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Evaluation of genetic potential of selected genotypes of silkworm, *Bombyx mori* L. under temperate climatic conditions

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ABSTRACT

Levels of genetic diversity in the silkworm populations affect with the yield of economic traits and its stability.Silkworm breeders across the country contributed significantly to the development of many bivoltine breeds not only with improved economic merit but also suitable for variable climatic conditions so as to make sericulture a sustainable avocation. The study was carried out to evaluate genetic potential of the ten silkwormgenotypes (CSR2, CSR4, SH6, NB4D2, PAM101, PAM111, PAM114, PAM115, PAM117 and CS6) for various traits during spring season (May-June) from2014 to 2018 at Central Sericultural Research and Training Institute, Central Silk Board, Pampore, Kashmir. On the basis of the evaluation index values ranking PAM117 (58.20), SH6 (53.46), PAM114 (52.03), PAM115 (51.88) and CSR2 (51.85) were identified as good performing genotypes for various economically important traits and are recommended for hybridization and other breeding programmes under temperate climatic conditions.

Keywords: EI, genetic potential, silkworm and temperate climate

For many years, the rearing of silkworms as the most economically important insects throughout the world is being practised for silk production. It was one of the most important industries in more than thirty countries, especially in China, Japan, Korea, Thailand, India, France, Italy, Russia, Rumania and Bulgaria (Hirobe,1968 and Hong *et al*., 1992). Silkworm breeding approaches were re-oriented aimed at sustainability and increased qualitative silk production. In this direction, unstinted and coordinated efforts have been made by various silkworm breeders in the country (Datta, 1984, Basavaraja *et al*., 1995 and Ramesh Babu *et al*., 2002)which resulted in the development of many bivoltine silkworm breeds and hybrids over the last few decades. Taking cue of exploiting the heterosis, various silkworm-breeding efforts have significantly transformed the sericulture scenario by increased qualitative and quantitative production. In fact, silkworm is the only animal where hybrids are used compulsorily on the commercialscale. Systematic breeding approaches adapted by various silkworm breeders in different sericulturally advanced countries (Hirobe, 1968; Krisnaswamy and Tikoo, 1971;Heyi, 1991, Mano *et al*., 1991, Hong *et al*., 1992; Thiagarajan *et al*., 1993 and Datta *et al*., 2001) have contributed to synthesize silkworm (*Bombyx mori* L) genotypes of desirable constitution and improvement of several quantitative and qualitative traits of economic value. The silk yield is contributed by more than 21 traits (Thiagarajan *et al*., 1993) of which major traits are to be considered for its yield improvement. . The most useful evaluation index method proposed by Mano *et al*. (1993) was utilized in the present study for evaluating the potential of ten genotypes of the silkworm.

MATERIALS AND METHODS

Ten silkworm genotypes (CSR2, CSR4, SH6, NB4D2, PAM101, PAM111, PAM114, PAM115, PAM117 and CS6) were selected from the Germplasm Bank maintained at Central Sericultural Research and Training Institute, Central Silk Board, Pampore, Kashmir based on their phenotypic differences and data of various economically important parameters like cocoon yield 10000^{-1} larvae, single cocoon weight and single shell weight. The rearings have been conducted at Pampore representing the temperate climatic conditions of Kashmir. The characteristics of the selected genotypes are presented in the table 1 and fig. 1.

Table 1 : Characteristic feature of the 10 bivoltine genotypes studied

Sl. No.	Genotypes	Larval Marking	Cocoon Colour	Cocoon Shape	Sl. No.	Genotypes	Larval Marking	Cocoon Colour	Cocoon Shape
1	**CSR2**	Plain	White	Oval	6	**PAM 111**	Plain	White	Constricted
2	**CSR4**	Plain	White	Constricted	7	**PAM 114**	Plain	White	Oval
3	**SH6**	Marked	White	Oval	8	**PAM 115**	Plain	White	Constricted
4	**NB4D2**	Plain	White	Constricted	9	**PAM 117**	Plain	White	Constricted
5	**PAM 101**	Plain	Greenish White	Constricted	10	**CS 6**	Plain	White	Oval

