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Evaluation and Identification of Promising Bivoltine Hybrids of Silkworm, *Bombyx mori* L., for Monsoon and Spring Season of Uttar Pradesh

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An attempt was made to identify superior bivoltine silkworm hybrid suitable for monsoon and spring season of Uttar Pradesh. Breeds with superior cocoon characters and their more popularity in an area were major parameters on basis of which breeds from different regions were selected. Six bivoltine hybrids of silkworm (*Bombyx mori* L.) of different geographical regions were reared in monsoon (three hybrids) and spring season (three hybrids) during 2000 – 2002 *i.e.*, for three years at Babasaheb Bhimrao Ambedkar University, Lucknow. Their performances were analyzed statistically for nine characters. The analysis made on a number of traits *viz.*, hatching percentage, larval duration, pupation rate, yield / 10000 larvae (by no.), yield / 10000 larvae (by weight), cocoon weight, cocoon shell weight, cocoon shell ratio, showed the superiority of one bivoltine hybrid out of the three bivoltine hybrids studied in each season. SH6 × NB_4D_2 was found to be superior in major cocoon parameters in both the seasons i.e., monsoon and spring season of Uttar Pradesh.

Key words: Bivoltine hybrid, Silkworm, *Bombyx mori* L., Monsoon season, Spring season, Evaluation index value

Introduction

Evaluation of superior silkworm breeds presupposes recommendation on their release to the field for proper exploitation in different seasons. Datta and Pershad (1987) emphasized the importance of selection of parental material and biometrical evaluation of the breeds as a prerequisite for their utilization in future breeding programmes.

In India, especially in Karnataka, with the introduction of F_1 hybrids for commercial rearing in 1922, polyvoltine hybrids were reared till 1970. However much heterosis was not expressed in polyvoltine hybrids, as both the parents were polyvoltine with poor quantitative characters. In 1960, cross breeding programme was initiated to improve the polyvoltine races (Tazima, 1988). During late seventies, bivoltine races *viz.*, KA, NB7, NB18 and NB_4D_2 were utilized as male component in cross breed preparation (Krishnaswami and Tikoo, 1971). Although there was an increase in productivity, less larval mortality, longer cocoon filament, finer denier and low renditta were observed in cross breeds (Sengupta *et al.*, 1971; Nagaraju *et al.*, 1996), the quality of filament remained poor since the inherent defects of the polyvoltine races were passed on to the multivoltine × bivoltine hybrids. High quality, international grade silk can be achieved only by rearing bivoltine silkworms. Due to temperature fluctuations, poor management practices, poor mulberry quality, frequent bivoltine crop losses are often witnessed with farmers. Therefore, there is an urgent need to breed bivoltine silkworm breeds, which can withstand the tropical climatic conditions prevailing in India. Although extensive studies have been done on performance of multivoltine × bivoltine cross breeds (Tikoo *et al.*, 1971; Govindan *et al.*, 1987; Raju and Krishnamurthy, 1995; Rajashekhargouda *et al.*, 1997; Radhakrishna *et al.*, 2001). Rajashekhargouda *et al.* (1997) and Narayanaswami *et al.* (2000) have studied the performance of bivoltine × multivoltine cross breeds of silkworm. Pershad *et al.* (1986), Jayaswal *et al.* (1992) and Kalpana and Sreerama Reddy (1998) have studied the performance of multivoltine breeds of silk-

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worm. Tayade (1987), Thiagaran *et al.* (1993) and Rajashekhargouda *et al.* (1997) have evaluated some bivoltine breeds of silkworm, *Bombyx mori* L. But few studies have been done on performance of bivoltine silkworm hybrids (Tayade, 1987; Naseema Begum *et al.*, 2000a, b; Sudhakara Rao *et al.*, 2001) in different regions. But, none attempts were made to study and evaluate the performance of different bivoltine hybrids in different seasons of Uttar Pradesh. Therefore, an attempt was made to rear bivoltine hybrids in different seasons adopting latest technologies of bivoltine rearing which can be reared in the farmers dwellings under the prevailing climatic conditions.

