy and R.K. Datta (1992): An index for multiple trait selection for silk yield improvement in *Bombyx mori* L., *Nat. Conf Muib. Seric. Res. CSR&TI, Mysore P* 116.

Nirmal Kumar S. (1995): Studies on the synthesis of appropriate silkworm breeding (Bombyx mori

L.,) for tropics. Ph.D., Thesis, Univ. of Mysore, Mysore.

Nirupam R. and Singh R. (2007): Evaluation of polyvoltine breeds of the mulberry silkworm, *Bombyx mori* L. *J. Exp. Zool. India*, **10(2)**, 341-344.

Osawa K. and Harada C. (1944): Studies on the F_1 hybrids on the silkworm III. On the effects of heterosis.*Bull. Seric. Expt. Stn.*, **12**, 183-211

Raghavendra Rao D., Kariyappa B.K., Singh R., Banerjee S. and Dandin S.B. (2005): Heterosis for quantitative and qualitative attributes in the F_1 and three-way crosses between newly evolved multivoltine breed, BL_{67} and authorized CSR bivoltine breeds and hybrids of the silkworm, *Bombyx mori* L. *Advances in Tropical sericulture NASSI* pp. 63-66.

Ramesh Babu M., Chandrashekaraiah, Lakshmi H. and Prasad J. (2002): *Multiple trait evaluation of bivoltine hybrids of silkworm*, Bombyx mori *L. Int. J. Indust. Entomol.*, **5(1)**, 37-44.

Singh R., Basavaraja H.K. and Kariyappa B.K., Kariyappa B.K., Raghavendra Rao D., Rama Mohan Rao P., Premalatha V. and Gangopadyay D. (2006): Reciprocal effect in F_1 hybrids between multivoltine and bivoltine breeds of the silkworm, *Bombyx mori* L. *Indian J. Seric*., **45(2)**, 176-180.

Singh R., Sharma S.D., Raghavendra Rao D., Chandrashekaran K., Basavaraja H.K. and Kariyappa B.K. (2005): Line x Tester and heterosis analysis in the silkworm, *Bombyx mori* L. *Indian J. Seric*., **44(1)**, 92-99.

Sreerama Reddy G., Raju P. J. and Maribashetty V.G. (1992): Heterosis and its application in silkworm *Bombyx mon* L. *Recent advances in Ljfe Sciences, Man Pub. Kanpur, md.* 205-222.

Suresh Kumar N., Basavaraja H.K., Kalpan G.V., Malreddy N., Joge P.G., Palit A.K., Nanje Gowda B. and Dandin S.B. (2006): *Selection strategies for conventional breeding in the mulberry silkworm,* Bombyx mori *L. Indian. J. Seric.*, **45(2)**, 85-103.

Toyama K. (1906): Breeding methods of silkworm. *Sangyo Shimpo.*, **158**, 282-28.