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Murali S. and Sardar Singh

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Murali S.*[1] and Sardar Singh[2]

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A B S T R A C T

The study was conducted for silkworm germplasm breeds under continuous maintenance programme at RSRS, Miran Sahib, Jammu and data from three years of spring season (2018, 2019 & 2020) was taken for short-listing of breeds and breeding lines. The breeds (39 No.) and breeding lines (7 No.) was reared for three years and assessed their performance on economically important traits such as fecundity, hatching, yield per 10000 larvae by number and weight, single cocoon weight, shell weight, shell ratio and filament length was analyzed with statistical tools. Based on overall average of the three years data multiple traits Evaluation Index (EI) revealed that, the EI values shown above 50 were better compared to other breeds and breeding lines. EI values which ranges from 35.93 - 60.63 for breeds & 42.72-57.02 for breeding lines and totally almost 23 breeds and 4 breeding lines observed EI values above 50 were identified as superior compared to other breeds and breeding lines respectively. The shortlisted breeds/breeding lines were utilized for further breeding programmes in future.

***Key words*:** Evaluation index, Germplasm breeds, Breeding lines, Spring season

Evaluation and identification of genetic resources is an essential prerequisite for their effective utilization in order to determine the extent of variability among germplasm breeds and breeding lines maintained across the country. In silkworm, *Bombyx mori* L. large numbers of breeds were tested and promising ones were selected based on the economic traits [1]. The silk yield is contributed by more than 21 traits [2] and there exists an interrelationship between multiple traits in silkworm. Any effort to improve the yield requires consideration of cumulative effect of the major traits, which influences the silk yield impartially. Evaluation index method developed by [1] Mono *et al*. (1993) is one such method that increases the precision of selection of breed among an array of breeds by a common index giving due weightage to all the yield attributing traits [3].

As the goals of breeding change rapidly, evaluation needs to be adaptive [4] and necessity of identification of season specific breeds/ hybrids arises due to variation in quantitative characters during different environmental conditions. Silkworms have been evaluated in many environment and agro-climatic conditions in order to identify the season and region-specific breeds for utilization [5]. Series of studies were conducted to identify suitable bivoltine silkworm breed for Kashmir valley particularly for spring and autumn seasons [6-7]. To select the potential parents for breeding summer varieties bivoltine were evaluated in different seasons and selected based on performance [8] and isozyme variability [9]. Similarly, polyvoltine germplasm were evaluated for thermo-tolerance and identified few elite breeds having the thermo-tolerance [10]. Though, the state is known for producing bivoltine silk of international quality however, production of quality bivoltine silk is still a challenge in Jammu & Kashmir having enormous potential to produce bivoltine silk of international grade, which can help to reduce the import of bivoltine silk in the country. Presently, with unpredictable market trends of different kinds of produces by the farmers and the increased economic needs due to changing social status of the farmers, Sericulture in the state has assumed special significance as an important subsidiary occupation, as such the growing economic compromises resulting in decreased productivity must be anticipated to overcome shortfalls by concurrent genetic improvements of the silkworm genotypes/breeds/breeding lines to push up the productivity levels in the interest of the Subtropical condition of Jammu (J & K).

In the present study, an attempt was made to evaluate bivoltine germplasm breeds and breeding lines were shortlisted based on evaluation index suggested by [1] for three seasons average data was taken for analysis. The information generated will be useful for future breeding programmes.

* Murali S.
✉ dr.mmrl@rediffmail.com
[1-2] Central Silk Board, Regional Sericultural Research Station, Miran Sahib, Jammu - 181 101, J & K

Table 1 Showing list of germplasm breeds and breeding lines maintained at RSRS, Miran Sahib, Jammu

S. No.	Breeds	S. No	Breeds	S. No.	Breeding lines
1	JAM1	21	JAM127	1	O1
2	JAM2	22	RSJ1	2	O2
3	JAM10	23	RSJ3	3	O3
4	JAM11	24	RSJ4	4	D1
5	JAM18 (P)	25	RSJ5	5	D2
6	JAM18 (M)	26	RSJ6	6	322
7	JAM21	27	RSJ11	7	323
8	JAM22	28	RSJ13		
9	JAM23	29	RSJ14		
10	JAM24	30	RSJ15		
11	JAM25	31	RSJ16		
12	JAM27	32	RSJ17		
13	JAM103	33	CSR2		
14	JAM110	34	CSR4		
15	JAM118	35	CSR6		
16	JAM119	36	CSR26		
17	JAM121	37	CSR27		
18	JAM122	38	SH_6		
19	JAM124	39	NB_4D_2		
20	JAM125				

