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Improvement of Qualitative and Quantitative Traits of Autumn Season Specific Lines/Breeds for Temperate Climatic Conditions of Jammu and Kashmir

Shivkumar[1]*, Bharath Kumar Neelaboina[2], Mir Nisar Ahmad[3], Kiran R[4], S Roy Chowdhury[5]

[1]Scientist C, Silkworm Breeding and Genetics Laboratory, CSR&TI, Central Silk Board, Pampore-192121 Jammu and Kashmir, India

[2]Scientist C, Silkworm Breeding and Genetics Laboratory, CSR&TI, Central Silk Board, Pampore-192121 Jammu and Kashmir, India

[3]Scientist D, Silkworm Breeding and Genetics Laboratory, CSR&TI, Central Silk Board, Pampore-192121 Jammu and Kashmir, India

[4]Scientist B, Silkworm Breeding and Genetics Laboratory, CSR&TI, Central Silk Board, Pampore-192121 Jammu and Kashmir, India

[5]Director, CSR&TI, Central Silk Board, Pampore-192121 Jammu and Kashmir, India

*Address for Correspondence: Dr. Shivkumar, Scientist C, Silkworm Breeding and Genetics Laboratory, CSR&TI, Central Silk Board, Pampore-192121 Jammu and Kashmir, India

E-mail: shivabsajjan@gmail.com

ABSTRACT

Background: The present study having relevance to the improvement of qualitative and quantitative traits by utilizing eighteen (18) autumn specific lines (ASL) of F9 generation with SH6 × NB4D2 as control.

Methods: Total 18 ASL were incubated and reared as per the standard rearing procedures to understand their suitability and data was recorded for the targeted economic traits *viz.*, Fec. (no.), h(%), yield by no. and wt. (kg)/10,000 larvae brushed, SCW (g), SSW (g), SR (%), PR(%) and FL(m).

Results: The data obtained in regards to rearing performance revealed that, among all the lines, the higher SR of 21.38% was recorded in line-3 and greater FL of 990 (m) was also observed in the same line. For the trait, PR was found >90 in all the ASL and highest of 96 exhibited in line-5. Hence, an increase of traits observed *viz.,* fec.(no.), h(%), SCW(g), SSW(g), SR(%), FL (m) and PR(%) were noticed with an increase of 45no., 4.02%, 0.09 g, 0.04 g, 1.99%, 240 m and 2%, respectively over the control (SH6 × NB4D2). The data obtained was subjected to the multiple trait EI (Evaluation Index) and results clearly showed that, out of 18 lines under study, eight lines *viz.*,1, 5, 6, 7, 9, 16, 17, and 18 have shown higher index values (>50) and influenced significantly on the improvement of traits over the control and have economically importance.

Conclusion: Lines identified from the study can conveniently be utilized for developing high yielding autumn specific bivoltine hybrids and can be used for commercial exploitation at farmer's level during the autumn season in the temperate region of Jammu and Kashmir.

Key-words: Autumn specific lines, *Bombyx mori* L, EI, Kashmir valley, Temperate climate, Qualitative and Quantitative traits

INTRODUCTION

Jammu and Kashmir is a traditional sericulture state, which enjoys temperate climate congenial for bivoltine

silkworms rearing during the spring season (April-May) and bivoltine silkworm races are primarily suited for temperate climatic conditions of Jammu and Kashmir. The commercial rearing in Kashmir is mainly conducted during the spring season and only 10–15% farmers' conduct second rearing during the summer season by Sahaf *et al.* [1]. Till date, the limited number of silkworm breeds/ hybrids has been developed for the spring season under temperate climatic conditions of Kashmir by Trag *et al.* [2], Kamili *et al.* [3], Malik *et al.* [4] and Malik *et*

al.[5]. Few attempts have also been made for identification of hybrids for summer or autumn season by Farooq *et al*. [6], Malik *et al.* [7] and Mir Nisar *et al*. [8]. The cocoon productivity has been reported as 30–40 kg/100 dfls in spring crop and 20–25 kg/100 dfls in autumn crop by Chauhan *et al*. [9].