In the present study, the rearing performance of six bivoltine hybrids collected from different traditional silk producing states *viz.*, two most popular races from West Bengal, two most popular races from Karnataka and one most popular race from Uttaranchal as the climatic conditions prevalent here are most congenial for rearing bivoltine hybrid silkworms. The observations were made on hatching percentage, larval duration (hrs), pupation rate (%), yield / 10000 larvae (by no.), yield / 10000 larvae (by weight in kg), cocoon weight (g), cocoon shell weight (cg) and cocoon shell ratio (%). Data were statistically analyzed to select the best bivoltine hybrid silkworm race in each season.

Materials and Methods

The experiments were conducted in monsoon and spring seasons during 2000 – 2002. Three bivoltine hybrids *viz.*, SH6 × NB_4D_2 (collected from Uttaranchal), CSR18 × CSR19 (collected from Karnataka) and SH6 × KA (collected from West Bengal) were reared in monsoon season of Uttar Pradesh. The standard rearing practices were followed (Krishnaswami, 1978). Three treatment of each hybrid were maintained: one (control at Lucknow), second (field conditions at Lucknow) and third (field conditions at Gonda). Each treatment was having three replications of 400 larvae maintained after third instar. Chawki rearing was done at mass level.

Similarly, three bivoltine hybrids *viz.*, SH6 × NB_4D_2 (collected from Uttaranchal), CSR2 × CSR4 (collected from Karnataka) and P5 × NB18 (collected from West Bengal) were reared in spring season of Uttar Pradesh. Remaining procedure was same as that adopted in monsoon season of rearing.

In the control conditions, all the breeds were reared under laboratory conditions at a temperature of 26 – 29°C and humidity of 70 – 85%, following the standard rearing technology by Krishnaswami (1978, 1979) but in field conditions natural climatic conditions were provided to the silkworms *i.e.*, monsoon (August - September) season characterized by high temperature, high humidity and heavy rainfall and spring (February - March) season characterized by low temperature, low humidity and no rainfall.

The rearing performance of these hybrids were studied in two different seasons of the year with respect to nine quantitative traits *i.e.*, hatching percentage, larval duration, pupation rate, cocoon yield (by no.), cocoon yield (by weight), cocoon weight, cocoon shell weight and shell ratio.

An evaluation index (E. I.) was calculated for each character by the formula mentioned below:

$$\text{E. I.} = \frac{A-B}{C} \times 10 + 50$$

Where A = Value of a particular hybrid for a character,
B = Mean value,
C = Standard deviation, 10 = Standard unit and
50 = Fixed value

Evaluation index values (Mano *et al.*, 1993) were calculated for each hybrid for all the nine characters by following the above method. The indices obtained from all the characters in each hybrid were combined and the average value was calculated (E. I.). The average E. I. value fixed for the selection of hybrid was 50 or greater than 50. The hybrids, which scored above the limit, were considered to possess greater economic value.

Results

The mean values of the eight characters of bivoltine hybrids for monsoon season and spring season are presented in Table 1 and 3 and their evaluation index values are presented in Table 2 and 4. The results obtained for various parameters among different hybrids are given below:

Hatching percentage

Monsoon season: In the control treatment, it ranges from 97 in SH6 × NB_4D_2, 96 in $C_{SR1}8$ × CSR19 and 96.0 in SH6 × KA. In Gonda and Lucknow level treatment, values range from 97 and 96 in SH6 × NB_4D_2, 86 and 85 in CSR18 × CSR19 and 93 and 93 in SH6 × KA, respectively.

Spring season: In control treatment, values range was observed to be 98 in SH6 × NB_4D_2, 96 in CSR2 × CSR4 and 97 in P5 × NB18. Similarly, in both the Gonda and Lucknow level treatments, values obtained were highest for SH6 × NB_4D_2 (97 and 98), medium for CSR2 × CSR4 (96 and 96), lowest for P5 × NB18 (95 and 95).