MATERIALS AND METHODS

The study was conducted for silkworm germplasm breeds and breeding lines were maintained at Regional Sericultural Research Station (RSRS), Miran Sahib, Jammu for their qualitative and quantitative traits (Table 1). The rearing was carried out during spring (2018, 2019 & 2020) at RSRS, Miran Sahib, Jammu and all the 39 breeds & 7 breeding lines were reared in three replications by following standard rearing techniques [11]. Three hundred larvae were retained after 2nd moult in each replication. The data pertaining to the economic parameters were recorded from time to time. During the entire period of rearing, same microclimate and feeding conditions were ensured as per the larval stage. For feeding of silkworm, S-146 mulberry variety grown in loamy soil with spacing of 3×3 ft plantation was used and maintained in the institute. The data was collected on the following parameters for pre-cocoon viz., Fecundity, hatchability (%), larval period, weight of full-grown larvae (g), ERR by weight and number, pupation rate (%), single cocoon weight, single shell weight and cocoon shell ratio (%) etc. and post cocoon parameters viz. average filament length was recorded.

Observations on various economic traits recorded during rearing and three years data was taken (2018, 2019 & 2020) and average overall performance of breeds and breeding lines were analyzed statistically by Evaluation Indices (E.I) suggested as per [1] Mano *et al.* (1993):

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

Where,

A = Value of a particular hybrid for a character.

B = Mean value of particular trait of all the hybrids combination.

C = Standard deviation of particular trait of all the hybrids combinations

10 = Standard Unit

50 = Fixed value

The index value obtained for all the traits was combined separately and the average EI value was obtained. The EI value fixed for the selection of breed is > 50 for traits. The breeds and breeding lines which scored above the limit is considered to possess greater economic value.

RESULTS AND DISCUSSION

For success of any breeding programme, the selection of breeding resource material is of prerequisite importance and selection of superior parents determines the degree of success of the breeding programme to a large extent. Therefore, the study was undertaken to analyze the breeds and breeding lines maintained at RSRS, Jammu and it is highly important to select and evaluate the suitable silkworm breeds/lines before initiating any breeding programme or any hybridization under Subtropical condition of Jammu. Accordingly, the 39 silkworm breeds and 7 breeding lines were reared during spring season (2018, 2019 & 2020) for three years and the average data obtained was taken for analysis and used for short-listing of breeds and breeding lines through evaluation index and ranked accordingly. The important quantitative and qualitative traits *viz.* fecundity, hatching percentage, yield per 10,000 larvae by number and weight, single cocoon weight, single shell weight, shell ratio, pupation rate and filament length were recorded.

Table 2 Showing overall average data of spring season (2018), (2019) and (2020) for germplasm breeds maintained at RSRS, Miran Sahib, Jammu

S. No.	Breeds	F (No.)	H (%)	LW (g)	ERR/10000 Larvae		SCW (g.)	SSW (g.)	SR (%)	PR (%)	AFL (mtrs)
					By No.	By wt. (Kg)					
1	JAM1	425.66	95.22	43.67	9388.89	14.18	1.55	0.28	18.30	94.55	621.33
2	JAM2	429.56	95.78	43.33	9388.78	14.48	1.58	0.28	17.67	93.89	618.67
3	JAM10	533.22	95.89	43.22	9155.45	13.86	1.55	0.28	17.61	96.00	781.33
4	JAM11	448.78	94.89	41.78	9292.67	13.90	1.53	0.27	17.39	94.78	647.33
5	JAM18 (P)	524.78	96.33	41.56	9014.78	13.28	1.51	0.26	17.39	95.33	650.33
6	JAM18(M)	483.78	93.89	41.89	9199.89	14.00	1.56	0.26	17.03	95.89	690.33
7	JAM21	440.11	96.33	42.00	9503.67	13.95	1.50	0.26	17.32	96.67	734.33
8	JAM22	458.45	96.22	42.56	9222.00	13.71	1.52	0.27	17.42	96.56	807.33
9	JAM23	457.78	95.00	40.44	8929.55	12.75	1.45	0.25	16.79	93.55	709.00
10	JAM24	476.22	95.22	41.44	9062.89	12.93	1.48	0.25	16.88	96.11	777.67
11	JAM25	463.78	95.55	43.78	9229.67	13.94	1.54	0.27	17.35	94.62	774.00
12	JAM27	488.22	94.44	39.78	8955.33	12.94	1.47	0.25	17.03	95.18	638.00
13	JAM103	465.00	94.89	42.89	9118.44	13.86	1.55	0.27	17.67	97.47	679.00
14	JAM110	485.22	95.44	42.00	9203.56	13.71	1.53	0.27	17.94	96.45	703.67
15	JAM118	482.67	94.67	42.67	9381.44	13.97	1.53	0.27	17.56	96.99	725.00