The univoltines and bivoltines are known for better quantitative characters with quality silk but they are sensitive to environmental and dietary stress. The exploitation of heterosis through single hybrids in silkworms for economic traits triggered a revolutionary change in overall qualitative and quantitative silk output [10]. It has demonstrated the superiority of single, three-way and double hybrids over their parental races [11]. Utilization of hybrid vigour for development of new genotypes was introduced in 1901 [12] and with this strategy, different races were crossed to utilize their hybrid vigour and variation as a tool to develop new genotypes. Although survival could be maintained in single hybrids they are handicapped by less number of eggs laid by inbred pure mother moth. Unless the mother moth is a hybrid, the fecundity cannot be increased [13]. It advocated the repeated backcrossing method for the improvement of cocoon quality [14] and few attempts were also made in India for the success of autumn crop at the temperate zone of Kashmir by Malik *et al.* [5], Farooq *et al*. [6] and Malik *et al.* [7].

Breeding for autumn specific silkworm genotypes for temperate climatic conditions remained a challenge before silkworm breeders in North-West India and autumn rearing are entailed with high temperature and high humidity at the initial stage of silkworm rearing. Higher pathogen load and inferior quality of mulberry leaf at farmers' field also affect the crop under temperate conditions, although the temperature is not high, yet the production is far below the spring average due to poor quality of mulberry leaf and non-availability of potential autumn specific breeds and hybrids. Hence, present research work is focused on the improvement of qualitative and quantitative traits as a phase-wise manner and at the end of the programme; it is the main target to evolving autumn specific bivoltine breeds and hybrids during the autumn season in the temperate region of Jammu and Kashmir.

MATERIALS AND METHODS

The present study proceeded from April 2019 to June 2019 in the Silkworm Breeding and Genetics Laboratory, Central Sericultural Research and Training Institute (CSR&TI), Central Silk Board, Pampore-192121 Jammu and Kashmir, India.

Selection of parentages for the study- Parental seed of the above said line's races/breeds were collected from the Germplasm Bank of Central Sericultural Research and Training Institute (CSR&TI), Mysore (CSR2, CSR26, CSR27, CSR50, and CSR52), Andhra Pradesh State Sericulture Research and Development Institute, Hindupur, Andhra Pradesh (APS4, APS5 and APS9) and CSR&TI, Pampore (Pam101 and Pam117) along with control (SH6 and NB_4D_2).

Crossing and location of study- The crossing of collected parental material was carried out with different combination in the Silkworm Breeding and Genetics laboratory of CSR&TI, Pampore during spring season 2016 and eighteen (18) autumn specific lines (ASL) of F9 generations comprising different combinations of bivoltine silkworm *Bombyx mori (B. mori)* were selected for the present investigation.

Methods Adopted- The eighteen lines of F9 generation were incubated and reared during spring, 2019 along with a control (SH6×NB_4D_2) by adopting the methods described by Tazima [14] and Krishnaswami [15], respectively.

Silkworm rearing and target traits for data analysis- The silkworm larvae were fed with suitable quality mulberry leaves for both young (Ichinose and KNG) and late age (Goshoerami). For assessing the comparative performance of the eighteen lines of F9 generation along with control was done for targeted traits such as fecundity no. (Fec. no.), hatching percentage (h%), larval duration (days) yield by number/10,000 larvae brushed (no.), yield by weight/ 10,000 larvae brushed (kg), single cocoon weight (SCWg), single shell weight (SSWg), shell ratio (SR%), pupation rate (PR%) and filament length (FL.m).

Statistical Analysis- The data generated were subjected to multi-traits evaluation Index method developed by Mano *et al.* [16] as per the formula details given below.