Table 1. Performance of bivoltine silkworm hybrids in monsoon season of Uttar Pradesh

Hybrid	Treatment	Hatching (%)	Larval duration (h)	Pupation rate (%)	Yield /10,000 Larvae		Cocoon. weight (g)	Cocoon shell weight (cg)	Cocoon shell ratio (%)
					(No)	(kg)			
SH6 × NB_4D_2	Control	97	570	96.5	9,100	15.5	1.70	40.8	23.9
	Gonda	97	576	86.7	8,425	13.2	1.57	36.9	23.5
	Lucknow	96	598	84.2	8,225	12.6	1.53	34.8	22.6
CSR18 × CSR19	Control	96	516	93.7	9,225	15.3	1.65	34.8	22.0
	Gonda	86	537	66.8	6,225	8.3	1.33	29.4	21.9
	Lucknow	85	574	65.5	6,300	8.1	1.29	28.2	21.9
SH6 × KA	Control	96	576	92.8	9,200	14.7	1.59	34.2	21.4
	Gonda	93	611	70.3	6,700	10.6	1.58	33.4	21.1
	Lucknow	93	612	68.9	6,550	10.2	1.55	33.9	21.8

Each value obtained is mean of three replications.

Table 2. Evaluation index values of different characters among different hybrids in monsoon season

	Hybrid	Hatching (%)	Larval duration (h)	Pupation rate (%)	Yield / 10,000 larvae		Cocoon weight (g)	Cocoon shell weight (cg)	Cocoon shell ratio (%)
					(No.)	(kg)			
Control	SH6 × NB_4D_2	97 (60.57)	570 (54.73)	96.5 (61.28)	9,100 (38.66)	15.5 (58.63)	1.70 (60)	40.8 (61.53)	23.9 (61.32)
	CSR18 × CSR19	96 (49.14)	516 (38.50)	93.7 (46.71)	9,225 (57.55)	15.3 (52.95)	1.65 (52)	34.8 (45.10)	22.0 (46.64)
	SH6 × KA	96 (40.57)	576 (56.75)	92.8 (42.05)	9,200 (53.77)	14.7 (38.86)	1.59 (40)	34.2 (43.40)	21.4 (42.10)
Mean		96	554	94.3	9,175	15.0	1.64	36.6	22.4
SD		0.702	32.887	1.956	66.143	0.447	0.055	3.644	1.285
Gonda	SH6 × NB_4D_2	97 (58.40)	576 (50.30)	86.7 (61.40)	8,425 (61.30)	13.2 (60.24)	1.57 (55.67)	36.9 (59.76)	23.5 (60.98)
	CSR18 × CSR19	86 (38.93)	537 (39.85)	66.8 (42.65)	6,225 (42.30)	8.3 (40.24)	1.33 (38.65)	29.4 (39.73)	21.9 (47.78)
	SH6 × KA	93 (52.65)	611 (59.84)	70.3 (45.95)	6,700 (46.40)	10.6 (49.51)	1.58 (56.38)	33.4 (50.50)	21.1 (41.31)
Mean		92.0	574	74.6	7,116	10.7	1.49	33.3	22.2
SD		5.651	36.682	10.629	1157.673	2.452	0.141	3.758	1.223
Lucknow	SH6 × NB_4D_2	96 (58.22)	598 (51.65)	84.2 (61.38)	8,225 (61.46)	12.6 (60.31)	1.53 (55.55)	34.8 (57.06)	22.6 (61.44)
	CSR18 × CSR19	85 (38.85)	574 (39.27)	65.5 (42.59)	6,300 (43.07)	8.0 (40.22)	1.29 (38.88)	28.2 (38.55)	21.9 (45.76)
	SH6 × KA	93 (52.94)	612 (59.07)	68.9 (46.03)	6,550 (45.46)	10.2 (49.50)	1.55 (56.94)	33.9 (54.43)	21.8 (42.79)
Mean		91	594	72.9	7,025	10.3	1.45	32.3	22.1
SD		5.686	18.863	9.936	1046.721	2.249	0.144	3.543	0.472

Each value before bracket is a mean of 3 replications.
Values in brackets indicate evaluation index values.

Larval duration (hrs)

Monsoon season: Longest larval duration was observed in SH6 × KA of 612 hrs in Lucknow level treatment and 611 hrs in Gonda level treatment followed by 598 hrs in Lucknow level treatment and 576 hrs in Gonda level treatment in SH6 × NB_4D_2 and least larval duration of 574, 537 hrs in CSR18 × CSR19, respectively.