16	JAM119	497.22	95.78	42.11	8955.45	13.79	1.54	0.27	17.37	96.67	657.33
17	JAM121	431.78	94.22	41.78	9066.78	13.61	1.48	0.25	17.08	95.89	689.00
18	JAM122	434.33	94.44	41.89	9062.89	12.23	1.51	0.25	16.06	96.33	744.67
19	JAM124	471.44	95.22	41.78	9040.56	13.20	1.51	0.26	17.55	93.78	719.33
20	JAM125	457.44	96.11	44.11	9470.22	14.40	1.57	0.28	18.14	94.00	745.33
21	JAM127	446.45	94.89	42.67	9062.78	13.70	1.55	0.27	17.54	96.33	763.33
22	RSJ1	507.45	94.33	44.78	9281.33	14.03	1.57	0.29	18.61	96.22	709.67
23	RSJ3	507.45	94.00	44.34	9225.89	14.14	1.58	0.30	18.90	94.22	736.67
24	RSJ4	507.67	94.67	42.11	9066.55	13.22	1.51	0.28	18.32	96.34	841.00
25	RSJ5	488.56	92.67	43.33	9463.00	14.47	1.56	0.30	19.38	96.44	626.67
26	RSJ6	483.11	90.89	44.00	9203.67	13.79	1.53	0.29	20.12	97.00	899.00
27	RSJ11	540.22	94.67	43.89	9103.78	13.88	1.57	0.31	19.59	95.11	767.67
28	RSJ13	487.56	94.55	42.45	9237.00	13.43	1.52	0.29	19.07	95.67	881.67
29	RSJ14	485.78	94.00	43.56	9211.00	13.87	1.56	0.31	20.33	94.33	772.33
30	RSJ15	482.45	93.33	44.44	9459.11	14.16	1.56	0.31	20.10	96.22	898.67
31	RSJ16	437.00	95.22	42.56	9170.33	13.60	1.53	0.27	18.02	95.78	653.67
32	RSJ17	439.56	96.22	41.78	9125.89	13.50	1.50	0.28	18.87	96.11	837.33
33	CSR2	463.33	93.44	41.55	9114.78	13.38	1.51	0.31	20.24	95.56	1115.33
34	CSR4	436.11	95.89	44.00	9311.11	13.89	1.55	0.29	18.64	95.89	714.00
35	CSR6	519.11	94.89	41.33	9388.89	14.05	1.54	0.29	19.01	97.22	834.00
36	CSR26	442.67	95.34	46.00	9222.11	14.40	1.62	0.32	19.39	96.78	851.33
37	CSR27	482.78	94.11	44.78	9140.78	13.66	1.56	0.30	19.33	95.00	817.00
38	SH_6	523.56	95.89	44.33	9115.00	13.84	1.58	0.30	18.69	95.22	712.33
39	NB_4D_2	471.00	96.11	45.00	9303.55	14.46	1.59	0.31	19.19	96.11	850.00
	Mean	474.54	94.89	42.86	9201.27	13.75	1.54	0.28	18.23	95.70	753.71
	SD±	30.95	1.11	1.35	151.35	0.49	0.03	0.02	1.08	1.02	98.85

Note: F - Fecundity; H - Hatching; LW- Larval weight; PR- pupation rate; ERR - Effective Rate of Rearing; SCW- Single cocoon weight; SSW- Single shell weight; SR - Shell ratio; AFL - Average Filament Length

