IDENTIFICATION OF BIVOLTINE BREEDS AND HYBRIDS OF THE MULBERRY SILKWORM, *BOMBYX MORI* L.

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ABSTRACT: Identification of promising bivoltine breeds and hybrids of the mulberry silkworm, *Bombyx mori* L. was carried out utilizing three different statistical tools namely, multiple traits evaluation indices, combining ability and hybrid vigour. Out of six bivoltine silkworm breeds, DNB_1 was found promising exhibiting maximum values based on its performance and multiple traits evaluation indices exhibiting maximum values for six characters *viz.,* hatching %, pupation rate, cocoon shell %, filament length, raw silk percentage and neatness followed by DNB_6 which exhibited higher values for three characters *viz.*, cocoon yield/10,000 larvae by weight, cocoon weight and cocoon shell weight. DNB_1 showed its superiority by exhibiting maximum GCA effects for seven characters. Among twenty four hybrids, $DNB_1 \times CSR_2$ recorded maximum rearing performance values for four characters *viz.,* cocoon shell weight, cocoon shell %, filament length and raw silk % followed by two hybrids $DNB_6 \times CSR_2$ and $DNB_7 \times CSR_2$ exhibiting maximum values for two characters each. Different hybrids exhibited higher values for special combining ability (SCA). $DNB_4 \times CSR_4$ manifested higher hybrid vigour for pupation rate, cocoon yield/10,000 larvae by weight and cocoon shell weight.

KEY WORDS: *Bombyx mori,* Combining ability, Hybrid vigour, Multiple traits evaluation indices, Performance, Bivoltine silkworm breeds and hybrids.

Attempts to identify promising silkworm breed / hybrids have been carried out based on multiple traits evaluation indices (Vidyunmala et al.,1998; Kariappa & Rajan, 2005; Gangopadhyay et al., 2006; Nazia Choudhary & Ravindra Singh, 2006a) and multiple traits evaluation indices (Ramesh Babu et al., 2002; Rao et al., 2006; Nirupama & Ravindra Singh, 2007; Nirupama et al., 2008a;b) and through analysis of combining ability and hybrid vigour (Datta et al., 2001; Gangopadhyay & Ravindra Singh, 2006; Nazia Choudhary & Ravindra Singh, 2006b; Ravindra Singh et al., 2000; 2001; 2010). It is important to identify breeds/hybrids based on cumulative effect of several characters (Narayanaswamy et al., 2002). Recently, Ravindra Singh and Nirupama (2012) have short-listed promising multivoltine breeds and multivoline × bivoltine hybrids utilizing various statistical tools. The present study has been undertaken to identify promising bivoltine breeds and hybrids based on the performance, other statistical methods like multiple traits evaluation indices method of Mano et al. (1993), analysis of combining ability method of Kempthorne (1957) and hybrid vigour.

MATERIALS AND METHODS

Six bivoltine silkworm breeds namely, DNB_1, DNB_2, DNB_3, DNB_4, DNB6 and DNB7 and twenty four bivoltine hybrids were utilized in this study. Rearing of both silkworm breeds and hybrids was conducted with three replications in each and 250 larvae were retained after III moult. Data were recorded for eleven economic characters namely, fecundity, hatching %, pupation rate, yield/10,000 larvae by weight, cocoon weight, cocoon shell weight, cocoon shell percentage, filament length, reelability, raw silk percentage and neatness. Data were analyzed based on rearing performance, multiple traits evaluation index method, combining ability and hybrid vigour.

RESULTS AND DISCUSSION

In order to shortlist promising bivoltine silkworm breeds / hybrids, average rearing performance, values based on multiple traits evaluation indices, general combining ability (GCA) of parents, specific combining ability (SCA) of hybrids and hybrid vigour for 11 economic characters namely, fecundity, hatching, pupation rate, yield/10,000 larvae by weight, cocoon weight, cocoon shell weight, cocoon shell percentage including post cocoon parameters like filament length, reelability, raw silk and neatness have been given in Table 1. DNB_1 showed distinct superiority based on its performance and multiple traits evaluation indices exhibiting maximum values for six characters v*iz.,* hatching % (96.28% and 56.91), pupation rate (91.33% and 68.79), cocoon shell % (21.22% and 64.84), filament length (870m and 63.62), raw silk percentage (15.70% and 60.03) and neatness (92p and 59.52) respectively followed by DNB_6 which exhibited higher values for three characters *viz.*, cocoon yield/10,000 larvae by weight (15.630 kg and 61.43), cocoon weight (1.973g and 64.78) and cocoon shell weight (0.380g and 63.01). DNB_1 exhibited maximum GCA effects for seven characters. Three characters namely, cocoon yield/10,000 larvae by weight (15.630 kg and 61.43), cocoon weight (1.973g and 64.78), cocoon shell weight (0.380g and 63.01) were maximum in DNB_6 based on average performance and evaluation index value whereas fecundity in that breed was found highest when the GCA effects for that particular character was compared with other breeds.