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The selected genotypes were reared during the spring season (May-June) every year from 2014 to 2018. The standard rearing techniques (Krishnaswamy, 1978) were followed. The important quantitative and qualitative traits *viz*., fecundity, hatching percentage, yield $10{,}000^{-1}$ larvae by weight, single cocoon weight, single shell weight, shell ratio, pupation rate and filament length were recorded during spring season every year from 2014 to 2018.The rearing was conducted in 3 × 2ft plastic trays and three trays were maintained in each genotype. All the genotypes were reared following completely randomized design with three replications each and 250 larvae were maintained in each replication after 3rd moult. At the end of 5th instar, the spinning larvae were collected manually and mounted in plastic collapsible mountages. The evaluation index value was calculated for all the eight traits studied. The evaluation index (EI) was ca1cuated as per the below-mentioned procedure outlined by Mano *et al.* (1993).

$$\text{Evaluation Index} = \frac{A - B}{C} \times 10 + 50$$

Where A = Value obtained for a trait in a breed
B = Mean value of a trait of all the breed
C = Standard deviation of a trait of all the breeds
10 = Standard unit
50 = Fixed value

The index value obtained for all the traits was combined and the average EI values were obtained. The EI value fixed for the selection of a line is 50 or >50. The genotype, which scored above the limit, is considered to possess greater economic value.

RESULTS AND DISCUSSION

Silkworm breed is the most influential factor in the development of sericulture. In the long history of sericulture, many silkworm races have been recognizedas valuable for commercial use and the same has been preserved. Accordingly, the ten silkworm genotypes selected for the present study were studied during the spring season (May-June) every year from 2014 to 2018. The important quantitative and qualitative traits *viz*., fecundity, hatching percentage, yield $10{,}000^{-1}$ larvae by weight, single cocoon weight, single shell weight, shell ratio, pupation rate and filament length were recorded. The data of five years is presented in the table 2.

The data of five spring seasons (2014 to 2018) was pooled and the average pooled data is presented in the table 3. Perusal of the data reveals that fecundity ranged from 485 (PAM101) to 545 (SH6). Hatching was recorded above 96% in the 10 lines studied and ranged from 96.50% (PAM 117) to 97.46% (SH6). Cocoon yield 10000^{-1} larvae ranged from 15.01 Kg (CSR2) to 15.91 (PAM117). Pupation rate was highest in (94.40%) and lowest 92.00% (CSR4). Single cocoon weight was recorded in the range of 1.602g (NB4D2) to 1.691g

Table 2: Comparative rearing performances of the silkworm genotypes during the years 2014 to 2018

Genotypes	Season and year	Fecundity	Hatching (%)	Yield $10{,}000^{-1}$ larvae by weight (kg)	Pupation rate (%)	Single cocoon weight (g)	Single shell weight (g)	Shell ratio (%)	Filament length (m)
CSR2	Spring 2014	574	96.17	15.00	94.00	1.612	0.358	22.21	935
	Spring 2015	536	96.33	14.30	91.00	1.732	0.381	21.98	933
	Spring 2016	505	98.24	15.26	92.00	1.604	0.319	19.89	862
	Spring 2017	502	98.01	15.48	91.00	1.618	0.349	21.57	889
	Spring 2018	475	94.25	15.20	94.00	1.713	0.378	22.08	950
	Average	**518**	**96.60**	**15.05**	**92.40**	**1.656**	**0.357**	**21.56**	**914**
CSR4	Spring 2014	537	95.39	14.96	93.00	1.603	0.331	20.64	890
	Spring 2015	550	96.14	14.55	93.00	1.647	0.342	20.78	901
	Spring 2016	499	97.44	14.78	91.00	1.595	0.356	22.32	845
	Spring 2017	513	98.13	15.63	91.00	1.603	0.353	22.02	854
	Spring 2018	469	95.12	15.12	92.00	1.630	0.350	21.47	925
	Average	**514**	**96.44**	**15.01**	**92.00**	**1.616**	**0.346**	**21.41**	**883**
SH6	Spring 2014	547	96.89	16.01	95.00	1.639	0.334	20.41	750
	Spring 2015	583	97.30	15.85	91.00	1.724	0.337	19.53	755
	Spring 2016	496	97.76	14.80	91.00	1.612	0.340	21.09	773
	Spring 2017	517	97.10	15.14	93.00	1.613	0.311	19.28	750
	Spring 2018	580	98.27	16.10	98.00	1.832	0.338	18.45	811
	Average	**545**	**97.46**	**15.58**	**93.60**	**1.684**	**0.332**	**19.71**	**768**

Contd.