Thirty-nine breeds were studied by rearing during spring (2018), (2019) and (2020) under germplasm maintenance programme and overall average of the data for three years observed that, among these breeds, the fecundity observed was highest in RSJ11 is 540.00 and lowest in JAM 1 is 426.00 whereas hatching percentage was highest in JAM18 (P) & JAM21 (96.33) and lowest in RSJ 6 (90.89). Yield per 10,000 larvae by weight (Kg) recorded as highest of about 14.48 Kg in JAM 2 and lowest of about 12.23 Kg in JAM122 with regard to weight basis and by number was highest recorded in RSJ5 (9463.00) and was lowest in JAM23 (8929.55) whereas single cocoon weight was highest in CSR26 (1.62 g) and lowest in JAM23 (1.45 g). The shell ratio (%) was highest in RSJ 14 (20.33) and lowest in JAM 122 (16.06) respectively (Table 2). The pupation rate was recorded as maximum in JAM103 (97.47%) and lowest in JAM23 (93.55%). The filament length was recorded highest in CSR2 (1115.33 mtrs) and lowest in JAM 2 (618.67 mtrs) (Table 2). The performance of breed mainly depends on the combined action of its hereditary potential and extent to which such potential is permitted to express in the environment [12]. One of the objectives of breeder is to recommend stable breeds to the farmers for rearing under different environmental conditions [13]. Similar study was reported by [14], twelve bivoltine silkworm, *Bombyx mori* L. genotypes were evaluated for cocoon associated traits during spring and summer seasons of 2012 and 2013 respectively. The data generated in respect of different traits was pooled separately, analyzed statistically and subjected to multiple trait evaluation indexes. The genotypes were ranked as per the cumulative score and the value of a particular trait in a particular genotype was compared with the ranking.

Table 3 Showing overall average data of spring season (2018), (2019) and (2020) for germplasm breeding lines maintained at RSRS, Miran Sahib, Jammu

S. No.	Breeds	F (No.)	H (%)	LW (g.)	ERR/10000 Larvae		SCW (g.)	SSW (g.)	SR (%)	PR (%)	AFL
					By No.	By wt. (Kg)					
1	O1	444.89	95.56	42.67	9344.44	14.04	1.56	0.29	18.30	95.89	814.67
2	O2	427.33	95.11	44.00	9277.78	14.23	1.57	0.30	19.11	95.44	758.67
3	O3	456.11	95.67	40.56	8928.11	12.89	1.50	0.28	18.94	97.00	916.00
4	D1	457.67	96.33	39.34	9037.00	12.85	1.48	0.27	18.29	94.45	830.33
5	D2	435.11	95.56	43.44	9326.11	14.02	1.57	0.30	19.09	96.56	882.67
6	322	460.89	95.67	41.00	9026.22	13.38	1.51	0.28	18.67	95.22	704.00
7	323	434.89	96.33	39.78	8885.11	12.94	1.51	0.28	18.44	93.44	674.00
	Mean	445.27	95.75	41.54	9117.83	13.48	1.53	0.29	18.69	95.43	797.19
	SD±	13.22	0.44	1.83	193.82	0.61	0.04	0.01	0.36	1.22	89.60

Note: F - Fecundity; H - Hatching; LW- Larval weight; PR- pupation rate; ERR - Effective Rate of Rearing; SCW- Single cocoon weight; SSW- Single shell weight; SR - Shell ratio; AFL - Average Filament Length

Seven breeding lines were studied by rearing during spring (2018), (2019) and (2020) under continuous maintenance programme and performance data for overall average for three years observed that, the fecundity was highest in 322 is 461.00 and lowest in O2 is 427.00 whereas hatching percentage was highest in 323 & D1 (96.33) and lowest in O2 (95.11). Yield per 10,000 larvae by weight (Kg), the highest was about 14.23 Kg in O_2 and lowest of about 12.85 Kg in D1 with regard to weight basis and by number was highest in O1 (9344.00) and lowest in 323 (8885.00) with single cocoon weight was highest in O2 (1.57 g) and lowest was recorded in D1 (1.48 g). The shell ratio (%) was highest in O-2 (19.11) and lowest in D1 (18.29) respectively (Table 3). The pupation rate was recorded as maximum in O3 (97.00%) and lowest in 323 (93.44%). The filament length was recorded highest in O3 (916 mtrs) and lowest in 323 (674 mtrs) [15]. The variation observed in the cocoon traits analyzed can be attributed to the genetic constitution of the genotype and the degree of expression to which the particular genotype is exposed during the rearing period [16-17].