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

Where,

A: Value obtained for a particular trait of a particular line

B: Mean value of particular trait of all the particular lines

C: Standard Deviation of a particular trait of all the particular lines

10: Standard Unit and **50:** Fixed Value

The index value obtained as described above was estimated for each of the traits analyzed. Further, the indices obtained for all the traits were combined to get a single value, which is the average E.I. The average index value fixed for the selection of a line was >50. The index values of lines which are relatively higher than 50 are considered as greater economic value.

reared at Silkworm Breeding and Genetics Section of CSR&TI, Pampore, Jammu and Kashmir by recording the traits *viz.*, Fecundity (No,), Hatching %, Yield /10,000 larvae by no. and by weight (kg), Single cocoon weight (g), Single shell weight (g), Shell ratio (%), Pupation rate (%) and Filament length (m) along with statistical analysis of multi- traits evaluation index values.

RESULTS

Target characters for the experiment- The results regarding the rearing performance of selected traits of 18 autumn specific breeding lines along with a control (SH6 × NB4D2) at F9 generation during spring 2019 were

Rearing performance of autumn specific lines at F9 generation- The perusal of data in regards to the rearing performance of 18 autumn specific breeding lines along with a control (SH6 × NB4D2) at F9 generation during spring 2019 (Table 1).

Table 1: Rearing performance of selected traits of 18 autumn specific lines along with a control (SH6×NB4D2) of bivoltine silkworm at F9 generation of silkworm *B. mori* L.

Traits Lines	Fecundity (no.)	Hatching (%)	Yield/10,000 Larvae By no.	By wt (kg)	Single Cocoon Wt (g)	Single Shell Weight (g)	Shell Ratio (%)	Pupation Rate (%)	Filament Length (m)
Line-1	444	94.14	9560	15.80	1.84	0.38	20.42	92	751
Line -2	519	95.91	9560	13.52	1.60	0.31	19.48	94	853
Line -3	511	95.69	9560	12.64	1.51	0.32	21.38	94	990
Line -4	569	95.86	9100	13.16	1.81	0.35	19.06	93	865
Line -5	565	95.15	9780	14.02	1.62	0.33	20.44	96	870
Line -6	552	95.31	9280	14.41	1.75	0.34	19.39	94	972
Line -7	510	95.47	9860	15.60	1.77	0.35	20.00	94	908
Line -9	599	95.90	9740	15.25	1.75	0.35	20.11	95	881
Line -11	603	95.69	9240	13.36	1.65	0.33	19.85	91	758
Line -12	585	95.50	9460	13.85	1.65	0.30	18.08	92	693
Line -14	493	95.36	9760	13.89	1.61	0.33	20.62	93	820
Line -15	607	96.05	9500	13.68	1.63	0.31	19.24	93	718
Line -16	531	99.52	9460	13.90	1.66	0.32	19.17	92	955
Line -17	564	95.18	9820	13.63	1.57	0.32	20.55	95	971
Line -18	572	95.20	9740	15.57	1.78	0.35	19.69	95	882
Line -19	591	95.74	9240	14.63	1.78	0.32	18.22	91	815
Line -21	485	94.96	9180	14.61	1.79	0.33	18.40	91	778
Line -24	498	94.98	9540	14.41	1.70	0.32	18.95	93	728
Control (SH6×NB4D2)	562	95.50	9280	14.41	1.75	0.34	19.39	94	750
Ranges	444-607	94.96-99.52	9100-9820	13.36-15.80	1.51-1.84	0.30-0.38	18.08-21.38	91-96	693-990
Average	545	95.64	9508	14.23	1.70	0.33	19.60	93.26	839.89

Std Dev.	46.07	1.04	235.9	0.87	0.09	0.02	0.87	1.48	93.31

INDEX: Line-1 (Pamp101 × CSR2), Line -2 (Pamp101 × CSR26), Line -3 (Pamp101 × CSR27), Line -4 (Pamp101 × CSR50), Line -5 (Pamp101 × CSR52), Line -6 (Pamp117 × CSR2), Line -7 (Pamp117X × CSR26), Line -9 (Pamp117 × CSR50), Line -11 (APS4 × CSR2), Line -12 (APS4 × CSR26), Line -14 (APS4 × CSR50), Line -15 (APS4 × CSR52), Line -16 (APS5 × CSR2), Line -17 (APS5 × CSR26), Line -18 (APS5 × CSR27), Line -19 (APS5 × CSR50), Line -21 (APS9 × CSR2), Line -24 (APS9 × CSR50) and Control (SH6 × NB4D2).

