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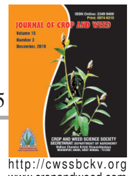

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Development of autumn specific silkworm stable breeds and hybrids for temperate climatic condition of Jammu and Kashmir

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ABSTRACT

This research work was conducted for development of autumn specific stable bivoltine breeds and hybrids by utilizing eighteen silkworm autumn specific lines (ASLs) and six autumn specific hybrids (ASH). These line/hybrids were developed, incubated and evaluated during autumn season as per the standard rearing procedure to identify stable breeds and hybrids suitable for temperate climatic conditions of Jammu and Kashmir (UT). The results obtained through EI at F9, F10 and F11 generations clearly showed that eight out of eighteen breeding lines (BLs) viz., Line-3, Line-5, Line-6, Line-7, Line-9, Line-16, Line-17 & Line-18 and four out of six ASHs viz., ASH-1, ASH-1R, ASH-3 and ASH-3R have exhibited higher index values (>50) and influenced significantly on the expression of traits with stable and have economically importance. Hence, the lines identified from the study can conveniently be utilized for developing stable and productive hybrids and also the hybrids developed i.e. ASH-1 & ASH-3 can be used for commercial exploitation at farmers level during the autumn season in temperate climatic condition of Jammu and Kashmir.

***Keywords*:** Development of ASH breeds/hybrids, stable and productive, temperate climate, Kashmir.

INTRODUCTION

Jammu and Kashmir is a traditional temperate sericulture Union Territory (UT) in India having temperate climate favorable for bivoltine silkworms rearing during spring season (April-May) and autumn season (August-September) at commercial level. It is important to understand the variation in climatic fluctuation from region to region and from season to season in India. Silk production has achieved remarkable growth In India during recent times and increased from 23,060 MT in 2011-12 to 35,820 MT in 2019-20 and in particularly, bivoltine raw silk production achieved 7009 MT during 2019-20. Jammu & Kashmir (UT), Himachal Pradesh, Uttarakhand, Haryana, Punjab and Uttar Pradesh have produced about 501 MT bivoltine raw silk during 2019-20 thus contributing 7.15% in the total bivoltine silk production and 1.40% in the total silk production of the country. The Northern and North western states of Indian region has a tremendous potential in contributing further in the total silk production of the country and rearing of recommended and authorized region and season specific hybrids will help to achieve the targets.

The silkworm rearing at farmers level is mainly conducted during spring season and only 10-15% farmer's conduct second rearing during summer (Sahaf *et al.,* 2016) in Kashmir. Till date very few silkworm breeds / hybrids has been developed for the spring season (Trag *et al.,* 1992, Kamili., 1996, Malik *et al.,* 2006 and 2010). Whereas, during summer, 10-15 per cent farmers take up sericulture in temperate regions of Kashmir (Sahaf *et al.,* 2016), few attempts have also been made for identification of hybrids for summer or autumn season (Farooq *et al*., 2006 ; Malik *et al.,* 2009 and Mir Ahmad *et al*., 2013). The cocoon productivity has been reported as 30 - 40 kg / 100 dfls in spring crop and 20-25 kg /100 dfls in autumn crop (Chauhan *et al*., 2008). The continuous inbreeding and interaction with environment has resulted in inbred depression (Faster, 1969). Harada (1961) reported that silkworm races will be developed by hybridization and selection technique. The univoltines and bivoltines are known for better quantitative characters with quality silk but they are sensitive to environmental and dietary stress. Exploitation of heterosis through single hybrids in silkworms for economic traits kicked a revolutionary development in overall qualitative and quantitative silk production (Gamo, 1976). Harada (1961), Pannegpet and Jaroonchai (1975) have researched on the superiority of single, three way and double hybrids over their parental races. Toyama (1906) introduced utilization of hybrid vigour for development of new genotypes in 1901 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 but they are handicapped by less number of eggs laid by inbred pure mother moth. But unless, the mother moth is a hybrid, the fecundity cannot be increased (Yokoyama, 1979). The advocated repeated

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back crossing method was followed by the Tazima (1964) for the improvement of cocoon quality and some minor works were also made in India for success of autumn crop at temperate zone of Kashmir (Farooq *et al*., 2006, Malik *et al.,* 2009 and Malik *et al.,* 2010 & 2010a).

