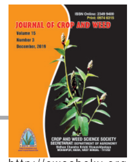
Journal of Crop and Weed, 18(1): 129-135 (2022)

ISSN- O : 2349 9400 ; P : 0974 6315



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Identification of mulberry silkworm (*Bombyx mori* L.) foundation crosses ideal for temperate climatic conditions of North West India

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Received : 28.09.2021 ; Revised : 18.02.2022 ; Accepted : 28.02.2022

DOI: https://doi.org/10.22271/09746315.2022.v18.i1.1543

ABSTRACT

The silkworm rearing was conducted at Central Sericultural Research and Training Institute (CSR&TI), Central Silk Board, Pampore, Jammu & Kashmir (J&K) during spring (May-June) and summer (July-August), 2019 to evaluate twenty four bivoltine silkworm foundation crosses (FC) along with two controls.The silkworm rearing was conducted by adopting a standard method coupled with uniformed laboratory conditions. Evaluation index (E.I) values indicates that three constricted FC viz., SK-6 × SK-7, Pam-117 × APS-4, Pam-117 × SK-7 along with five oval foundation crosses viz., CSR-27 × CSR-50, CSR-27 × Pam-114, CSR-50 × Pam-114, Pam-114 × CSR-27 and Pam-114 × CSR-50 performed well in both spring and summer seasons. In the case of constricted FC, SK-6 × Pam-117 & SK-7 × Pam-117 emerged as spring specific and SK6 × APS-4 and SK-7 × SK-6 as summer specific foundation crosses. Among oval FC, APS-5 × Pam-114 and APS-5 × CSR-27 emerged as spring and summer specific foundation crosses respectively.

Keywords: Evaluation index, foundation cross, mulberry silkworm, spring, summer

The climatic condition of North India is suited for bivoltine sericulture but the unit production and the quality of the silk produced are much lower than the sericulturally advanced countries like Japan and China. The cocoon productivity in North India is 34.17 kg/ ounce at the commercial level and the average renditta is 9.5 kg, while it is 6.5 kg at the national level (Anil *et al*., 2009). Apart from the season and mulberry leaf, silkworm diseases also lead to low cocoon productivity. Efforts of silkworm breeders by different premier research institutes lead to development of bivoltine breeds and hybrids with high productivity (Trag *et al*., 1992; Basavaraja *et al*., 1995; Farooq *et al*., 2006; Malik *et al*., 2009; Nisar *et al*., 2013; Sahaf *et al*., 2016; Bharath *et al*., 2018a, 2018b, 2019a and 2019b and Shivkumar *et al*., 2020). By utilizing those breeds we can address the problems such as sub-optimal conditions (high temperature and high humidity) coupled with problems encountered by environmental factors/high load of diseases prevailing in the temperate region resulting in a decline in cocoon yield. The scope of silkworm breeding increases towards the development of silkworm hybrids sustaining climate change (Bharath *et al*., 2018a).

Foundation crosses have several advantages like higher survival, an increase of egg recovery, and a fast multiplication rate in silkworm hybrid production. A similar type of parents are involved in the crossing of a foundation cross hence, the foundation cross is not considered as a true hybrid (Moorthy *et al*., 2011). Silkworm double hybrid involving two foundation crosses has added advantage compared to single hybrids. The hybrid vigour of a single hybrid depends upon two genetically distant parents but in double hybrid with four parental breeds ensures better hybrid vigour results in assured profitability to silkworm rearers. The qualitative and quantitative characteristics are enhanced in double hybrid as their genetic base is very broad compared to single hybrids. Further double hybrids are easy to rear with better growth parameters along with improved yield and quality post cocoon traits. Above all silkworm double hybrids can withstand harsh climatic conditions and ensures crop stability (Basavaraja *et al*., 2006).

Hence, the present study aims to identify mulberry silkworm foundation crosses suitable for temperate climatic conditions of northwest India.