The trait regarding fecundity revealed that the highest fecundity 607 (no.) was observed in line-15 and followed by 603 in line11among all the lines and a lowest of 444 (no.) was recorded in line-1. The trait hatching percentage was observed maximum of 99.52% in line-16 and a minimum percentage of 94.96 was recorded in line-21 (Fig. 1). Similarly, cocoon yield/10,000 larvae by number were maximum 9820 in line-17 and the minimum 9100 in line-4 and yield by weight (kg)/10,000 larvae was maximum 15.80 in line1-18, whereas minimum 13.36 in line-11. Further, single cocoon weight (Fig. 2), Single shell weight (Fig. 3) and shell ratio (Fig. 4) were observed 1.848 g, 0.38 g, and 21.38% were highest in line-1, line-1 and line-3 respectively. The filament length of 990 meters was recorded highest in line-3 and pupation rate was found above 90% in all lines and the maximum was 96% in line-6. Further, it is very interesting to know regarding the improvement of qualitative and quantitative traits among all the selected lines. The data obtained in regards to rearing performance of F9 generation revealed that, among all the selected eighteen breeding lines, the higher shell ratio of 21.38 % was recorded in line-3 and filament length greater of 990 (m) in the same line-03. For the trait, pupation rate was found above 90% (>90%) in all the selected autumn specific lines and highest of 96% was exhibited in line-5.
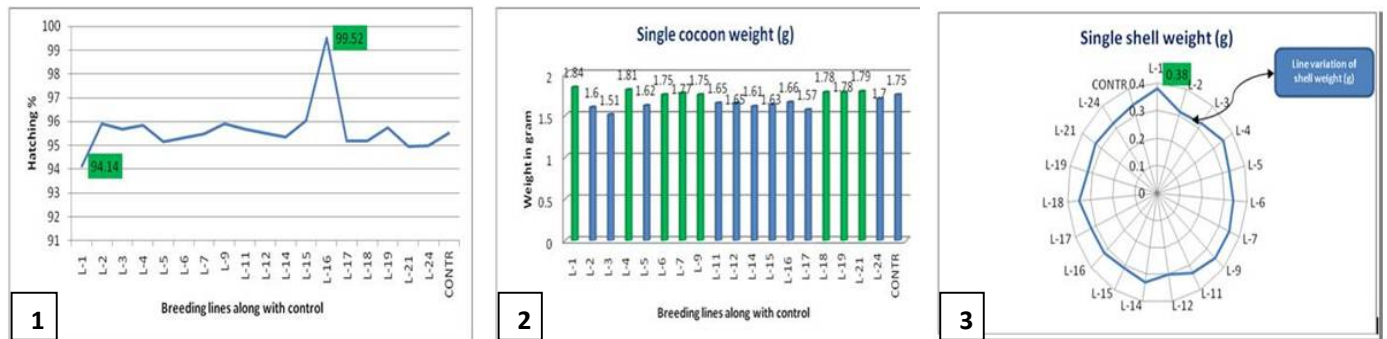

Fig. 1: Variation of hatching percentage among autumn specific breeding lines at F9 generation of the silkworm *B. mori* L.

Fig. 2: Single cocoon weight among autumn specific breeding lines at F9 generation of the silkworm *B. mori* L.