It has been a challenge since several years for the development of autumn specific silkworm genotypes for temperate climatic conditions in North West India and autumn rearing is being remained with high temperature and high humidity. Because of higher pathogen load and inferior quality of mulberry leaf at farmers' field which affect the crop loss under temperate conditions, although the temperature is not high, 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 in the region. Hence, development of stable and productivity bivoltine breeds and hybrids during autumn season in temperate climatic condition is urgent need of the hour to the farmers of North West India for commercial utilization.

MATERIALS AND METHODS

Eighteen (18) breeding lines of F9, F10 and F11 generations comprising of different geographical combinations of bivoltine silkworms were selected for the research work. Parental seeds of the said races/ breeds were procured from the Central Sericultural Research & Training Institute (CSR&TI), Mysore (CSR2, CSR26, CSR27, CSR50 & CSR52), Andhra Pradesh State Sericulture Research and Development Institute, Hindupur, Andhra Pradesh (APS4, APS5 & APS9) and CSR&TI, Pampore (Pam101 & Pam117) along with control (SH6 and NB4D2). The partial diallel method was followed for the preparation of different crossing combinations in the Silkworm Breeding and Genetics laboratory of CSR&TI, Pampore during first season of the year 2016. Five (05) breeding lines (line-5, line-7, line-9, line-17 and line-18) with high ranking were selected and crossing was made between Line-1× Line-7, Line-18× Line-9 and Line-17× Line-9 and F11 seed was produced during summer 2019 and three hybrids were prepared designated as ASH-1 (Autumn Specific Hybrid-1), ASH-2 and ASH-3 along with three reciprocal ASHs. These hybrids were reared during autumn, 2019 along with 18 lines of F11 generation through the methods advised by Tazima (1978) and Krishnaswami (1978). The initial stages silkworm larvae (chawki) were fed with quality mulberry leaves of Ichinose and later stages silkworm larvae (late age) were fed with Goshoerami mulberry leaves. Assessment of the comparative performance of the 6 hybrids along with 18 autumn specific lines was done for targeted traits *viz.,* fecundity (no.), hatching percentage (H in %), yield by number / 10,000 larvae brushed (no.), yield by weight/ 10,000 larvae brushed (kg), single cocoon weight (SCW in g), single shell weight (SSW in g), shell ratio (SR in %), pupation rate (PR) and filament length (FL in m). The obtained data was further statistically evaluated through multi-traits evaluation Index method which was designed by Mano *et al.* (1993) as details given below.

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

Where,

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

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

C : Standard Deviation of particular trait of all the particular hybrids/lines

10 : Standard Unit & 50: Fixed Value.

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

RESULTS AND DISCUSSION

Results of rearing performance of 18 autumn specific breeding lines along with a control (SH6×NB4D2) at F9 generation were obtained by recording the traits *viz*., Fecundity (No,), Hatching %, Larval weight (g), Yield /10,000 larvae by no. and by weight (kg), Single cocoon weight (g), Single shell weight (g), Shell ratio (%), Pupation rate, Filament length (m) along with statistical analysis of multi- traits evaluation index as shown in Table 1.

The perusal of data in regards to the 18 autumn specific breeding lines along with a control (SH6×NB4D2) at F9 generation reveals that the highest fecundity 607 (no.) was observed in line-15 followed by 603 in line11among all the lines and the lowest of 444 (no.) was recorded in line-1. The trait hatching percentage was observed maximum 99.52% in line-16 and a minimum percentage 94.96 was recorded in line-21. Similarly, cocoon yield by 10,000 larvae by number was 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, SCW, SSW and SR were observed 1.848g, 0.38g & 21.38% were highest in line-1, line-1 and line-3 respectively. The FL of 990m was recorded highest in line-3 and pupation rate was found above 90% in all hybrids and maximum was 96% in line-6. Besides,