MATERIALS AND METHODS

A total of 12 oval and 12 constricted silkworm foundation crosses along with two controls (FC1 {CSR6×CSR26} and FC2 {CSR2×CSR27}) were reared during spring and summer, 2019 at CSR&TI, Pampore. The silkworm rearing techniques were followed as per the standard procedure. Nine important economic parameters *viz*., fecundity (No.), hatching (%), yield 10000^{-1} larvae by number and by weight (kg), single cocoon weight (g), single shell weight (g), shell ratio (%), pupation rate (%) and Filament length (m) were recorded during the experiment. Three replications were maintained for twenty four foundation crosses and two controls following a completely randomized design. In each replication, 250 larvae were maintained during

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late age rearing. At the end of the 5th instar, the mounting of silkworms was carried out manually by handpicking and transferred to plastic collapsible mountages. The evaluation index (Mano *et al.*, 1993) values were calculated as per the below-mentioned procedure.

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

A = Value of a specific trait in a particular breed/ hybrid

B = Mean value of a specific trait of all the breeds/ hybrids

C = Standard deviation of a specific trait of all the breeds/ hybrids

50 = Fixed value

10 = Standard unit

The E.I value of all the traits were added and the average index value were recorded. The fixed index value for the selection of a breed/ hybrid was 50 or >50. Silkworm breed or hybrid with highest E.I value was recorded as best breed/ hybrid.

RESULTS AND DISCUSSION

The perusal of spring 2019 constricted foundation crosses data for the traits fecundity (No.), hatching (%), yield 10000^{-1} larvae by no. and by weight (kg), single cocoon weight (g), single shell weight (g), shell ratio (%), pupation rate (%) and Filament length (m) presented in Table 1 revealed that highest fecundity (539), hatching percentage (96.10) and yield 10000^{-1} larvae by number (9660) observed in PAM117×SK6, SK7×APS4, and SK6×SK7 respectively. Further, PAM117×SK7 recorded the highest yield 10000^{-1} larvae by weight (14.69), single cocoon weight (1.69), single shell weight (0.35), shell ratio (20.41), and filament length (967). Average multi-traits evaluation index of spring, 2019 constricted foundation crosses data was presented in Table 2 and same was depicted as a graph in Fig. 1 which revealed that PAM117×SK7 (60.67) showed the maximum and APS4×PAM117 (40.82) recorded lowest evaluation index over control FC1 (56.42). In the case of spring, 2019 oval foundation crosses data, presented in Table 3 revealed that the highest fecundity (549), hatching percentage (96.23), yield 10000^{-1}larvae by number (9800), yield 10000^{-1}larvae by weight (15.39), single cocoon weight (1.76), single shell weight (0.37), shell ratio (21.11) and filament length (963) observed in PAM114×CSR27, PAM114×CSR27, PAM114× CSR50, APS5×PAM114, APS5×PAM114, PAM114× CSR50, PAM114×CSR27 and CSR50×CSR27 respectively. Average multi-traits evaluation index of spring, 2019 oval foundation crosses data was presented in Table 4 and same was depicted as a graph in Fig. 2 which revealed that PAM114×CSR50 (59.88) showed the maximum and PAM114×APS5 (37.18) recorded lowest evaluation index over control FC2 (52.88).

The perusal of summer, 2019 constricted foundation crosses data presented in Table 5 revealed that highest fecundity (542), hatching percentage (95.47), yield 10000^{-1} larvae by number (9240), yield 10000^{-1}larvae by weight (13.03), single cocoon weight (1.59), single shell weight (0.32), pupation rate (90.00) and filament length (845) were observed in SK6×SK7, APS4×PAM117, SK6×SK7, PAM117×SK7, PAM117× SK7, PAM117× SK7, SK6×SK7, and SK7×SK6 respectively. Average multi-traits evaluation index of summer, 2019 constricted foundation crosses data was presented in Table 6 and same was depicted as a graph in Fig. 3 which revealed that PAM117×SK7 (61.86) showed the maximum and PAM117×SK6 (39.71) recorded lowest evaluation index over control FC1 (53.48). In the case of summer, 2019 oval foundation crosses data, presented in Table 7 revealed that the highest fecundity (552), yield 10000^{-1} larvae by weight (13.03), single cocoon weight (1.62), and filament length (861) observed in PAM114×CSR27, APS5×CSR27, APS5×CSR27 and PAM114×APS5 respectively. Further, CSR50×PAM114 recorded the highest hatching percentage (95.84), yield 10000^{-1} larvae by number (9160), shell ratio (20.60), and pupation rate (90.00). Average multi-traits evaluation index of summer, 2019 oval foundation crosses data was presented in Table 8 and same was depicted as a graph in Fig. 4 which revealed that PAM114×CSR50 (58.55) showed the maximum and CSR50×CSR27 (38.22) recorded lowest evaluation index over control FC2 (58.44). The results are in conformity with Bharath *et al.* (2019a). Moorthy *et al.* (2011) identified silkworm foundation cross D6 (P) N×SK4C suitable for tropics for a better silkworm seed crop. Evaluation index is a useful tool adopted by silkworm breeders in silkworm breeding for identification of the best silkworm breed/hybrid (Quadir *et al.*, 2000; Suresh *et al.*, 2006; Nisar *et al.*, 2013; Bharath *et al.*, 2017 and 2020).