Table 4 Showing overall evaluation index of spring season (2018), (2019) and (2020) for germplasm breeds maintained at RSRS, Miran Sahib, Jammu

S. No.	Breeds	F (No.)	H (%)	LW (g.)	ERR/10000 Larvae		SCW (g.)	SSW (g.)	SR (%)	PR (%)	AFL (mtrs)	Avg. EI	Ranking
					By No.	By wt. (Kg)							
1	CSR26	39.70	54.04	73.27	51.38	63.27	74.92	68.50	60.74	60.57	59.88	60.63	1
2	RSJ5	60.45	58.00	60.35	61.73	61.48	60.66	61.17	61.07	60.73	58.71	60.43	2
3	NB4D2	48.86	61.01	65.86	56.76	64.49	66.25	63.39	58.90	54.06	59.74	59.93	3
4	RSJ15	52.55	35.98	61.73	67.04	58.38	56.63	66.79	67.27	55.14	64.66	58.62	4
5	CSR6	64.40	49.98	38.68	62.40	56.07	49.89	54.87	57.18	64.95	58.12	55.65	5
6	RSJ11	71.22	48.00	57.63	43.56	52.68	58.55	63.39	62.53	44.25	51.41	55.32	6
7	RSJ1	60.63	44.99	64.23	55.29	55.73	58.55	54.87	53.49	55.14	45.54	54.85	7
8	SH6	65.83	59.03	60.92	44.30	51.93	62.40	58.28	54.25	45.30	45.81	54.81	8
9	JAM125	44.48	61.01	59.26	67.77	63.34	58.55	51.46	49.21	33.33	49.15	53.76	9
10	RSJ14	53.63	41.98	55.16	50.64	52.54	55.28	67.59	69.42	36.60	51.88	53.47	10
11	RSJ3	60.63	41.99	60.94	51.63	57.97	61.44	59.98	56.19	35.49	48.28	53.45	11
12	JAM10	68.96	59.00	52.69	46.97	52.20	54.70	48.06	44.26	52.95	52.79	53.26	12
13	CSR27	52.66	42.98	64.23	46.00	48.20	55.66	61.68	60.19	43.14	56.40	53.12	13
14	CSR4	37.58	59.03	58.45	57.26	52.88	53.74	54.87	53.82	51.87	45.98	52.55	14
15	RSJ6	52.77	13.92	58.45	50.16	50.91	48.92	53.17	67.45	62.76	64.70	52.32	15
16	CSR2	46.38	36.97	40.31	44.29	42.56	41.22	63.39	68.59	48.60	86.58	51.89	16
17	RSJ13	54.20	46.98	46.93	52.36	43.51	44.11	56.57	57.76	49.71	62.94	51.51	17
18	JAM118	52.62	48.00	48.56	61.90	54.44	48.92	44.65	43.86	62.66	47.10	51.27	18
19	JAM22	44.80	62.00	47.74	51.37	49.28	46.04	42.95	42.51	58.41	55.42	50.05	19
20	JAM2	35.47	58.01	53.50	62.39	64.90	62.40	49.76	44.87	32.22	36.34	49.99	20
21	JAM21	38.88	63.02	43.64	69.98	54.17	39.30	41.24	41.64	59.49	48.04	49.94	21
22	JAM103	46.92	50.01	50.19	44.53	52.34	52.77	46.35	44.81	67.34	42.44	49.77	22
23	JAM110	53.45	55.00	43.64	50.15	49.15	48.92	46.35	47.30	57.33	44.94	49.62	23
24	JAM1	34.21	53.02	56.00	62.40	58.86	52.77	49.76	50.66	38.76	36.61	49.30	24
25	RSJ17	38.70	62.03	41.96	45.02	45.01	40.26	51.46	55.92	54.06	58.46	49.29	25
26	JAM25	46.52	55.99	56.79	51.88	53.83	50.85	42.95	41.92	39.45	52.05	49.22	26
27	RSJ4	60.70	48.00	44.43	41.10	39.17	42.18	49.76	50.87	56.25	58.83	49.13	27
28	JAM127	40.92	49.98	48.56	40.85	48.94	53.74	46.35	43.64	56.22	50.97	48.02	28
29	JAM119	57.33	58.01	44.46	33.76	50.91	50.85	42.95	42.11	59.49	40.25	48.01	29
30	JAM18(M)	52.98	41.00	42.80	49.91	55.19	55.66	41.24	38.97	51.87	43.59	47.32	30
31	RSJ16	37.87	53.02	47.74	47.96	47.04	47.00	46.35	48.07	50.76	39.88	46.57	31
32	JAM18 (P)	66.23	63.02	40.33	37.68	40.52	43.15	41.24	42.26	46.41	39.54	46.04	32
33	JAM11	41.68	50.01	41.96	56.04	53.02	47.00	42.95	42.29	40.98	39.24	45.52	33
34	JAM24	50.54	53.02	39.49	40.86	33.33	33.52	36.13	37.58	54.03	52.42	43.09	34
35	JAM124	49.00	53.02	41.96	39.38	38.76	42.18	41.24	43.77	31.14	46.52	42.70	35
36	JAM121	36.18	44.00	41.99	41.11	47.25	34.48	36.13	39.40	51.87	43.45	41.59	36
37	JAM122	37.01	45.99	42.80	40.86	19.14	43.15	34.43	30.02	56.19	49.09	39.87	37
38	JAM27	54.42	45.99	27.13	33.75	33.60	31.59	34.43	38.91	44.91	38.29	38.30	38
39	JAM23	44.58	51.00	32.08	32.05	29.73	25.82	32.73	36.72	28.95	45.48	35.91	39