Spring season: Highest larval duration of 670 hrs was

Table 3. Performance of bivoltine silkworm hybrids in spring season of Uttar Pradesh

Hybrid	Treatment	Hatching (%)	Larval duration (h)	Pupation rate (%)	Yield /10,000 Larvae		Cocoon. weight (g)	Cocoon shell weight (cg)	Cocoon shell ratio (%).
					(No.)	(kg)			
SH6 × NB_4D_2	Control	98	541	96.6	9,250	16.4	1.76	41.6	23.6
	Gonda	97	664	92.8	8,525	13.8	1.62	37.4	23.1
	Lucknow	98	546	88.0	8,350	13.4	1.61	36.4	22.6
CSR2 × CSR4	Control	96	476	95.4	9,100	15.1	1.66	37.0	22.2
	Gonda	96	645	85.6	7,500	12.3	1.65	35.3	21.4
	Lucknow	96	484	82.0	7,625	11.8	1.53	31.6	20.7
P5 × NB18	Control	97	566	80.7	7,950	12.9	1.58	35.9	22.8
	Gonda	95	670	75.0	6,975	10.9	1.61	35.3	21.8
	Lucknow	95	560	71.3	5,875	10.4	1.51	30.6	20.3

Each value obtained is mean of three replications.

Table 4. Evaluation index values of different characters among different hybrids in spring season

	Hybrid	Hatching (%)	Larval duration (h)	Pupation rate (%)	Yield / 10,000 larvae		Cocoon weight (g)	Cocoon shell weight (cg)	Cocoon shell ratio (%)
					(No.)	(kg)			
Control	SH6 × NB_4D_2	98 (60)	541 (52.95)	96.6 (56.44)	9,250 (56.80)	16.4 (59.26)	1.76 (61.11)	41.0 (63.33)	23.6 (60.57)
	CSR2 × CSR4	96 (40)	476 (38.85)	95.4 (55.09)	9,100 (54.69)	15.1 (51.47)	1.66 (50)	37.0 (50)	22.2 (40.69)
	P5 × NB18	97 (50)	566 (58.19)	80.7 (38.47)	7,950 (38.52)	12.9 (39.37)	1.58 (41.11)	35.0 (43.33)	22.8 (48.73)
Mean		97	527	90.9	8,766	14.8	1.66	37.0	22.8
SD		1	46	8.9	711	1.8	0.09	0.0	0.7
Gonda	SH6 × NB_4D_2	97 (60)	664 (53.41)	92.8 (59.29)	8,525 (60.89)	13.8 (60.06)	1.62 (45)	37.0 (59.09)	23.1 (61.22)
	CSR2 × CSR4	96 (50)	645 (38.74)	85.6 (51.28)	7,500 (47.89)	12.3 (50)	1.65 (60)	35.0 (40.90)	21.4 (41.89)
	P5 × NB18	95 (40)	670 (57.84)	75.0 (39.41)	6,975 (41.23)	10.9 (40)	1.61 (40)	35.0 (40.90)	21.8 (47.10)
Mean		96	660	84.5	7,666	12.3	1.63	36.0	22.1
SD		1	13	8.9	788	1.5	0.02	0.0	0.9
Lucknow	SH6 × NB_4D_2	98 (60.98)	546 (54.03)	88.0 (58.95)	8,350 (58.38)	13.4 (60.26)	1.61 (61.53)	36.0 (61.53)	22.6 (61.44)
	CSR2 × CSR4	96 (47.82)	484 (38.61)	82.0 (51.84)	7,625 (52.68)	11.8 (49.60)	1.53 (46.15)	32.0 (46.15)	20.7 (45.84)
	P5 × NB18	95 (41.25)	560 (57.35)	71.3 (39.20)	5,875 (38.93)	10.4 (40.19)	1.51 (42.30)	31.0 (42.30)	20.3 (42.72)
Mean		96	530	80.4	7,283	11.9	1.55	33	21.2
SD		1	40	8.4	1,272	1.5	0.05	0.0	1.2

Each value before bracket is a mean of 3 replications.
Values in brackets indicate evaluation index values.

observed in Gonda level treatment and 560 hrs in Lucknow level treatment of P5 × NB18 and least larval duration of 645 hrs in Gonda level treatment and 484 hrs in Lucknow level treatment of CSR2 × CSR4 hybrid.