Among 24 foundation crosses, five constricted foundation crosses *viz.*, SK-6×Pam-117, SK-6×SK-7, Pam-117×APS-4, Pam-117×SK-7 and SK-7×Pam-117performed well over control FC1 in the spring season along with six oval foundation crosses *viz.*, CSR-27×CSR-50, CSR-27×Pam-114, CSR-50×Pam-114, Pam-114×CSR-27, Pam-114×CSR-50 and APS-5×Pam-114 over the control FC2.

In the case of summer season, constricted foundation crosses *viz.*, SK6×APS-4, SK-6×SK-7, Pam-117×APS4, Pam-117×SK-7 and SK-7×SK-6 performed well over control FC1 along with oval foundation crosses CSR-27×CSR-50, CSR-27×Pam-114, CSR-50×Pam-114, Pam-114×CSR-27, Pam-114×CSR-50 and APS-5×CSR 27 performed at par with control FC2 in summer, 2019.

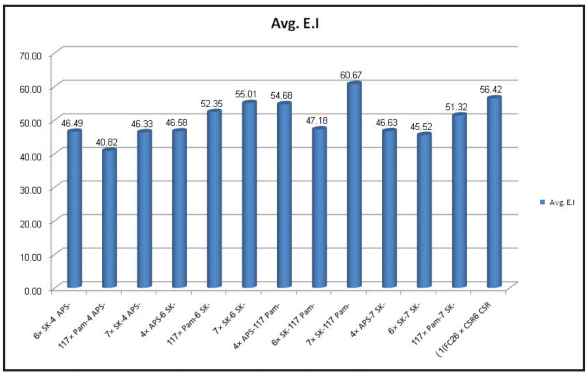

Fig. 1: Average multi-traits evaluation index values of constricted foundation crosses during spring, 2019

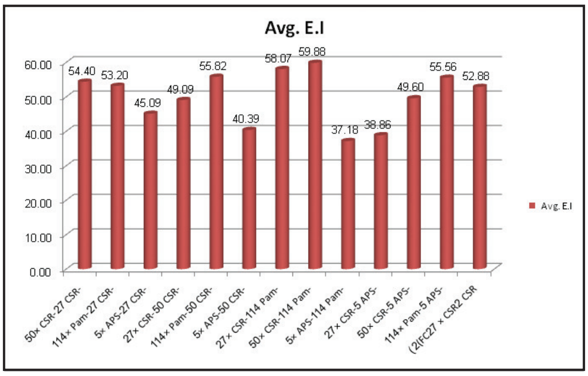

Fig. 2: Average multi-traits evaluation index values of oval foundation crosses during spring, 2019

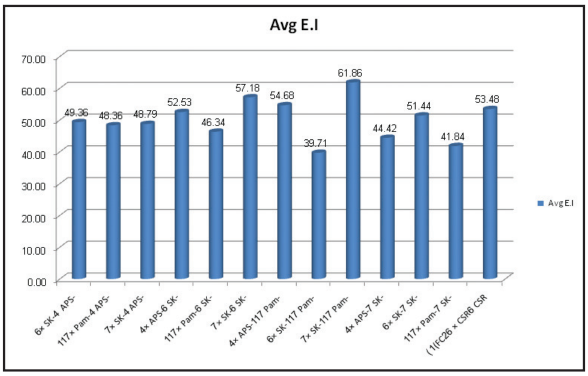

Fig. 3: Average multi-traits evaluation index values of constricted foundation crosses during summer, 2019