Note: F - Fecundity; H - Hatching; LW- Larval weight; PR- pupation rate; ERR - Effective Rate of Rearing; SCW- Single cocoon weight; SSW- Single shell weight; SR - Shell ratio; AFL - Average Filament Length

Hence, identification of potential genotypes call for consideration of the cumulative effects of the entire cocoon associated traits. Also, agreement with study reported by [18) revealed that, the data obtained on the traits such as fecundity, hatching, yield per 10000 larvae by number and weight, single cocoon weight, shell weight, shell ratio and filament length was analyzed with statistical tools. Based on the two popular evaluation methods such as multiple traits Evaluation Index (EI) and Sub ordinate Function (SF) methods, the eight breeds (BHR 2, BHR 3, B.con 1, B.con 4, ATR 16, CSR50, RSJ 14 and NB_4D_2) shown above 50 EI values with SF values varied from 2.07 - 6.73 identified as superior compared to other breeds. The shortlisted breeds were utilized for further breeding programme for hybrid preparation.

The overall average evaluation index for the 39 breeds reared during the year spring (2018), (2019) and (2020) revealed that, the breeds showing the values >50 were better performer than other breeds evaluated during the same years. The breeds were shortlisted and were given ranking as highest to lowest values of the EI (Table 4) viz., CSR 26 (60.63), RSJ5 (60.43), NB_4D_2 (59.93), RSJ15 (58.62), CSR6 (55.65), RSJ11 (55.32), RSJ1 (54.85) etc. whereas breeding lines were shortlisted as according evaluation index viz., D2 (57.02), O2 (54.02), O1 (52.56), O3 (50.43) respectively (Table 5). In silkworm, *Bombyx mori* L. multiple trait evaluation method has been utilized in testing large number of breeds and promising ones have been selected based on the economic traits [19-22). Evaluation index is one such method that increases the precision of selection of breed among an array of breeds by a common index giving due weightage to all the yield component traits [23]. The silk yield is contributed by more than 21 traits [2) and there exists an interrelationship between multiple traits in silkworm. Any effort to improve the yield requires consideration of cumulative effect of the major traits, which influences the silk yield impartially. Based on evaluation index (EI) almost 23 breeds and 4 breeding lines were observed EI values >50 and given ranking accordingly for each breeds and lines respectively.

Table 5 Showing overall evaluation index of spring season (2018), (2019) and (2020) for germplasm breeding lines maintained at RSRS, Miran Sahib, Jammu

S. No.	Breeds	F (No.)	H (%)	LW (g.)	ERR/10000 Larvae		SCW (g.)	SSW (g.)	SR (%)	PR (%)	AFL	Avg. EI	Ranking
					By No.	By Wt. (Kg)							
1	D2	42.31	45.72	60.38	60.75	58.98	60.41	61.73	61.12	59.26	59.54	57.02	1
2	O2	36.43	35.65	63.42	58.25	62.34	62.16	64.56	61.58	50.12	45.70	54.02	2
3	O1	49.71	45.72	56.14	61.69	59.20	57.77	50.40	39.20	53.78	51.95	52.56	3
4	O3	58.20	48.21	44.63	40.21	40.32	41.98	47.57	57.03	62.90	63.26	50.43	4
5	322	61.82	48.21	47.05	45.27	48.41	46.36	44.74	49.32	48.31	39.60	47.91	5
6	D1	59.38	63.25	37.98	45.83	39.61	36.71	36.25	38.74	41.94	53.70	45.34	6
7	323	42.14	63.25	40.39	37.99	41.15	44.61	44.74	43.01	33.70	36.25	42.72	7