Pupation rate (%)

Monsoon season: In all the treatments, SH6 × NB_4D_2 depicted more pupation% of 96, 86, 84 followed by least pupation% of SH6 × KA of 92.8, 70.3 and 68.9.

Spring season: SH6 × NB_4D_2 recorded more values ranging from 96.6 to 92.8 to 88.0 in control, Gonda and Lucknow level treatment followed by lowest values ranging from 80.7 to 75.0 to 71.3 in P5 × NB18 in all the treatments.

Yield / 10000 larvae (No.)

Monsoon season: In control treatment, for 10,000 larvae, yield obtained by CSR18 × CSR19 was 9,225 followed by SH6 × KA (9,200) and SH6 × NB_4D_2 (9,100). In Gonda treatment, the values were 8,425 for SH6 × NB_4D_2, 6,225 for CSR18 × CSR19 and 6,700 for SH6 × KA and similarly, in Lucknow treatment, values obtained were 8,225, 6,300 and 6,550, respectively.

Spring season: In control treatment, values obtained for SH6 × NB_4D_2, CSR2 × CSR4 and P5 × NB18 were 9,250, 9,100 and 7,950 respectively. Similarly in Gonda and Lucknow level treatment, yield obtained for 10,000 larvae were 8,525, 8,350; 7,500, 7,625, 6,975 and 5,875, respectively.

Yield / 10000 larvae (kg)

Monsoon season: Cocoon yield was obtained in SH6 × KA in Control (14.7 kg), Gonda (10.6 kg) and Lucknow level (10.2 kg) treatment followed by highest yield in SH6 × NB_4D_2 of 15.5, 13.2 and 12.6 kg, respectively.

Spring season: SH6 × NB_4D_2 recorded highest cocoon yield 16.4, 13.8 and 13.4 in control, Gonda and Lucknow level treatment respectively and lowest values of 12.9, 10.9 and 10.4 were obtained for P5 × NB18.

Cocoon weight (g)

Monsoon season: In Control, Gonda and Lucknow level treatment, values range was observed to be 1.70, 1.57, 1.53 in SH6 × NB_4D_2; 1.65, 1.33, 1.29 in CSR18 × CSR19 and 1.59, 1.58, 1.55 in SH6 × KA, respectively.

Spring season: In Control, Gonda and Lucknow level treatment, values recorded were 1.76, 1.62, 1.61 in SH6 × NB4D2; 1.66, 1.65, 1.53 in CSR2 × CSR4 and 1.58, 1.61, 1.51 in P5 × NB18, respectively.

Cocoon shell weight (cg)

Monsoon and spring season: In both the seasons, in all the treatments, highest value was obtained for SH6 × NB_4D_2 (40.8, 36.9, 34.8 in monsoon season; 41.6, 37.4, 36.4 in spring season) followed by CSR2 × CSR4 (37.0, 35.3, 31.6 in spring season), CSR18 × CSR19 (34.8, 29.4, 28.2 in monsoon season) and lowest values were obtained for SH6 × KA (34.2, 33.4, 33.9 in monsoon season) and P5 × NB18 (35.9, 35.3, 30.6 in spring season).

Cocoon shell ratio (%)

Monsoon season: In Control, Gonda and Lucknow level treatment, SH6 × NB_4D_2 recorded highest values of 23.9, 23.5, 22.6 followed by 22.0, 21.9, 21.9 of CSR18 × CSR19 still followed by lowest values of 21.4, 21.1 and 21.8, respectively.