Table 1: Rearing performance of autumn specific breeding lines at F9 generation

Traits Lines	Fec. (No)	Hat. (%)	Yield / 10, 000 larvae brushed		SCW (g)	SSW (g)	SR (%)	Pup. rate (%)	Fil. Length (m)	Average E.I
			By No.	By Wt.(kg)						
Line-1	444	94.14	9560	15.80	1.84	0.38	20.42	92	751	51.76
Line -2	519	95.91	9560	13.52	1.60	0.31	19.48	94	853	47.21
Line -3	511	95.69	9560	12.64	1.51	0.32	21.38	94	990	49.16
Line -4	569	95.86	9100	13.16	1.81	0.35	19.06	93	865	49.40
Line -5	565	95.15	9780	14.02	1.62	0.33	20.44	96	870	53.48
Line -6	552	95.31	9280	14.41	1.75	0.34	19.39	94	972	52.00
Line -7	510	95.47	9860	15.60	1.77	0.35	20.00	94	908	56.24
Line -9	599	95.90	9740	15.25	1.75	0.35	20.11	95	881	58.16
Line -11	603	95.69	9240	13.36	1.65	0.33	19.85	91	758	46.10
Line -12	585	95.50	9460	13.85	1.65	0.30	18.08	92	693	43.18
Line -14	493	95.36	9760	13.89	1.61	0.33	20.62	93	820	48.96
Line -15	607	96.05	9500	13.68	1.63	0.31	19.24	93	718	47.11
Line -16	531	99.52	9460	13.90	1.66	0.32	19.17	92	955	51.99
Line -17	564	95.18	9820	13.63	1.57	0.32	20.55	95	971	52.60
Line -18	572	95.20	9740	15.57	1.78	0.35	19.69	95	882	57.01
Line -19	591	95.74	9240	14.63	1.78	0.32	18.22	91	815	47.14
Line -21	485	94.96	9180	14.61	1.79	0.33	18.40	91	778	43.91
Line -24	498	94.98	9540	14.41	1.70	0.32	18.95	93	728	45.63
Control	562	95.50	9280	14.41	1.75	0.34	19.39	94	750	49.80
Average	**545**	**95.64**	**9508**	**14.23**	**1.70**	**0.33**	**19.60**	**93.26**	**839.89**	**-**
SD	**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) & Control (SH6×NB4D2).*

Table 2: Rearing performance of autumn specific breeding lines at F10 generation

Traits Lines	Fec. (No)	Hat. (%)	Yield / 10, 000 larvae brushed		SCW (g)	SSW (g)	SR (%)	Pup. rate (%)	Fil. Length (m)	Average E.I
			By No.	By Wt.(kg)						
Line-1	442	92.84	8220	11.96	1.68	0.32	19.10	82	741	40.99
Line -2	450	92.60	8540	11.86	1.60	0.30	18.47	85	810	41.35
Line -3	509	94.05	9740	14.81	1.71	0.34	19.97	93	840	57.94
Line -4	493	94.03	8600	12.51	1.59	0.29	17.92	86	750	42.85
Line -5	511	94.28	9500	14.59	1.73	0.37	21.30	92	851	59.84
Line -6	547	94.45	9500	14.26	1.69	0.34	20.15	93	874	58.79
Line -7	550	94.74	9740	14.90	1.72	0.35	20.58	92	863	61.02
Line -9	531	94.06	9620	14.89	1.74	0.36	20.58	93	877	60.88
Line -11	558	93.92	8900	13.06	1.65	0.31	18.58	88	741	48.59
Line -12	445	91.96	8940	12.99	1.65	0.29	17.24	88	756	42.06
Line -14	518	93.81	8880	12.25	1.58	0.30	18.64	89	800	46.50
Line -15	488	93.40	9060	12.46	1.57	0.29	18.10	90	799	45.22
Line -16	553	94.42	9540	14.03	1.66	0.35	20.83	93	856	58.77
Line -17	499	94.45	9720	14.58	1.69	0.35	20.47	94	847	58.66
Line -18	513	94.31	9640	14.20	1.66	0.34	20.18	93	835	56.64
Line -19	446	93.61	8840	12.26	1.59	0.28	17.30	88	745	41.18
Line -21	510	94.06	8940	12.15	1.56	0.26	16.35	88	746	41.55
Line -24	441	90.19	8720	12.06	1.59	0.28	17.30	86	723	36.00
Control	474	94.34	8220	11.60	1.63	0.30	18.10	90	750	45.36
Average	**499**	**94**	**9140**	**13**	**1.65**	**0.32**	**19.01**	**89.63**	**800.21**	**-**
SD	**40**	**1.10**	**468.24**	**1.20**	**0.06**	**0.03**	**1.47**	**3.37**	**53.76**	**-**