Note: F - Fecundity; H - Hatching; LW- Larval weight; PR- pupation rate; ERR - Effective Rate of Rearing; SCW- Single cocoon weight; SSW- Single shell weight; SR - Shell ratio; AFL - Average Filament Length

Therefore, the objective of silkworm breeding is not only to synthesize new genotypes or hybrid combinations but also to identify sustainable silkworm hybrids for commercial exploitation by farmers. Selection of suitable parents and information on nature and magnitude of gene action of traits of economic importance determine the success of any crop [24]. Critical assessment of variability present in the breeding materials is one of the prerequisites for paving the way of combining most of the desirable traits present in different genotypes into single hybrid combination. However, the performance of parental breeds is not always be the good reflection of the combining ability and its analysis therefore helps the breeders to understand the nature of gene action to identify prospective parents/hybrids [25].

In the present study an attempt was being made to identify the superior breeds/breeding lines through assessment by average data for overall performance of breeds for three years on multiple traits of the studied silkworm breeds as an important task in predicting the potential breeding material. The present data was analyzed with equal weight to all the important economic traits by using multiple evaluation index [1] (Mano *et al.*, 1993). These methods were successfully employed by many silkworm breeders for evaluation of the silkworm hybrids and breeds [26-31].

CONCLUSION

From the overall performance of the breeds and lines reared in the laboratory for three years, 23 breeds and 4 breeding lines were showed good performance based on multiple trait evaluation index and given ranking accordingly for breeds and lines respectively. The findings of this study prove the superiority of the breeds with improved productivity traits than other breeds/lines. The breeds and lines having scored above the limit of EI values were considered to possess greater economic value and shortlisted breeds/lines can be utilized in future breeding programmes for development of season/region specific hybrids under Subtropical climatic conditions of Jammu (Jammu & Kashmir).

LITERATURE CITED

1. Mano Y, Nirmal Kumar S, Basavaraja HK, Mal Reddy N, Datta RK. 1993. A New method to select promising silkworm breeds/combinations. *Indian Silk*, 31(10): 53.
2. Thiagarajan V, Bhargava SK, Ramesh Babu, M, Nagaraj B. 1993. Differences in seasonal performance of twenty six strains of silkworm, *Bombyx mori* L. (Bombycidae). *Journal of Lepidopteron Society*. 47 : 321-337.
3. Bhargava SK, Raja Lakshmi E, Thiagarajan V. 1994. An evaluation index for silk yield contributing traits in Bombyx mori L. *Indian Textile Journal*, 105: 83 - 84.