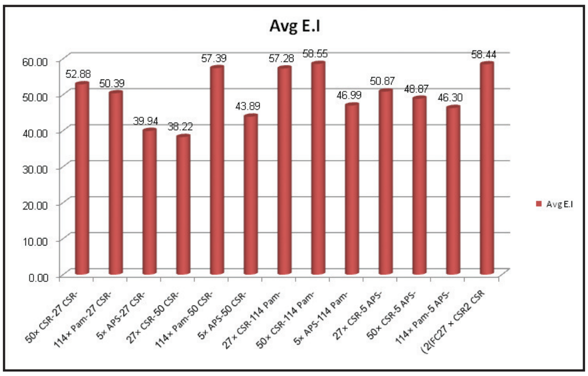

Fig. 4: Average multi-traits evaluation index values of oval foundation crosses during summer, 2019

Table 1: Rearing performance of the constricted foundation crosses during spring, 2019

Foundation crosses	Fecundity (No)	Hatching (%)	Yield 10000^{-1} larvae brushed		Single cocoon weight(g)	Single shell weight(g)	Shell Ratio (%)	Pupation rate (%)	Filament Length (m)
			By No.	By Wt.(kg)					
APS4 × SK6	515	95.65	9640	13.68	1.59	0.31	19.24	93.00	786
APS4 × Pam117	521	95.69	9600	12.75	1.50	0.29	19.06	92.00	854
APS-4 × SK7	506	95.41	9520	14.20	1.66	0.32	19.28	91.00	871
SK6 × APS4	512	95.95	9600	13.90	1.62	0.31	19.20	93.00	740
SK6 × Pam117	533	92.59	9640	14.55	1.68	0.34	20.00	94.00	690
SK6 × SK7	537	93.93	9660	14.15	1.63	0.33	20.25	94.00	863
Pam117 × APS4	522	94.32	9640	14.31	1.65	0.34	20.30	94.00	840
Pam117 × SK6	539	95.33	9520	13.58	1.60	0.31	19.44	91.00	903
Pam117 × SK7	534	94.66	9640	14.69	1.69	0.35	20.41	94.00	967
SK7 × APS4	528	96.10	9440	13.65	1.62	0.31	19.20	92.00	913
SK7 × SK6	527	95.07	9560	13.94	1.63	0.31	19.08	92.00	728
SK7 × Pam117	530	96.05	9640	13.73	1.59	0.31	19.18	94.00	915
CSR6 × CSR26 (FC1)	534	95.48	9640	14.26	1.65	0.33	20.06	94.00	876
Average	**526**	**95.09**	**9595**	**13.95**	**1.62**	**0.32**	**19.59**	**92.92**	**842**
Standard Deviation	**10**	**1.00**	**66**	**0.50**	**0.05**	**0.02**	**0.52**	**1.19**	**83**

Table 2: Evaluation index values of the constricted foundation crosses during spring, 2019

Foundation crosses	Fecundity (No)	Hatching (%)	Yield 10000^{-1} larvae brushed		Single cocoon weight(g)	Single shell weight(g)	Shell ratio (%)	Pupation rate (%)	Filament length (m)	Average E.I
			By No.	By Wt.(kg)						
APS4 × SK6	39.22	55.55	56.72	44.55	42.80	42.38	43.32	50.65	43.22	46.49
APS4 × Pam117	45.12	55.95	50.69	26.06	24.67	31.36	39.87	42.23	51.45	40.82
APS-4 × SK7	30.36	53.10	38.65	55.00	57.90	50.64	43.97	33.81	53.51	46.33
SK6 × APS4	36.26	58.54	50.69	49.03	48.84	45.13	42.40	50.65	37.66	46.58
SK6 × Pam117	56.53	25.00	56.72	61.85	60.92	61.65	57.85	59.07	31.61	52.35
SK6 × SK7	60.86	38.38	59.73	53.94	51.86	56.14	62.56	59.07	52.54	55.01
Pam117 × APS4	46.10	42.27	56.72	57.05	55.89	61.65	63.61	59.07	49.76	54.68
Pam117 × SK6	62.83	52.35	38.65	42.66	44.81	45.13	47.02	33.81	57.38	47.18
Pam117 × SK7	57.91	45.66	56.72	64.70	63.94	67.15	65.72	59.07	65.13	60.67
SK7 × APS4	52.01	60.04	26.60	43.88	48.84	45.13	42.40	42.23	58.59	46.63
SK7 × SK6	51.02	49.76	44.67	49.65	50.85	45.13	40.13	42.23	36.20	45.52
SK7 × Pam117	53.87	59.54	56.72	45.51	43.80	42.38	42.15	59.07	58.83	51.32
CSR6 × CSR26 (FC1)	57.91	53.85	56.72	56.13	54.88	56.14	59.00	59.07	54.11	56.42