Contd. table 2

Genotypes	Season and year	Fecundity	Hatching (%)	Yield $10,000^{-1}$ larvae by weight (kg)	Pupation rate (%)	Single cocoon weight (g)	Single shell weight (g)	Shell ratio (%)	Filament length (m)
NB4D2	Spring 2014	547	95.69	15.12	95.00	1.567	0.291	18.56	782
	Spring 2015	578	93.24	15.16	92.00	1.569	0.286	18.21	777
	Spring 2016	511	98.14	14.56	94.00	1.569	0.327	20.84	802
	Spring 2017	514	97.89	15.03	93.00	1.565	0.315	20.13	790
	Spring 2018	550	97.00	15.42	96.00	1.740	0.336	19.31	825
	Average	**540**	**96.39**	**15.06**	**94.00**	**1.602**	**0.311**	**19.41**	**795**
PAM 101	Spring 2014	446	96.84	15.48	91.00	1.622	0.314	19.36	790
	Spring 2015	495	96.47	14.95	91.00	1.598	0.319	19.97	800
	Spring 2016	490	98.06	15.00	93.00	1.619	0.315	19.46	825
	Spring 2017	517	97.52	15.46	92.00	1.603	0.320	19.96	808
	Spring 2018	475	96.89	16.02	94.00	1.820	0.358	19.67	845
	Average	**485**	**97.16**	**15.38**	**92.20**	**1.652**	**0.325**	**19.67**	**814**
PAM 111	Spring 2014	597	96.89	15.04	96.00	1.575	0.304	19.16	810
	Spring 2015	491	95.52	15.42	94.00	1.617	0.369	22.83	845
	Spring 2016	506	97.62	15.04	95.00	1.610	0.309	19.19	830
	Spring 2017	500	96.82	15.04	91.00	1.618	0.315	19.47	818
	Spring 2018	522	97.12	15.75	96.00	1.786	0.342	19.15	832
	Average	**523**	**96.79**	**15.26**	**94.40**	**1.641**	**0.328**	**19.99**	**827**
PAM 114	Spring 2014	570	96.28	15.81	93.00	1.615	0.319	19.77	825
	Spring 2015	535	95.35	16.63	94.00	1.709	0.351	20.54	851
	Spring 2016	500	97.35	15.31	93.00	1.647	0.330	20.03	840
	Spring 2017	499	97.55	15.05	91.00	1.627	0.335	20.59	828
	Spring 2018	543	96.53	15.95	94.00	1.742	0.358	20.57	910
	Average	**529**	**96.61**	**15.75**	**93.00**	**1.668**	**0.339**	**20.32**	**851**
PAM 115	Spring 2014	550	96.95	15.64	97.00	1.596	0.312	19.76	828
	Spring 2015	499	94.82	16.47	95.00	1.724	0.369	21.43	880
	Spring 2016	512	97.71	15.28	93.00	1.622	0.327	20.16	815
	Spring 2017	511	97.43	15.05	91.00	1.623	0.330	20.33	833
	Spring 2018	490	96.28	15.68	94.00	1.734	0.362	20.88	925
	Average	**512**	**96.64**	**15.62**	**94.00**	**1.66**	**0.34**	**20.48**	**856**
PAM 117	Spring 2014	505	96.20	15.43	97.00	1.625	0.347	21.37	907
	Spring 2015	502	93.95	17.66	94.00	1.830	0.407	22.22	895
	Spring 2016	509	97.26	14.86	92.00	1.617	0.353	21.83	872
	Spring 2017	501	97.25	15.79	92.00	1.625	0.339	20.86	844
	Spring 2018	552	97.83	15.80	96.00	1.760	0.370	21.02	930
	Average	**514**	**96.50**	**15.91**	**94.20**	**1.69**	**0.36**	**21.47**	**890**
CS 6	Spring 2014	532	95.67	14.99	96.00	1.587	0.320	20.17	885
	Spring 2015	510	95.00	16.38	95.00	1.689	0.354	20.98	833
	Spring 2016	511	97.65	14.64	92.00	1.603	0.320	19.96	820
	Spring 2017	501	97.70	15.18	92.00	1.603	0.328	20.46	832
	Spring 2018	510	96.52	15.50	94.00	1.720	0.346	20.12	890
	Average	**513**	**96.51**	**15.34**	**93.80**	**1.640**	**0.33**	**20.37**	**852**