Table 3: Rearing performance of autumn specific breeding lines at F11 generation during autumn, 2019

Traits Lines	Fec. (No)	Hat. (%)	Yield / 10, 000 larvae brushed		SCW (g)	SSW (g)	SR (%)	Pup. rate (%)	Fil. Length (m)	Average E.I
			By No.	By Wt.(kg)						
Line-1	483	93.03	9560	13.93	1.65	0.33	19.76	92	759	49.61
Line -2	485	93.73	9500	13.54	1.62	0.31	18.89	92	734	46.48
Line -3	527	94.25	9840	14.53	1.66	0.34	20.18	95	902	58.05
Line -4	441	92.89	9280	13.15	1.6	0.3	18.50	90	744	41.09
Line -5	495	93.40	9500	14.26	1.69	0.36	21.04	93	893	57.05
Line -6	489	93.80	9800	14.91	1.71	0.36	20.82	94	911	59.69
Line -7	500	92.18	9860	14.91	1.70	0.36	21.06	96	950	59.86
Line -9	499	93.00	9800	15.20	1.74	0.36	20.78	95	890	60.41
Line -11	436	92.95	9360	13.35	1.62	0.30	18.61	90	750	42.18
Line -12	413	91.00	9180	13.53	1.67	0.33	19.46	89	801	43.63
Line -14	430	90.33	8900	12.62	1.62	0.32	19.44	88	778	39.11
Line -15	485	93.97	8960	12.67	1.61	0.31	19.20	89	789	44.10
Line -16	462	94.07	9860	14.77	1.68	0.35	20.83	95	922	58.20
Line -17	520	94.00	9840	14.73	1.68	0.35	20.83	95	888	59.45
Line -18	510	93.88	9860	14.72	1.68	0.34	20.54	94	915	58.20
Line -19	472	93.63	8700	12.3	1.62	0.30	18.52	86	776	39.96
Line -21	466	93.63	8820	12.53	1.63	0.30	18.46	89	701	40.54
Line -24	441	91.22	8700	12.47	1.64	0.31	18.60	86	762	37.78
Control	529	93.84	9460	13.72	1.64	0.32	19.21	93	844	51.51
Average	**478**	**93.09**	**9409**	**13.78**	**1.66**	**0.33**	**19.72**	**91.63**	**826.79**	**-**
SD	**34**	**1.13**	**422.55**	**0.97**	**0.04**	**0.02**	**0.99**	**3.18**	**78.25**	**-**

Table 4: Rearing performance of pooled data of F9, F10 and F11 generations during the year 2019