Fig. 3: single shell percentage among autumn specific breeding lines at F9 generation of the silkworm *B. mori* L.
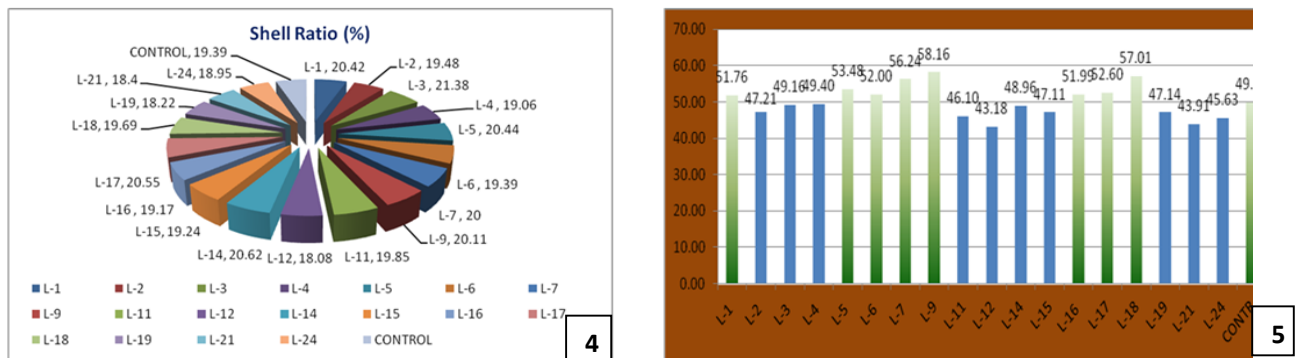

Fig. 4: Variation of shell ratio (%) among autumn specific breeding lines at F9 generation of the silkworm *B. mori* L.

Fig. 5: Multi-traits evaluation index among autumn specific breeding lines at F9 generation of the silkworm *B. mori* L.

The positive influence of qualitative and quantitative traits towards quality cocoon production- There was an increase of qualitative and quantitative traits observed *viz.,* fecundity (no.), hatching (%), single cocoon weight (g), single shell weight (g), shell ratio (%), filament length (m) and pupation rate(%) were noticed with an increase of 45no., 4.02%, 0.09g, 0.04g, 1.99%, 240m and 2.00% respectively over the control (SH6 × NB4D2).

Multi-traits evaluation index- The data obtained was subjected to the statistical analysis of multi- traits evaluation index of F9 generation during spring season was presented in Table 2 and the same was represented as Fig. 5. The results obtained was clearly shown, line-9 (58.16) was exhibited highest index value among all autumn specific breeding lines under study. Further, out of 18 lines under the study, there were 08 autumn specific breeding lines (line-1, line-5, line-6, line-7, line-9,

line-16, line-17, and line-18) have recorded the >50 index values (Table 2 and Fig. 5), which is considered as economically viable autumn specific breeding lines. The index value along with the mean of all the traits and standard deviation are presented in the same table. Further, statistically analyzed data in regards to mean evaluation index of selected traits was given as per their rank for all the breeding lines and it was found that highest index value of 58.16 was observed in line-9 (1st rank) and followed by line-18 (57.01), line-7 (56.24), line-5 (53.48), line-17 (52.60), line-6 (52.00), line-16 (51.99), line-1 (51.76), and remaining lines exhibited <50 index values, which is economically not viable. The details regarding photographs of larvae and cocoon of highest index values (>50) autumn specific lines along with a control (SH6 × NB4D2), which are economically viable are represented as figures with silkworm larvae (Fig. 6 to 14) and silkworm cocoons (Fig. 15 to 23).

Table 2: Multi-traits evaluation index of selected traits of 18 autumn specific lines along with a control (SH6×NB4D2) of bivoltine silkworm at F9 generation of silkworm *B. mori* L.