Spring season: Highest values were obtained again for SH6 × NB_4D_2 *viz.*, 23.6, 23.0, 22.6 followed by 22.2, 21.4, 20.7 of CSR2 × CSR4 and 22.8, 21.8 and 20.3 of P5 × NB18. Similarly, evaluation index values were obtained for each trait in different treatments and it was observed that in monsoon season, in the control treatment evaluation index was greater than 50 for all cocoon parameters except yield / 10,000 larvae by no. in SH6 × NB_4D_2 (Table 2) and in CSR18 × CSR19, evaluation index was greater than fifty for only two cocoon parameters *i.e.*, yield / 10,000 larvae by no. and yield / 10,000 larvae by weight and remaining cocoon parameters had E. I. value below 50. Also in SH6 × KA race, only two parameters larval duration and yield / 10,000 larvae by no. had E. I. value above 50. Similarly, in Gonda level treatment, SH6 × NB_4D_2 showed E. I. value above 50 for all the cocoon parameters but CSR18 × CSR19 did not have a single cocoon parameter showing E. I. value above 50 but SH6 × KA expressed E. I. value above 50 for four cocoon parameters *viz.*, hatching % (52.65), larval duration (59.84), cocoon weight (56.38), cocoon shell weight (50.50). Similarly, in Lucknow level treatment, E. I. value was obtained greater than 50 for all cocoon parameters in SH6 × NB_4D_2 (Table 2) but none of the cocoon parameters showed E. I. value above 50 in CSR18 × CSR19. But SH6 × KA showed E. I. values greater than 50 for four cocoon parameters *i.e.*, hatching % (52.94), larval duration (59.07), cocoon weight (56.94), cocoon shell weight (54.43). Similarly in autumn season among all the treatments, SH6 × NB_4D_2 excelled for major cocoon parameters in E. I. values compared to other races as that can be seen in Table 4.

Discussion

China being a tropical country has succeeded in evolving silkworm breeds suitable for spring, summer and autumn rearings (Sohn *et al.*, 1987; He *et al.*, 1990; Shao *et al.*, 1990; Zhang *et al.*, 1994).

Commercial exploitation of hybrid vigour in silkworm commenced in Japan as early as 1902 (Hirobe, 1961). Subsequently, many Japanese workers have shown the importance of hybrid rearing (Harada, 1949; Harada, 1961). Also in Japan, silkworm breeds suitable for spring, summer and autumn seasons were evolved and are commercially exploited (Kamijyo *et al.*, 1985; Shirota, 1992; Eguchi *et al.*, 1995).

Hybridisation studies have also been carried out in India (Sengupta *et al.*, 1974; Datta, 1984; Ashoka and Govindan, 1990; Rajeshekharagowda *et al.*, 1993). Different seasons express different changes in the physical and biotic factors governing the expression of commercial characters in silkworm (Kobayashi *et al.*, 1986). Present study also showed similar results. The performance of the hybrids showed variations in respect of survival rate, yield / 10,000 larvae and other quantitative characters during monsoon and spring season at Gonda and Lucknow sites (Table 1). Different hybrids exhibited different values for different quantitative traits in two different seasons. In monsoon season, under the control treatment, SH6 × NB_4D_2 showed hatching % of 97 followed by 96 in CSR18 × CSR19 and 95.6 in SH6 × KA. Also pupation rate of SH6 × NB_4D_2 was highest (97.0%). Larval duration was recorded maximum for SH6 × KA of 576 hrs followed by SH6 × NB_4D_2 of 570 hrs and CSR18 × CSR19 of 516 hrs. SH6 × NB_4D_2 recorded cocoon weight / 10,000 larvae of 15.5 kg followed by 15.3 kg and 14.7 kg in CSR18 × CSR19 and SH6 × KA, respectively. SH6 × NB_4D_2 recorded highest shell ratio of 23.9% compared to other races. Similarly under Gonda level treatment, in monsoon season, variability among the races for a particular trait was noticed. As regards hatching %, SH6 × NB_4D_2, CSR18 × CSR19 and SH6 × KA recorded 97, 86 and 93.0, respectively. SH6 × KA recorded highest larval duration of 611 hrs followed by 576 hrs of SH6 × NB_4D_2 and 537 hrs of CSR18 × CSR19. SH6 × NB_4D_2 recorded highest pupation % of 86.7 and as regards shell ratio, SH6 × NB_4D_2 recorded 23.5% followed by 21.9% of CSR18 × CSR19 and 21.1 of SH6 × KA. Under Lucknow level treatment again in monsoon season, highest hatching and pupation % of 95.5% and 84.2% was recorded by SH6 × NB_4D_2 followed by lowest values of 84.5 and 65.5% respectively in CSR18 × CSR19. Once again in this treatment shell ratio of SH6 × NB_4D_2 came out to be 22.6% which was the highest compared to CSR18 × CSR19 (21.9) and SH6 × KA (21.8). Similarly, in spring season different hybrids showed different values pertaining to different traits. In the control treatment, SH6 × NB_4D_2, CSR2 × CSR4 and P5 × NB18 recorded hatching % of 98, 96, 97; larval duration of 541, 476, 566 hours; pupation rate of 96.6, 95.4, 80.7; yield per 10,000 larvae (by weight) of 16.4, 15.1, 12.9 kg; shell ratio of 23.6, 22.2 and 22.8, respectively. Similarly in Gonda level treatment, highest hatching % was obtained by SH6 × NB_4D_2 and maximum larval duration of 670 hrs was recorded by P5 × NB18 but highest cocoon shell ratio was obtained by SH6 × NB_4D_2 with 23.1% followed by 21.4% of CSR2 × CSR4 and 21.8% of P5 × NB18. In Lucknow level treatment also, highest values were obtained by SH6 × NB_4D_2 with reference to hatching % (98), pupation rate (88%), yield / 10,000 larvae (by no.) of 8,350, yield / 10,000 larvae (by wt.) of 13.4, cocoon weight of 1.61 g, shell weight of 36.4 cg and shell ratio of 22.6% (Table 1 and 3).