4. Frankel OH, Bennet, E. 1989. *Use of plant genetic resource*, Cambridge University Press, Cambridge, 18-25.
5. Venugopal Pillai S, Kishnaswamy S, 1987. Adaptability of silkworm, Bombyx mori (L.) to tropical conditions. III. Studies on the effect of high temperature during later developmental stages of silkworm. *Indian Journal of Sericulture*, 26(2): 63-71.
6. Trag AR, Kamili AS, Malik, GN, Kukiloo FA.1992. Evolution of high yielding bivoltine silkworm (Bombyx mori L.) genotypes. *Sericologia*, 32 (2): 321-324.
7. Malik GN, Kamili AS, Wani SA, Dar HU, Ahmad R, Sofi AM. 2000. Evaluation of some bivoltine silkworm (*Bombyx mori* L.) genotypes. *SKUAST Journal of Research*, 4: 83-87.
8. Moorthy SM, Das SK, Rao PRT, Debnath S, Raje Urs S. 2006. *Indian Journal of Genetics and Plant breeding*, 66(1):82-84.
9. Moorthy SM, Das SK, Rao PRT, Raje Urs S, Sarkar A. 2007. *International Journal of Industrial Entomology*,14(1):1-7.
10. Koundinya PR, Kumaresan P, Sinha RK, Thangavelu K. 2003. *Indian Journal of Sericulture*, 42 (1): 67-70.
11. Krishnaswami S. 1978. *Bulletin No.2, Central Sericultural Research and Training Institute, Mysore, India*, 1 -24.
12. Roa MRP. 2016. Selection in Silkworm Breeding, Gupta Offset Printing Vidyaranyapuram, Mysuru, pp.10.
13. Basavaraja HK, Nirmal KS, Suresh KN, Mal Reddy N, Kashama G, Ahsan MM, Datta RK.1995. New productive bivoltine hybrids. *India Silk*, 34, pp. 5.
14. Buhroo ZI, Malik MA, Ganai NA, Kamili AS, Bhat BA. 2016. Evaluation of some silkworm Bombyx mori L. genotypes for cocoon associated traits during different seasons. *Int. J. Adv. Res. Biol. Sci.* 3(10): 225-231.
15. Nisar M, Chisti MZ, Khan MA. 2013. Studies on the identification of summer specific silkworm Bombyx mori L. hybrids under temperate climatic conditions of Jammu and Kashmir, India. *Journal of International Academic Research for Multidisciplinary*,1(3): 1-14
16. Naseema Begam M, Basavaraja HK, Sudhakara Roa P, Rekha M, Ahsan MM. 2001. Identification of bivoltine silkworm hybrids suitable for tropical climate. *Indian Journal of Sericulture*, 39(1): 24-29.
17. Narayanaswamy TK, Govindan R, Ananthanarayana SR. 2002. Selection of multivoltine × bivoltine cross breeds of silkworm, *Bombyx mori* L. through evaluation indices. *Indian J. Seric.*, 41:176-178.
18. Murali S, Sardar Singh. 2021. Evaluation and Identification of Superior Bivoltine Breeds of Silkworm, *Bombyx mori* L. during different Seasons at Jammu. *Res. Jr. of Agril. Sci.* **12**(1): 17-22.
19. Malik GN, Kamili AS, Wani SA, Dar HU, Raies Ahamed, Sofi AM. 2002. *Skuast Journal of Research***,** 4:83-87.
20. Malik GN, Rufaie SZ, Baqual MF, Kamili AS, Dar HU. 2006. Comparative performance of some bivoltine silkworm, *Bombyx mori* L. hybrids. *Entomon.* 1: 61-64.
21. Malik MA, Kamili AS, Sofi AM, Malik GN, Sabahat A, Malik, F. 2010. Evaluation and identification of region/season specific hybrids of the silkworm, *Bombyx mori* L. suitable for Kashmir climatic conditions. *Journal of Experimental zoology.* 13:171-176.
22. Nooruldin S, Bhat SA, Malik MA, Khan IL, Sahaf KA. 2014. Comparative performance of silkworm, Bombyx mori L. hybrids during different seasons under Kashmir climatic conditions. *Green Farming*, 6 (6): 1392-1395.
23. Bhargava SK, Thiagarajan V, Majumdar MK, 1993. Impact of silkworm breeds on reeling parameters. *Indian Textile Journal*, 104: 66 - 69.
24 Chouhan TPS, Lakshmanan V and Rajalakshmi E. 2000. Combining ability studies in bivoltine silkworm, *Bombyx mori* L. *Indian J. Seric.*, 39: 127-130.
25. Narayanswami TK, Govindan R, Anantha Narayana SR, Ramesh S. 2002. Genetic divergence among some breeds of silkworm, *Bombyx mori* L. *Entomon*, 27(3): 319–321.
26. Krishnaswamy S, Jolly MS and Subba Rao. 1964. Diallel analysis of quantitative characters in multivoltine races of silkworm. *Indian J. Genet.*, 24: 213-222.
27. Singh T, Subba Rao G. 1993. Multiple trait evaluation index to select useful silkworm (*Bombyx mori* L.) hybrid genotypes. *Italian Entomol.*, 6: 370-382.
28. Sudhakar Rao P, Singh R, Kalpana GV, Naik KN, Basavaraja HK, Ramaswamy GN and Datta R K. 2001. Evaluation and identification of promising bivoltine hybrids of silkworm, *Bombyx mori* L. for tropics. *Int. J. Indust. Entomol.*, 3: 31-35.
29. Ramesh Babu, Chandrashekaraiah M, Lakshmi H and Prasad J. 2002. Multiple trait evaluation of bivoltine hybrids of silkworm (*Bombyx mori* L.). *Int. J. Indust. Entomol.*, 5: 37-43.
30. Rao CGP, Seshagiri SV, Ramesh C, Basha KI, Nagaraju H and Chandrashekaraiah 2006. Evaluation of genetic potential of the polyvoltine silkworm (*Bombyx mori* L.) germplasm and identification of parents for breeding programme. *J. Zhejiang Univ. Sci. B.*, 7: 215-220.
31. Ramesha C, Seshagiri SV, Basha KI and Rao CGP. 2008. Synthesis of superior polyvoltine crossbreeds of silkworm (*Bombyx mori* L.). National seminar on Scenario of seri biotechnological research in India, August 28-30, S. V. Mahila University, Tirupati, A. P., India.