Table 3: Rearing performance of the oval foundation crosses during spring, 2019

Foundation crosses	Fecundity (No)	Hatching (%)	Yield 10000^{-1} larvae brushed		Single cocoon weight(g)	Single shell weight(g)	Shell ratio (%)	Pupation rate (%)	Filament length (m)
			By No.	By Wt.(kg)					
CSR27 × CSR50	512	96.07	9720	14.97	1.71	0.36	20.82	94.00	921
CSR27 × Pam114	523	95.42	9680	15.19	1.74	0.36	20.46	93.00	922
CSR27 × APS5	504	95.23	9600	14.10	1.64	0.34	20.49	92.00	957
CSR50 × CSR27	511	95.97	9640	14.31	1.65	0.34	20.30	93.00	963
CSR50 × Pam114	548	95.28	9680	15.10	1.73	0.36	20.87	94.00	928
CSR50 × APS5	534	94.56	9520	13.87	1.63	0.32	19.38	91.00	952
Pam114 × CSR27	549	96.23	9760	15.04	1.71	0.36	21.11	95.00	862
Pam114 × CSR50	545	95.48	9800	15.35	1.73	0.37	21.10	95.00	960
Pam114 × APS5	515	95.43	9440	13.65	1.62	0.31	19.20	88.00	935
APS5 × CSR27	526	95.68	9480	14.09	1.66	0.32	19.34	89.00	783
APS5 × CSR50	523	95.52	9640	14.69	1.69	0.34	20.12	93.00	927
APS5 × Pam114	536	95.20	9680	15.39	1.76	0.36	20.51	94.00	934
CSR2 × CSR27 (FC2)	545	95.57	9640	14.84	1.71	0.36	20.82	93.00	877
Average	**529**	**95.51**	**9637**	**14.66**	**1.69**	**0.34**	**20.35**	**92.62**	**917**
Standard Deviation	**16**	**0.43**	**105**	**0.59**	**0.05**	**0.02**	**0.66**	**2.14**	**50**

Table 4: Evaluation index values of the oval foundation crosses during spring, 2019

Foundation crosses	Fecundity (No)	Hatching (%)	Yield 10000^{-1} larvae brushed		Single cocoon weight(g)	Single shell weight(g)	Shell ratio (%)	Pupation rate (%)	Filament length (m)	Average E.I
			By No.	By Wt.(kg)						
CSR27 × CSR50	39.07	62.90	57.90	55.29	53.93	56.08	57.14	56.46	50.80	54.40
CSR27 × Pam114	46.70	47.93	54.10	59.05	60.46	56.08	51.71	51.80	51.00	53.20
CSR27 × APS5	33.93	43.52	46.49	40.45	38.70	45.54	52.13	47.13	57.97	45.09
CSR50 × CSR27	39.00	60.69	50.29	44.00	41.96	45.54	49.32	51.80	59.16	49.09
CSR50 × Pam114	62.62	44.68	54.10	57.41	58.29	58.72	57.87	56.46	52.19	55.82
CSR50 × APS5	53.76	27.86	38.88	36.62	36.52	35.00	35.46	42.46	56.97	40.39
Pam114 × CSR27	63.32	66.73	61.70	56.44	53.93	58.72	61.57	61.13	39.04	58.07
Pam114 × CSR50	60.56	49.32	65.51	61.74	59.38	61.35	61.32	61.13	58.56	59.88
Pam114 × APS5	40.99	48.16	31.27	32.82	34.34	32.36	32.60	28.46	53.59	37.18
APS5 × CSR27	48.50	53.96	35.08	40.34	43.05	37.63	34.72	33.12	23.31	38.86
APS5 × CSR50	46.25	50.13	50.29	50.53	50.67	48.18	46.53	51.80	51.99	49.60
APS5 × Pam114	55.05	42.71	54.10	62.33	64.82	58.72	52.49	56.46	53.39	55.56
CSR2 × CSR27 (FC2)	60.24	51.41	50.29	52.98	53.93	56.08	57.14	51.80	42.03	52.88