(PAM117) while as the highest shell of 0.363g was recorded in PAM117 and lowest in NB4D2 (0.311g). The highest shell was recoded in CSR2 (21.56%) and lowest of 19.41% in NB4D2. CSR2 recorded highest filament length (914m) while as SH6 recorded lowest (768m).

The evaluation index values of pooled data of all the traits are presented in the table 4. Based on the mean EI value, PAM117 (58.20), SH6 (53.46), PAM114 (52.03), PAM115 (51.88) and CSR2 (51.85) were identified as good performing genotypes for various economically important traits and are recommended for hybridization and other breeding programmes under temperate climatic conditions. Similar studies based on evaluation index values had also been conducted by Begum, 2000; Quadir *et al.*, 2000; Babu *et al.*, 2002; Kumar *et al.*, 2001 , 2002, 2003a, 2003b and 2006; Choudhary and Singh, 2006 ; Ganaie *et al.*, 2012; Nisar *et al.*, 2005, 2008a , 2008b and 2013 and Nooruldin *et al*., 2014.

PAM117 and CSR2 genotypes have emerged as best breeds in terms of silk content while as SH6 has emerged as the best breed in terms of survival, fecundity and hatchability. PAM 114 and PAM 115 have been identified as breeds having moderate silk content combined with good survival. The identified parental breeds can be utilized for further breeding programmes.

Table 3: Average rearing performances of 10 silkworm genotypes

Genotypes	Fecundity (No.)	Hatching (%)	Yield 10000^{-1} larvae by weight (kg)	Pupation rate (%)	Single cocoon weight (g)	Single shell weight (g)	Shell ratio (%)	Filament length (m)
CSR2	518	96.60	15.05	92.40	1.656	0.357	21.56	914
CSR4	514	96.44	15.01	92.00	1.616	0.346	21.41	883
SH6	545	97.46	15.58	93.60	1.684	0.332	19.71	768
NB4D2	540	96.39	15.06	94.00	1.602	0.311	19.41	795
PAM 101	485	97.16	15.38	92.20	1.652	0.325	19.67	814
PAM 111	523	96.79	15.26	94.40	1.641	0.328	19.99	827
PAM 114	529	96.61	15.75	93.00	1.668	0.339	20.32	851
PAM 115	512	96.64	15.62	94.00	1.660	0.340	20.48	856
PAM 117	514	96.50	15.91	94.20	1.691	0.363	21.47	890
CS 6	513	96.51	15.34	93.80	1.640	0.334	20.37	852
Mean	**519**	**96.71**	**15.40**	**93.36**	**1.65**	**0.334**	**20.44**	**845**
SD	**16.75**	**0.34**	**0.31**	**0.89**	**0.03**	**0.02**	**0.79**	**44.91**