Among twenty four hybrids, $DNB_1 \times CSR_2$ was found promising showing highest values for four characters namely, cocoon shell weight, cocoon shell percentage, filament length and raw silk based on average performance. $DNB_1 \times CSR_2$ revealed its superiority for four characters namely, cocoon shell weight (63.96), cocoon shell % (78.33), filament length (65.91) and raw silk % (74.25) based on evaluation index values. Two characters namely, pupation rate (98.80) and cocoon yield/10,000 larvae by weight (17.227 kg) in $DNB_6 \times CSR_2$ and two characters hatching (97.32%) and reelability (86.10%) in $DNB_7 \times CSR_2$ were found comparatively higher performance values. $DNB_6 \times CSR_2$ exhibited higher index values for pupation rate (76.81) and cocoon yield/10,000larvae by weight (63.99) whereas $DNB_7 \times CSR_2$ exhibited highest values for 2 characters namely, hatching (65.50) and reelability (68.24). Different hybrids expressed higher SCA effects for different characters. $DNB_3 \times CSR_{17}$ for cocoon and cocoon shell weight, $DNB_4 \times CSR_4$ for pupation rate and cocoon yield/10,000 larvae by weight and $DNB_4 \times NB4D_4$ for fecundity and reelability. On the basis of hybrid vigour studies, $DNB_4 \times CSR_4$ manifested higher hybrid vigour over mid paren values for 3 characters namely, pupation rate (14.08), cocoon yield/10,000 larvae by weight (28.30) and cocoon shell weight (21.46) whereas DNB_3 was poor combiner.

Selection of promising silkworm breeds and hybrids based on cumulative effect of several characters is important in silkworm breeding (Narayanaswamy et al., 2002).Extensive studies have been carried out to select silkworm breeds / hybrids through multiple traits evaluation index method (Ramesh Babu et al., 2002; Gangopadhyay et al., 2006; Nazia Choudhary; Ravindra Singh, 2006a, Rao et al., 2006; Lakshmi and Chandrashekharaiah, 2007; Nirupama and Ravindra Singh, 2007; Nirupama et al., 2008a;b) and through analysis of combining ability and hybrid vigour (Datta et al., 2001; Gangopadhyay and Ravindra Singh, 2006;

Nazia Choudhary and Ravindra Singh, 2006b; Nazia Choudhary and Ravindra Singh, 2006b; Ravindra Singh et al., 2000; 2001; 2010;). Ravindra Singh and Nirupama (2012) have short-listed promising silkworm breeds and hybrids utilizing evaluation index, subordinate function values, combining ability and hybrid vigour. The identified breeds DNB_1 and DNB_6 may be further utilized in future breeding programmes for the development of superior bivoltine silkworm breeds. The promising bivoltine hybrids $DNB_1 \times CSR_2$ $DNB_6 \times CSR_2$ may be exploited for commercial exploitation.

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Plate I: 1 - Larvae of DNB$_1$, 2 - Cocoons of DNB$_1$, 3 - Larvae of DNB$_6$ and 4 - Cocoons of DNB$_6$

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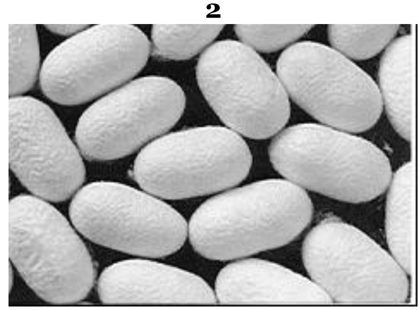

4

Plate II: 1 - Larvae of $DNB_1 \times CSR_2$, 2 - Cocoons of $DNB_1 \times CSR_2$, 3 - Larvae of $DNB_6 \times CSR_2$ and 4 - Cocoons of $DNB_6 \times CSR_2$

Table 1. Short-listing of bivoltine silkworm breeds / hybrids based on various statistical measures.