Table 5: Rearing performance of the constricted foundation crosses during summer, 2019

Foundation crosses	Fecundity (No)	Hatching (%)	Yield 10000^{-1} larvae brushed		Single cocoon weight(g)	Single shell weight(g)	Shell ratio (%)	Pupation rate (%)	Filament l ength (m)
			By No.	By Wt.(kg)					
APS4 × SK6	528	93.45	9100	12.64	1.57	0.30	19.17	88.00	712
APS4 × Pam117	536	95.47	9080	12.06	1.51	0.29	19.27	88.00	732
APS-4 × SK7	524	92.58	9120	12.39	1.54	0.30	19.54	89.00	737
SK6 × APS4	528	94.68	9160	12.60	1.55	0.30	19.35	89.00	709
SK6 × Pam117	531	94.10	9040	12.19	1.53	0.30	19.34	87.00	732
SK6 × SK7	542	94.86	9240	12.40	1.52	0.31	20.13	90.00	721
Pam117 × APS4	539	94.95	9080	12.43	1.55	0.31	20.06	88.00	741
Pam117 × SK6	512	94.89	8940	11.85	1.51	0.29	18.94	86.00	752
Pam117 × SK7	538	94.90	9200	13.03	1.59	0.32	20.13	89.00	750
SK7 × APS4	528	95.36	9040	11.96	1.50	0.28	18.67	87.00	802
SK7 × SK6	531	95.42	9140	12.16	1.51	0.29	19.27	88.00	845
SK7 × Pam117	507	93.58	9100	11.73	1.47	0.29	19.45	87.00	828
CSR6 × CSR26 (FC1)	540	94.90	8980	12.27	1.55	0.31	19.74	87.50	846
Average	**529**	**94.55**	**9094**	**12.29**	**1.53**	**0.30**	**19.47**	**87.96**	**762**
Standard Deviation	**11**	**0.87**	**83**	**0.35**	**0.03**	**0.01**	**0.45**	**1.09**	**50**

Table 6: Evaluation index values of the constricted foundation crosses during summer, 2019

Foundation crosses	Fecundity (No)	Hatching (%)	Yield 10000^{-1} larvae brushed		Single cocoon weight(g)	Single shell weight(g)	Shell ratio (%)	Pupation rate (%)	Filament length (m)	Ave-rage E.I
			By No.	By Wt.(kg)						
APS4 × SK6	48.29	37.40	50.74	60.09	61.65	52.38	43.39	50.35	39.98	49.36
APS4 × Pam117	55.93	60.59	48.33	43.62	43.29	43.53	45.60	50.35	43.98	48.36
APS-4 × SK7	44.52	27.42	53.15	52.97	52.47	52.38	51.71	59.54	44.98	48.79
SK6 × APS4	48.57	51.47	57.97	58.86	57.06	52.38	47.51	59.54	39.38	52.53
SK6 × Pam117	51.68	44.87	43.51	47.19	49.41	47.96	47.27	41.17	43.98	46.34
SK6 × SK7	61.87	53.53	67.60	53.21	46.35	56.81	64.77	68.72	41.78	57.18
Pam117 × APS4	58.94	54.57	48.33	54.06	55.53	61.24	63.28	50.35	45.78	54.68
Pam117 × SK6	33.67	53.88	31.47	37.81	43.29	39.10	38.22	31.99	47.98	39.71
Pam117 × SK7	57.72	54.05	62.79	71.04	69.29	70.09	64.64	59.54	47.58	61.86
SK7 × APS4	48.29	59.33	43.51	40.79	41.77	34.68	32.22	41.17	57.98	44.42
SK7 × SK6	51.78	59.96	55.56	46.33	43.29	43.53	45.60	50.35	66.58	51.44
SK7 × Pam117	28.39	38.90	50.74	34.32	31.06	39.10	49.71	41.17	63.18	41.84
CSR6 × CSR26 (FC1)	60.36	54.05	36.29	49.69	55.53	56.81	56.09	45.76	66.78	53.48