Table 4: Evaluation index values of selected traits

Genotypes	Fecundity (No.)	Hatching (%)	Yield 10000^{-1} larvae by weight (kg)	Pupation rate (%)	Single cocoon weight (g)	Single shell weight (g)	Shell ratio (%)	Filament length (m)	Average evaluation index	Rank
CSR2	49.40	46.76	38.71	39.21	51.67	59.50	64.18	65.36	51.85	V
CSR4	47.01	42.06	37.42	34.72	38.33	54.00	62.28	58.46	46.79	VIII
SH6	65.52	72.06	55.81	52.70	61.00	47.00	40.76	32.85	53.46	II
NB4D2	62.54	40.59	39.03	57.19	33.67	36.50	36.96	38.87	43.17	X
PAM 101	29.70	63.24	49.35	36.97	50.33	43.50	40.25	43.10	44.56	IX
PAM 111	52.39	52.35	45.48	61.69	46.67	45.00	44.30	45.99	49.23	VI
PAM 114	55.97	47.06	61.29	45.96	55.67	50.50	48.48	51.34	52.03	III
PAM 115	45.82	47.94	57.10	57.19	53.00	51.00	50.51	52.45	51.88	IV
PAM 117	47.01	43.82	66.45	59.44	63.33	62.50	63.04	60.02	58.20	I
CS 6	46.42	44.12	48.06	54.94	46.33	48.00	49.11	51.56	48.57	VII