Traits / Lines	Fecundity (no.)	Hatching (%)	Yield/10,000 By no.	Yield/10,000 By wt. (kg)	Single Cocoon Wt (g)	Single Shell Wt (g)	Shell Ratio (%)	Pupation Rate (%)	Filament Length (m)	Mean EI of all the traits	Ranking of lines
Line-1	28.08	35.58	52.21	68.05	65.56	75.00	59.43	41.49	40.47	51.76	8
Line -2	44.36	52.60	52.21	41.84	38.89	40.00	48.62	55.00	51.40	47.21	13
Line -3	42.62	50.48	52.21	31.72	28.89	45.00	70.46	55.00	66.09	49.16	11
Line -4	55.21	52.12	32.64	37.70	62.22	60.00	43.79	48.24	52.69	49.40	10
Line -5	54.34	45.29	61.57	47.59	41.11	50.00	59.66	68.51	53.23	53.48	4
Line -6	51.52	46.83	40.30	52.07	55.56	55.00	47.59	55.00	64.16	52.00	6
Line -7	42.40	48.37	64.98	65.75	57.78	60.00	54.60	55.00	57.30	56.24	3
Line -9	61.72	52.50	59.87	61.72	55.56	60.00	55.86	61.76	54.41	58.16	1
Line -11	62.59	50.48	38.60	40.00	44.44	50.00	52.87	34.73	41.22	46.10	16
Line -12	58.68	48.65	47.96	45.63	44.44	35.00	32.53	41.49	34.26	43.18	19
Line -14	38.71	47.31	60.72	46.09	40.00	50.00	61.72	48.24	47.87	48.96	12
Line -15	63.46	53.94	49.66	43.68	42.22	40.00	45.86	48.24	36.94	47.11	15
Line -16	46.96	87.31	47.96	46.21	45.56	45.00	45.06	41.49	62.34	51.99	7
Line -17	54.12	45.58	63.28	43.10	35.56	45.00	60.92	61.76	64.05	52.60	5
Line -18	55.86	45.77	59.87	65.40	58.89	60.00	51.03	61.76	54.51	57.01	2
Line -19	59.98	50.96	38.60	54.60	58.89	45.00	34.14	34.73	47.33	47.14	14

Line -21	36.98	43.46	36.04	54.37	60.00	50.00	36.21	34.73	43.37	43.91	18
Line -24	39.80	43.65	51.36	52.07	50.00	45.00	42.53	48.24	38.01	45.63	17
Control (SH6XNB4D2)	53.69	48.65	40.30	52.07	55.56	55.00	47.59	55.00	40.37	49.80	9

Fig. 6, 7, 8: Larvae of shortlisted lines *viz.*, line-1, line-5 and line-6 at F9 generation of the silkworm *B. mori* L.

Fig. 9, 10, 11: Larvae of shortlisted lines *viz.*, line-7, line-9 and line-16 at F9 generation of the silkworm *B. mori* L.

Fig.12, 13, 14: Larvae of shortlisted lines *viz.*, line-17, line-18 and control (SH6×NB4D2) at F9 generation of the silkworm *B. mori* L.

Fig.15, 16, 17: Cocoon of shortlisted lines *viz.*, line-1, line-5 and line-6 at F9 generation of the silkworm *B. mori* L.

Fig. 18, 19, 20: Cocoons of shortlisted lines *viz.*, line-7, line-9 and line-16 at F9 generation of the silkworm *B. mori* L.

Fig. 21, 22, 23: Cocoons of shortlisted lines *viz.*, line-17, line-18 and control (SH6×NB4D2) at F9 generation of the silkworm *B. mori* L.

DISCUSSION

The results from Table 1 in regards to rearing performance revealed, among all the eighteen autumn specific lines. Higher shell ratio was recorded of 21.38% in line-3 and greater filament length was also observed at 990 (m) in the same line. For the trait, pupation rate was found >90 in all the autumn specific lines and highest of 96 exhibited in line-5. Hence, an increase of qualitative and quantitative traits observed *viz.,* fecundity (no.), hatching percentage (%), single cocoon weight(g), single shell weight(g), shell ratio(%), filament length(m) and pupation rate(%) was noticed with an increase of 45no., 4.02%, 0.09 g, 0.04 g, 1.99%, 240 m and 2.00% respectively over the control (SH6 × NB4D). The breeding lines, which exhibited superior performance will serve as the base material for further selection as breeding resource material and also judging superiority of traits through evaluation index (Perkins and Jink [17], Freeman and Perkins [19], Anantha and Subramanya [22], Shiv and Subramanya [23]).