Table 7: Rearing performance of the oval foundation crosses during summer, 2019

Foundation crosses	Fecundity (No)	Hatching (%)	Yield 10000^{-1} larvae brushed		Single cocoon weight(g)	Single shell weight(g)	Shell ratio (%)	Pupation rate (%)	Filament length (m)
			By No.	By Wt.(kg)					
CSR27 × CSR50	518	95.23	9080	12.70	1.58	0.32	20.00	87.00	824
CSR27 × Pam114	529	95.68	8880	12.47	1.59	0.32	19.87	85.00	811
CSR27 × APS5	524	95.41	8920	11.60	1.48	0.29	19.59	85.00	728
CSR50 × CSR27	509	94.85	8980	11.47	1.46	0.29	19.59	86.00	765
CSR50 × Pam114	541	95.84	9160	12.19	1.51	0.31	20.60	90.00	842
CSR50 × APS5	534	94.56	8960	12.47	1.57	0.30	19.11	87.00	711
Pam114 × CSR27	552	95.68	9140	12.57	1.55	0.31	20.00	89.00	839
Pam114 × CSR50	542	95.42	9140	12.70	1.57	0.32	20.45	89.00	826
Pam114 × APS5	539	94.23	9000	12.13	1.53	0.30	19.67	87.00	861
APS5 × CSR27	502	95.12	9060	13.03	1.62	0.32	19.50	87.00	793
APS5 × CSR50	519	95.64	8880	12.56	1.60	0.31	19.44	85.00	838
APS5 × Pam114	537	95.12	8980	12.00	1.52	0.30	19.80	85.00	816
CSR2 × CSR27 (FC2)	546	95.28	9140	12.80	1.58	0.32	20.00	89.50	868
Average	**530**	**95.23**	**9025**	**12.36**	**1.55**	**0.31**	**19.82**	**87.04**	**809**
Standard Deviation	**15**	**0.47**	**102**	**0.46**	**0.05**	**0.01**	**0.41**	**1.83**	**48**

Table 8: Evaluation index values of the oval foundation crosses during summer, 2019

Foundation crosses	Fecundity (No)	Hatching (%)	Yield 10000^{-1} larvae brushed		Single cocoon weight(g)	Single shell weight(g)	Shell ratio (%)	Pupation rate (%)	Filament length (m)	Average E.I
			By No.	By Wt.(kg)						
CSR27 × CSR50	42.03	49.94	55.45	57.35	55.92	57.92	54.50	49.79	53.03	52.88
CSR27 × Pam114	49.22	59.46	35.78	52.47	58.02	57.92	51.39	38.87	50.33	50.39
CSR27 × APS5	45.53	53.69	39.71	33.60	35.90	34.52	44.52	38.87	33.13	39.94
CSR50 × CSR27	35.98	41.81	45.61	30.67	30.63	29.84	44.35	44.33	40.80	38.22
CSR50 × Pam114	57.49	62.88	63.31	46.22	41.17	53.24	69.22	66.17	56.76	57.39
CSR50 × APS5	52.85	35.51	43.65	52.30	54.86	43.88	32.54	49.79	29.61	43.89
Pam114 × CSR27	64.89	59.57	61.35	54.46	50.65	53.24	54.50	60.71	56.14	57.28
Pam114 × CSR50	58.17	53.90	61.35	57.42	53.81	62.60	65.51	60.71	53.44	58.55
Pam114 × APS5	55.68	28.55	47.58	44.91	45.38	43.88	46.43	49.79	60.70	46.99
APS5 × CSR27	31.28	47.59	53.48	64.50	64.34	57.92	42.30	49.79	46.60	50.87
APS5 × CSR50	42.30	58.60	35.78	54.39	60.13	53.24	40.61	38.87	55.93	48.87
APS5 × Pam114	54.27	47.48	45.61	42.31	43.27	43.88	49.62	38.87	51.37	46.30
CSR2 × CSR27 (FC2)	60.32	51.01	61.35	59.39	55.92	57.92	54.50	63.44	62.15	58.44

These identified foundation crosses may be recommended for temperate regions of northwest India during the spring and summer seasons for the development of bivoltine silkworm double hybrids.