Traits Lines	Fec. (No)	Hat. (%)	Yield / 10, 000 larvae brushed		SCW (g)	SSW (g)	SR (%)	Pup. rate (%)	Fil. Length (m)
			By No.	By Wt.(kg)					
Line-1	456	93.34	9113	13.90	1.72	0.34	19.76	88.67	750
Line -2	485	94.08	9200	12.97	1.61	0.31	18.95	90.33	799
Line -3	516	94.66	9713	13.99	1.63	0.33	20.51	94.00	911
Line -4	501	94.26	8993	12.94	1.67	0.31	18.49	89.67	786
Line -5	524	94.28	9593	14.29	1.68	0.35	20.93	93.67	871
Line -6	529	94.52	9527	14.53	1.72	0.35	20.12	93.67	919
Line -7	520	94.13	9820	15.14	1.73	0.35	20.55	94.00	907
Line -9	543	94.32	9720	15.11	1.74	0.36	20.49	94.33	883
Line -11	532	94.19	9167	13.26	1.64	0.31	19.01	89.67	750
Line -12	481	92.82	9193	13.46	1.66	0.31	18.26	89.67	750
Line -14	480	93.17	9180	12.92	1.60	0.32	19.57	90.00	799
Line -15	527	94.47	9173	12.94	1.60	0.30	18.85	90.67	769
Line -16	515	96.00	9620	14.23	1.67	0.34	20.28	93.33	911
Line -17	528	94.54	9793	14.31	1.65	0.34	20.62	94.67	902
Line -18	532	94.46	9747	14.83	1.71	0.34	20.14	94.00	877
Line -19	503	94.33	8927	13.06	1.66	0.30	18.01	88.33	779
Line -21	487	94.22	8980	13.10	1.66	0.30	17.74	89.33	742
Line -24	460	92.13	8987	12.98	1.64	0.30	18.28	88.33	738
Control	522	94.56	9253	13.24	1.67	0.32	18.90	92.33	781
Average	**507**	**94.13**	**9353**	**13.75**	**1.67**	**0.33**	**19.44**	**91.51**	**822**
SD	**25.58**	**0.81**	**315.20**	**0.79**	**0.04**	**0.02**	**1.01**	**2.33**	**69.04**

Table 5: Multi- traits evaluation index on pooled data of three generations (F9, F10 and F11) during the year 2019.

Traits Lines	Fec. (No)	Hat. (%)	Yield / 10, 000 larvae brushed		SCW (g)	SSW (g)	SR (%)	Pup. rate (%)	Fil. Length (m)	Average E.I
			By No.	By Wt.(kg)						
Line-1	30.04	40.25	42.41	51.90	63.47	58.50	53.12	37.78	39.58	46.34
Line -2	41.12	49.38	45.16	40.17	35.99	40.73	45.09	44.95	46.63	43.25
Line -3	53.24	56.55	61.44	53.12	40.70	53.66	60.52	60.71	62.80	55.86
Line -4	47.50	51.59	38.60	39.75	50.12	43.96	40.61	42.08	44.79	44.33
Line -5	56.37	51.80	57.64	56.89	53.26	63.35	64.63	59.28	57.10	57.81
Line -6	58.58	54.79	55.52	59.90	61.90	60.12	56.67	59.28	64.01	58.97
Line -7	54.93	50.00	64.83	67.64	65.04	63.35	60.88	60.71	62.27	61.07
Line -9	63.92	52.33	61.66	67.35	68.18	64.97	60.32	62.14	58.74	62.18
Line -11	59.75	50.69	44.10	43.77	43.84	43.96	45.74	42.08	39.48	45.94
Line -12	39.68	33.90	44.95	46.31	47.77	40.73	38.31	42.08	39.53	41.47
Line -14	39.42	38.16	44.52	39.49	35.21	45.58	51.21	43.51	46.67	42.64
Line -15	57.54	54.21	44.31	39.70	35.21	39.11	44.10	46.38	42.23	44.76
Line -16	53.11	73.01	58.48	56.17	50.12	56.89	58.22	57.84	62.85	58.52
Line -17	57.93	55.07	63.98	57.19	45.41	56.89	61.57	63.57	61.54	58.13
Line -18	59.49	54.09	62.50	63.75	59.54	58.50	56.83	60.71	57.97	59.27
Line -19	48.29	52.41	36.49	41.31	49.34	37.50	35.87	36.35	43.68	42.36
Line -21	42.03	51.06	38.18	41.74	48.55	35.88	33.14	40.65	38.32	41.06
Line -24	31.47	25.43	38.39	40.25	44.63	39.11	38.54	36.35	37.74	36.88
Control	**55.58**	**55.28**	**46.85**	**43.60**	**51.69**	**47.19**	**44.62**	**53.54**	**44.07**	**49.16**