Further, data in regards to the multi-traits evaluation index of selected traits of 18 autumn specific lines along with a control (SH6×NB4D2) of bivoltine silkworm at F9 generation of silkworm *B. mori* L (Table 2) clearly showed that, out of 18 lines under study, eight lines *viz.*, line-1,

line-5, line-6, line-7, line-9, line-16, line-17, and line-18 have shown higher index values (>50). The results obtained under the present study slightly corroborate with the results of [22,23]. Furthermore, economic parameters influenced significantly on the improvement of traits over the control and have economically importance, which was documented by several researchers (Masrat *et al.* [24], Maqbool *et al.* [25]).

The further performance of these lines not only depends on the quantitative traits but also on their adaptability under diverse environmental conditions during the autumn season in temperate climatic condition of Kashmir. Such variable performance of the races/breeds and seasonal influences on the performance of the races/ breeds/ livestock animals are very well documented by several breeders (Perkins and Jink [17], Sengupta [18], Freeman and Perkins [19], Krishnaswami and Narasimhanna [20], Subramanya and Murakami [21], Anantha and Subramanya [22], Shiv and Subramanya [23]). Further, several attempts were made in the temperate zone [2,3], Malik *et al.* [4], Nisar *et al.* [8], Masrat *et al.* [24], Maqbool *et al.* [25] and Shabir *et al.* [26] and also few reports carried out in regards to the autumn season for short listing of the breeds/ races/ hybrids for commercialization of the second crop in the temperate

region of Kashmir (Malik *et al.* [5,7,27] and Nooruldin *et al.* [28], Shivkumar *et al.* [29] and Shivkumar *et al.* [30].

Hence, under the present research study, the lines identified (line-1, line-5, line-6, line-7, line-9, line-16, line-17, and line-18) have shown superior in performance at F9 generation can conveniently be utilized for developing high yielding autumn specific bivoltine stable breeds/hybrids. Further, after passing through proper test trials for the identified eight lines/breeds to check out its feasibility/stability to withstand at temperate climatic condition can conveniently be used for commercial exploitation at farmer's level during the autumn season in the temperate climatic condition of Jammu and Kashmir.

CONCLUSIONS

The present findings evaluated based on multi-traits E.I demonstrated that the eight (08) autumn specific breeding lines explained above expressed more favourable at F9 generation. Further, based on the E.I values of all the 18 lines revealed different values for E.I and it is needless to say that, the 08 lines *viz.,* line-1, line-5, line-6, line-7, line-9, line-16, line-17 and line-18 with >50 evaluation index values have shown significant influence on the expression of qualitative and quantitative traits and have economic importance under the study. Hence, obtained results from the study will conveniently be utilized for selecting best-breeding lines for evolving lines for the autumn season, conveniently be utilized for developing high yielding autumn specific bivoltine hybrids and can be used for commercial exploitation at farmer's level during the autumn in temperate climatic conditions of the Jammu and Kashmir.

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CONTRIBUTION OF AUTHORS
Research concept- Shivkumar
Research design- Shivkumar
Supervision- Mir Nisar Ahmad
Materials- Shivkumar
Data collection- Shivkumar, Bharath Kumar Neelaboina, Kiran R
Data analysis and interpretation- Shivkumar, Mir Nisar Ahmad
Literature search- Shivkumar, Bharath Kumar Neelaboina, Kiran R
Writing article- Shivkumar
Critical review- Mir Nisar Ahmad
Article editing- Shivkumar, Mir Nisar Ahmad
Final approval- S Roy Chowdhury

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