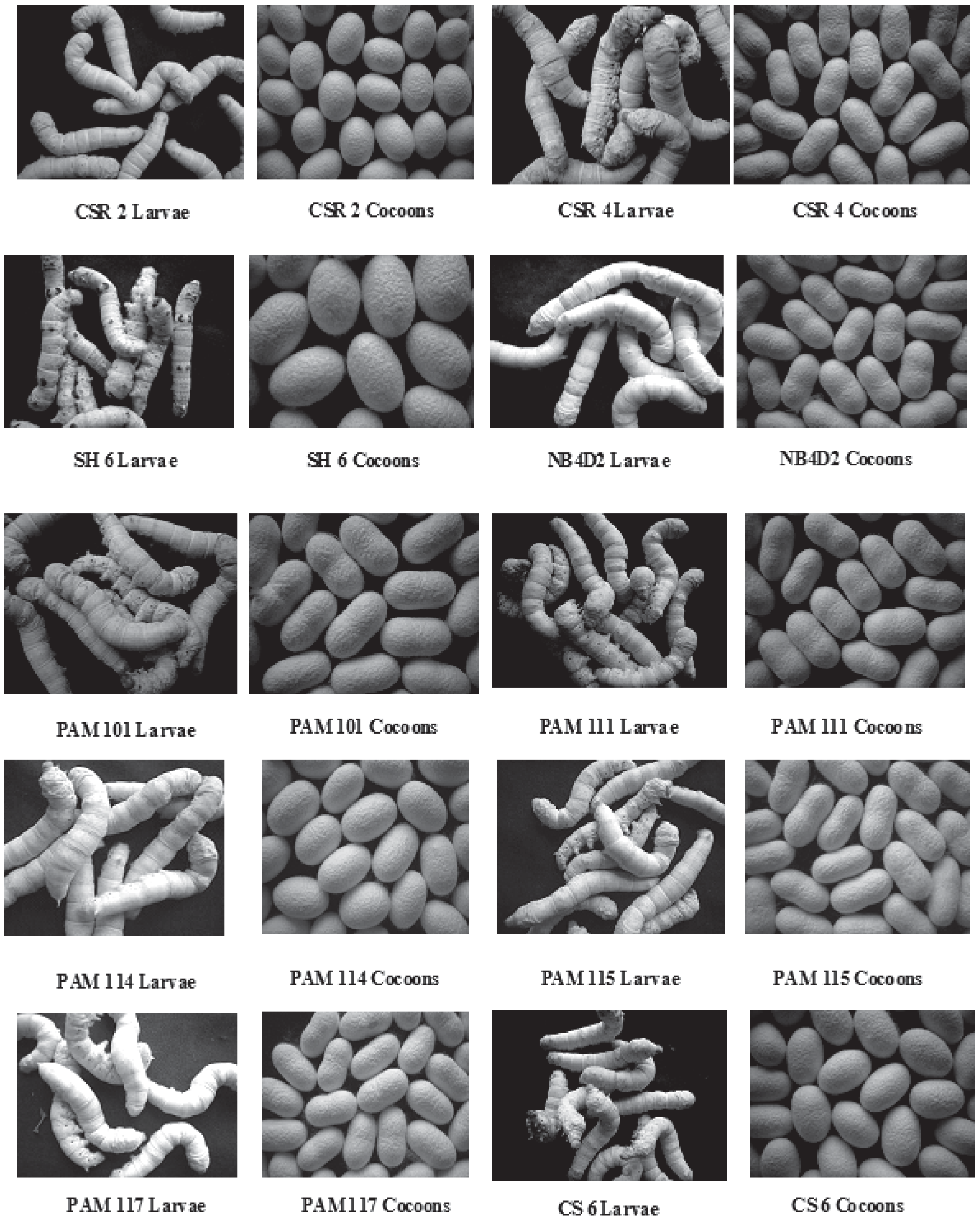

Fig. 1: Larval and cocoon photographs of the 10 silkworm genotypes studied

REFERENCES

Basavaraja, H.K., Nirmal Kumar, S., Suresh Kumar, N., Mal Reddy, N., Kshama Giridhar, Ahshan, M.M. and Datta, R.K. 1995. New productive bivoltine hybrids. *Indian Silk*., **34:** 5-9.

Datta, R.K., Basavaraja, H.K., Mal Reddy, N., Nirmal Kumar, S., Suresh Kumar, N. Ramesh Babu, M. Ahsan, M.M. and Jayaswal, K.P.2001. Breeding of new productive bivoltine hybrid, CSR12 x CSR6 of silkworm, *Bombyx mori* L. *Int. J. Indust. Entomol*., **3:** 127-33.

Datta, R.K. 1984. Improvement of silkworm race (*Bombyx mori* L.) in India. *Sericologia*., **24:** 393 15.

Ganie, N. A., Kamili, A.S., Baqual, M. F., Sharma, R.K., Dar, K.A. and Khan, I.L. 2012. Indian sericulture industry with particular reference to Jammu & Kashmir. *Intl. J.Appld. Biol. Res*.,**2:** 194-202.

He,yi.,Sima, Yang-lu., Jiang Da-xin.and Dai, ping. 1991. Breeding of the silkworm varieties for summer and autumn rearing, “Xuhua”, “Qiuxing” and their hybrids. *Acta Sericologia Sinica*, **17:**200-207.

Hirobe,T. 1968. Evolution, differentiation and breeding of the silkworm. The Silk Road past and present-genetics in Asian countries. In: *XII Intl. Congr. Genet.,* pp. 25-36.

Hong, K.W., Hwang, S.J., Ryu, K.S., Choi, S.R., Kim, K.Y. and Lee, S.P. 1992. Breeding of Bunongjam, a high silk yielding silkworm variety for spring rearing season. *Research Reports of the Rural Development Administration, Farm Management, Agricultural Engineering, Sericulture and Farm Products Utilization*, **34:** 30-35.

Krishnaswami, S. 1978. New technology of silkworm rearing, *Bulletin No. 2*, CSR&TI, Mysore, India, pp. 1-24.

Krishnaswami, S. and Tikoo, B. L. 1971. A Comparative study of performance of pure races currently under rearing in Mysore State. *Indian J. Seric*., **10**: 66-71.

Mano, Y., Nirmalkumar, S., Basavaraja, H.K., Mal Reddy, N. and Datta, R.K. 1993. A new method to select promising silkworm breed/hybrid combinations. *Indian Silk.,* **31:** 53.

Mano,Y.,Ohyanagi,M. , Nagayasu, K. and Murakami, A. 1991. Breeding of sex-limited larval marking silkworm [*Bombyx mori*] race, N147 x C145. *Bull.Natio.Inst.Seril.Entomol. Scie.,* **2**:1-29.

Naseema Begum, A., Basavaraja, H.K., Rao, P.S., Rekha, M. and Ahsan, M.M. 2000. Identification of bivoltine silkworm hybrids suitable for tropical climate. *Indian. J. Seric*., **39:** 24-29.

Choudhary, N. and Singh, R. 2006. Evaluation of few polyvoltine x bivoltine hybrids of the silkworm *Bombyx mori* L. *Indian. J. Seric*., **45**: 62-65.