Character	Parents			Hybrids			
	Based on average performance	Based on Evaluation Index values	Based on General Combining Ability	Based on average performance	Based on Evaluation Index values	Based on Specific Combining Ability	Based on Hybrid Vigour
Fecundity (no)	DNB_2 (644)	DNB_2 (64.29)	DNB_6 (76.33)	$DNB_6 \times NB_4D_2$ (630)	$DNB_6 \times NB_4D_2$(70.21)	$DNB_4 \times NB_4D_2$(51.97)	-
Hatching (%)	DNB_1 (96.28)	DNB_1 (56.91)	-	$DNB_7 \times CSR_2$ (97.32)	$DNB_7 \times CSR_2$ (65.50)	$DNB_7 \times CSR_2$ (2.65)	$DNB_7 \times CSR_2$ (36.62)
Pupation rate	DNB_1 (91.33)	DNB_1 (68.79)	DNB_1 (2.60)	$DNB_6 \times CSR_2$ (98.80) $DNB_7 \times CSR_2$ (97.73)	$DNB_6 \times CSR_2$ (67.81) $DNB_7 \times CSR_2$ (65.57)	$DNB_4 \times CSR_4$ (5.68) $DNB_7 \times CSR_2$ (5.13)	$DNB_4 \times CSR_4$ (14.08)
Cocoon yield/10,000 larvae by wt (kg)	DNB_6 (15.63)	DNB_6 (61.43)	DNB_1 (1.19)	$DNB_6 \times CSR_2$ (17.227) $DNB_3 \times CSR_2$ (17.107)	$DNB_6 \times CSR_2$ (63.99) $DNB_3 \times CSR_2$ (62.98)	$DNB_4 \times CSR_4$ (1.46) $DNB_3 \times CSR_2$ (0.91)	$DNB_4 \times CSR_4$ (28.30) $DNB_2 \times CSR_4$ (19.81)
Cocoon weight (g)	DNB_6 (1.973)	DNB_6 (64.78)	DNB_4 (0.04)	$DNB_3 \times CSR_{17}$ (1.962) $DNB_7 \times CSR_{17}$ (1.913)	$DNB_3 \times CSR_{17}$(65.73) $DNB_7 \times CSR_{17}$(60.79)	$DNB_3 \times CSR_{17}$ (0.12) $DNB_6 \times CSR_2$ (0.10)	$DNB_3 \times CSR_{17}$(21.50) $DNB_4 \times CSR_4$ (16.79)
Cocoon shell weight (g)	DNB_6 (0.380)	DNB_6 (63.01)	DNB_1(0.024)	$DNB_1 \times CSR_2$ (0.390) $DNB_3 \times CSR_{17}$ (0.383)	$DNB_1 \times CSR_2$ (63.93) $DNB_3 \times CSR_{17}$(60.97)	$DNB_3 \times CSR_{17}$(0.029) $DNB_6 \times CSR_2$ (0.025)	$DNB_4 \times CSR_4$ (21.46) $DNB_3 \times CSR_{17}$(18.94)
Cocoon shell %	DNB_1 (21.22)	DNB_1 (64.84)	DNB_1 (0.94)	$DNB_1 \times CSR_2$ (21.54) $DNB_1 \times CSR_4$ (21.00)	$DNB_1 \times CSR_2$ (78.33) $DNB_1 \times CSR_4$ (58.39)	$DNB_2 \times NB_4D_2$ (0.71) $DNB_1 \times CSR_2$ (0.65)	$DNB_7 \times CSR_4$ (5.81) $DNB_1 \times CSR_2$ (5.73) $DNB_1 \times CSR_4$ (5.00)
Filament length (m)	DNB_1 (870)	DNB_1 (63.62)	DNB_1(44.54)	$DNB_1 \times CSR_2$ (977) $DNB_6 \times CSR_2$ (963)	$DNB_1 \times CSR_2$ (65.91) $DNB_6 \times CSR_2$ (63.67)	$DNB_2 \times CSR_4$ (89.21) $DNB_7 \times NB_4D_2$(79.32)	$DNB_7 \times NB_4D_2$(23.50) $DNB_2 \times CSR_4$ (20.63)
Reelability (%)	DNB_7 (83.5)	DNB_7 (60.84)	DNB_4 (2.35)	$DNB_7 \times CSR_2$ (86.1) $DNB_6 \times CSR_2$ (84.9)	$DNB_7 \times CSR_2$ (68.24) $DNB_6 \times CSR_2$ (65.38)	$DNB_4 \times NB_4D_2$ (3.89) $DNB_2 \times CSR_{17}$ (3.66)	$DNB_4 \times CSR_2$ (8.79) $DNB_3 \times CSR_2$ (8.44)
Raw silk %	DNB_1 (15.70)	DNB_1 (65.03)	DNB_1 (1.14)	$DNB_1 \times CSR_2$ (17.10) $DNB_1 \times CSR_4$ (17.05)	$DNB_1 \times CSR_2$ (74.25) $DNB_1 \times CSR_4$ (73.68)	$DNB_1 \times CSR_4$ (0.69) $DNB_1 \times CSR_2$ (0.67)	$DNB_1 \times CSR_4$ (12.61) $DNB_1 \times CSR_2$ (9.71)
Neatness	DNB_1 (92)	DNB_1 (59.52)	DNB_1 (0.68)	$DNB_1 \times CSR_4$ (93) $DNB_1 \times CSR_2$ (92)	$DNB_1 \times CSR_4$ (65.91) $DNB_1 \times CSR_2$ (60.39)	$DNB_3 \times NB_4D_2$ (2.51) $DNB_4 \times CSR_{17}$ (2.21)	$DNB_4 \times CSR_{17}$ (3.94) $DNB_3 \times NB_4D_2$ (2.03)