REFERENCES

Anil, D., Chauhan, T.P.S., Singh. S., Mir, N.A. and Khan, M.A. 2009. Strategies for development of bivoltine sericulture in North India. *Asian Textile J.*, **18** (1): 75-77.

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

Basavaraja, H.K., Kumar, N.S. and Dandin, S.B. 2006. Breeding strategies for productivity and quality in Mulberry Silkworm Breeders' Meet, 14th-15th Feb 2006, CSRTI, Berhampore pp.1-6.

Bharath, K. N., Shivkumar, Gani, M., Babulal and Ghosh, M. K. 2017. Assessment of performance of autumn crop over spring in temperate region of Jammu & Kashmir. *J. Agroecology and Natural Resource Management.*,**4** (2): 112-114.

Bharath, K.N., Shivkumar, Gulzar, A.K., Mudasir, G., Mir, N.A. and Ghosh, M.K. 2018a. Impact of Climate Change on Agriculture and allied sectors. *J. Entomo. Zoolozy Stud.*, **6**(**5**): 426-429.

Bharath, K. N., Shivkumar, Mir, N. A. and Ghosh, M. K. 2019a. Evaluation of bivoltine mulberry silkworm *Bombyx mori* L breeds suitable for temperate region of Jammu and Kashmir, India. *J. Entomo. Zoology Stud.*,**7**(**1**): 423-427.

Bharath, K. N., Shivkumar, Mir, N. A. and Ghosh, M. K. 2019b. Evaluation of elite bivoltine silkworm (*Bombyx mori* L.) foundation crosses suitable for temperate region of Jammu & Kashmir, India. *Int. J.Curr. Microbiol. App. Sci.*,**8**(1): 2980-2990.

Bharath, K. N., Shivkumar, Mir, N. A. and Ghosh, M. K. 2018b. Studies on the performance of some silkworm, *Bombyx mori* L, breeds in temperate region of Jammu and Kashmir, India. *Int. J. Curr.Microbiol. App. Sci.*,**7**(11): 2192-2201.

Bharath, K.N., Shivkumar, Mir, N.A.,Kiran, R. and Sukhen, R.C. 2020. Seasonal variations in the performance of bivoltine mulberry silkworm (*Bombyxmori* L.) breeds under Kashmir climatic conditions.*SSR Inst. Int. J. Life Sci.*, **6**(6): 2678-2686.

Farooq, M., Singh, T.P., Nooruddin, R.Z.H., Baqual, M. and Dar, H. U. 2006. Second commercial crop to make sericulture a more profitable in Kashmir. Proceedings of regional Seminar on Prospects and Problems of Sericulture as are economic enterprise in North West India. 275-276.

Malik, M.A., Kamili, A.S., Sofi, A.M., Malik, G.N., Sabahat, A. and Bhat, S.A. 2009.Second commercial silkworm rearing in Kashmir- A ray of hope. *Indian Silk.*, **9**:10-11.

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**(10): 53.

Moorthy, S.M., Mandal, K., Kar, N.B. and Das, S.K. 2011. Identification of suitable bivoltine foundation cross for sustainable bivoltine silkworm seed crop in tropics. *Bioscan.*,**6**(4):697-700.

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**(3): 1-14.

Sahaf, K.A., Bhat, S.A. and Mir, N. A. 2016. Sericulture in North-west India with special reference to temperate region- problems and prospects. National seminar on sericulture development in temperate region- problems and prospects.34-38.

Shivkumar, Bharath, K. N., Mir, N.A. and Sukhen, R. C. 2020. Development of autumn season specific potential and high yielding silkworm (*Bombyx mori* L.) breeds & hybrids for temperate climate in Jammu & Kashmir. *Res. J. of Agril. Sci*.,**11**(1): 62-67.

Suresh, K.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**(1): 21-29.

Trag, A.R., Kamili, A.S., Malik, G.N. and Kukiloo, F.A. 1992. Evolution of high yielding bivoltine silkworm, *Bombyx mori* genotypes. *Sericologia*.,**32**: 321-324.

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, Central Sericultural Research and Training Institute, Srirampura, Mysore, India, 16-18, November 2000, pp.21.