Although there are about 21 characters contributing to silk yield (Thiagarajan *et al.*, 1993), the present study covered a combination of 9 important economic characters contributing to silk yield. Therefore, evaluation index method was employed giving due importance to all the economic traits contributing to silk yield in selection of hybrids as per the method given by Mano *et al.* (1993) and Singh and Subba Rao (1993). The results of the present study showed that in both the seasons, SH6 × NB_4D_2 showed the evaluation index values greater than 50 among the major characters studied (Table 2 and 4).

The stability of a variety or a breed is greatly influenced by the genotype environment interactions. The choice of a breed / hybrid, therefore depends not only on the genotype itself but also on its performance under diverse environmental condition (Rahman and Ahmed, 1988). The present study also shows the performance of races in two different seasons with reference to three different treatments *i.e.,* control (provided with standard environmental conditions), Gonda (provided with natural climatic conditions of Gonda) and Lucknow (provided with natural climatic conditions of Lucknow). In our study also, breed has been selected on the basis of influence of different treatments on cocoon parameters and not on genotype interactions. Silkworm, *B. mori* L. is very sensitive to climatic fluctuations and as a consequence silk content in the cocoon is greatly affected. It was found that the climatic conditions especially temperature, humidity and leaf quality during the rearing seasons was highly variable.

The primary goal of silkworm breeding includes simultaneous genetic improvement in the economic value of the population and to exploit it commercially. To assess the productivity of silkworm hybrids and to judge their suitability to different seasons, hybrids evolved are subjected to different seasons to evaluate them. The concept of genotype and environment interaction has been well documented in both plants and animal species (Griffing and Zsiros, 1971). In our study also, different bivoltine hybrids selected from different regions of India have been reared in two different seasons to evaluate the performance of different races in different seasons of Uttar Pradesh climatic conditions.

The bivoltine hybrids used in this experiment exhibit high degree of phenotypic variability and responded well to the monsoon and spring season of Lucknow and Gonda sites. The data analysed regarding the several rearing parameters showed maximum expression for majority of the quantitative traits during the monsoon and spring sea-

son. This is in conformity with the earlier findings of Krishnaswami and Narasimhanna (1974), Das *et al.* (1995) and Kalpana and Reddy (1998). The results of the present study indicate clearly that the hybrid SH6 × NB_4D_2 has excelled for important economic traits like pupation %, yield / 10,000 larvae by weight, cocoon weight, shell weight and shell ratios.

The longer larval duration observed in SH6 × NB_4D_2 (monsoon season) compared to spring season may be due to slow growth with reduced rate of metabolism in monsoon season and also due to other environmental conditions (Morohoshi, 1969). Thus the above results clearly indicate the superiority of SH6 × NB_4D_2 over other hybrids in both seasons. Hence, the most promising hybrid adjudged to rear is SH6 × NB_4D_2 in monsoon and spring season of Uttar Pradesh inspite of the diverse climatic conditions.

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