Nisar, M., Chisti, M.Z. and Khan, M.A. 2013. Studies on the identification of summer specific silkworm *Bombyx mori* L. hybrids under temperate climatic conditions of Jammu and Kashmir, India. *J. Intl. Acad. Res.Multidisci*., **1**: 1-14.

Nisar, M., Khan, M.A. and Quadir, S.M. 2005. Evaluation for identification of spring specific silkworm *Bombyx mori* L. hybrids for commercial exploitation under Kashmir climatic conditions. *In: 20th Congress of the Intl. Seric. Commiss., Bangalore, India, 15-18 December*, 2005, Vol I, pp.351-56.

Nisar, M., Khan, M.A. and Quadir, S.M. 2008b. Studies on identification of new silkworm *Bombyx mori* L. hybrids and their introduction in field for commercial exploitation. *Science for Better Tomorrow, University of Kashmir,* pp. 373-76.

Nisar, M., Khan, M.A., Quadir, S.M. and Siddiqui, A. A. 2008a. Breeding of Spring Specific Bivoltine Silkworm hybrid SBGP5 X SBGP22. *Mulberry Sericulture- Problems and Prospects*, APH Publishing Corporation, New Delhi, pp. 95-104.

Nooruldin, S., Bhat, S. A., Malik, M. A., Khan, I. L. and Sahaf, K. A. 2014. Comparative performance of silkworm, *Bombyx mori* L. hybrids during different seasons under Kashmir climatic conditions. *Green Farm*., **6:** 1392-95.

Quadir, S. M., Nisar, M., Khan, M. A. and Ahsan, M. M. 2000. Identification of season specific silkworm hybrids for temperate climatic conditions of Kashmir. *In: National Conference on Strategies for Sericulture Research and Development,* CSR &TI, Srirampura, Mysore, India,16-18, November 2000, pp.21.

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:** 37-43.

Suresh Kumar, N., Basavaraja, H.K., Joge, P.G,, Mal Reddy, N., Kalpana, G.V. and Dandin, S.B. 2006. Development of new robust bivoltine hybrid (CSR46 x CSR47) of *Bombyx mori* L. for the tropics. *Indian J. Seric*., **45**: 21-29.

Suresh Kumar, N., Basavaraja, H.K., Kalpana, G.V., Mal Reddy, N. and Dandin, S.B. 2003a. Effect of high temperature and high humidity on the cocoon shape and size of parents, foundation crosses, single and double hybrids of bivoltine silkworm, *Bombyx mori* L. *Indian J. Seric*., **42:** 35-40.

Suresh Kumar, N., Basavaraja, H.K., Kishor Kumar, C.M., Mal Reddy, N. and Datta, R.K. 2002. On the breeding of CSR18 x CSR19- A robust bivoltine hybrid silkworm, *Bombyx mori* L. for the tropics. *Int. J. Indust. Entomol*.,**5:** 155-162.

Suresh Kumar, N., Yamamoto, T., Basavaraja, H.K. and Datta, R.K. 2001. Studies on the effect of high temperature on F1 hybrids between polyvoltine and bivoltine silkworm races of *Bombyx mori* L. *Int. J. Indust. Entomol.*,**2:** 123-27.

Suresh Kumar, N., Basavaraja, H.K., Mal Reddy, N.and Dandin, S.B. 2003b. Effect of high temperature and high humidity on quantitative traits of parents, foundation crosses, single and double hybrids of bivoltine silkworm, *Bombyx mori* L. *Int. J. Indust. Entomol.*,**6:** 197-202.

Thiagarajan, V., Bhargava, S. K., Ramesh Babu, M. and Nagaraj, B. 1993.Difference in seasonal performance of 26 strains of silkworm *Bombyx mori*. (*Bombycidae*). *J. Lep. Soc*., **47:** 321-37.

Yamamoto, T., Mase, K., Nagasaka, K., Okada, E., Miyajima, T., Itsubo, T. and Enokijima, M. 2000. Breeding of the polyphagous silkworm race with thin cocoon filament "Honobono". *J. Seric. Sci. Japan.*,**69:**31-37.