Table 6: Rearing performance of autumn specific hybrids during autumn, 2019

Traits Hybrids	Fec. (No)	Hat. (%)	Yield / 10, 000 larvae brushed		SCW (g)	SSW (g)	SR (%)	Pup. rate (%)	Fil. Length (m)	Average E.I
			By No.	By Wt.(kg)						
ASH-1 (Line-5 × Line -7)	508	93.25	9860	14.91	1.70	0.36	20.94	95	942	61.18
ASH-1 (Reciprocal)	500	92.11	9820	14.60	1.67	0.34	20.06	94	819	51.49
ASH-2 (Line -18 × Line -9)	460	92.41	9100	13.35	1.67	0.34	20.12	90	748	43.69
ASH-2 (Reciprocal)	425	90.30	8980	13.02	1.65	0.33	19.70	89	829	37.98
ASH-3 (Line -17 × Line -9)	514	94.50	9880	14.80	1.68	0.35	20.83	95	931	59.67
ASH-3 (Reciprocal)	512	93.24	9240	13.72	1.68	0.35	20.54	91	828	51.09
Control	529	93.84	9460	13.72	1.64	0.32	19.21	93	844	45.96
Mean	**492.57**	**92.81**	**9477**	**14.02**	**1.67**	**0.34**	**20.20**	**92.43**	**848.71**	**-**
ST Dev.	**36.71**	**1.37**	**381.3**	**0.75**	**0.02**	**0.01**	**0.62**	**2.44**	**67.50**	**-**

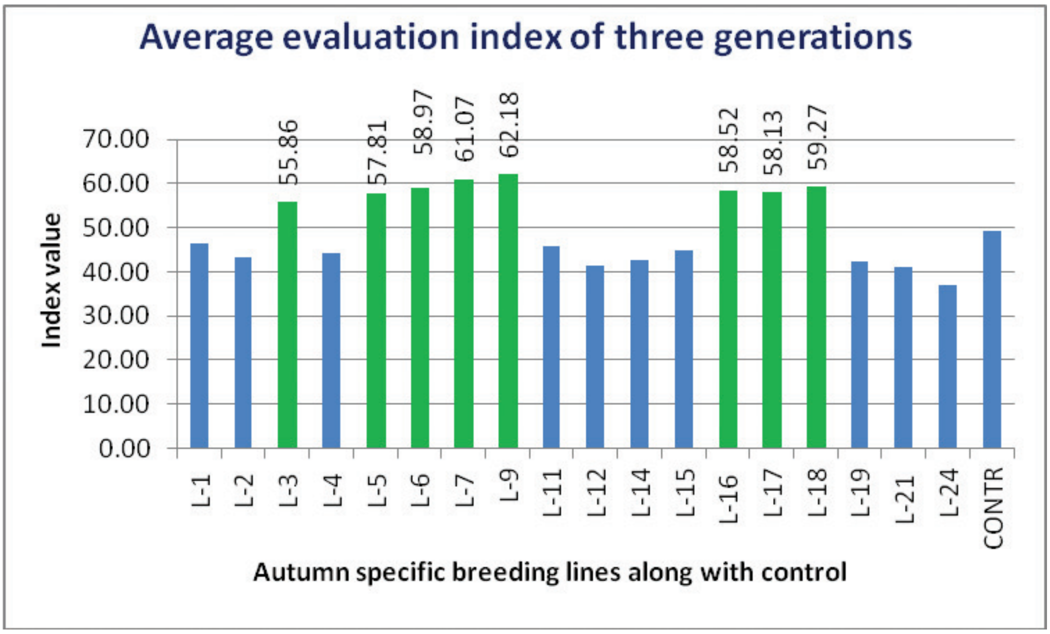

Fig. 1: Showing variation of multi- traits evaluation index values on pooled data of three generations (F9, F10 and F11) during the year 2019.

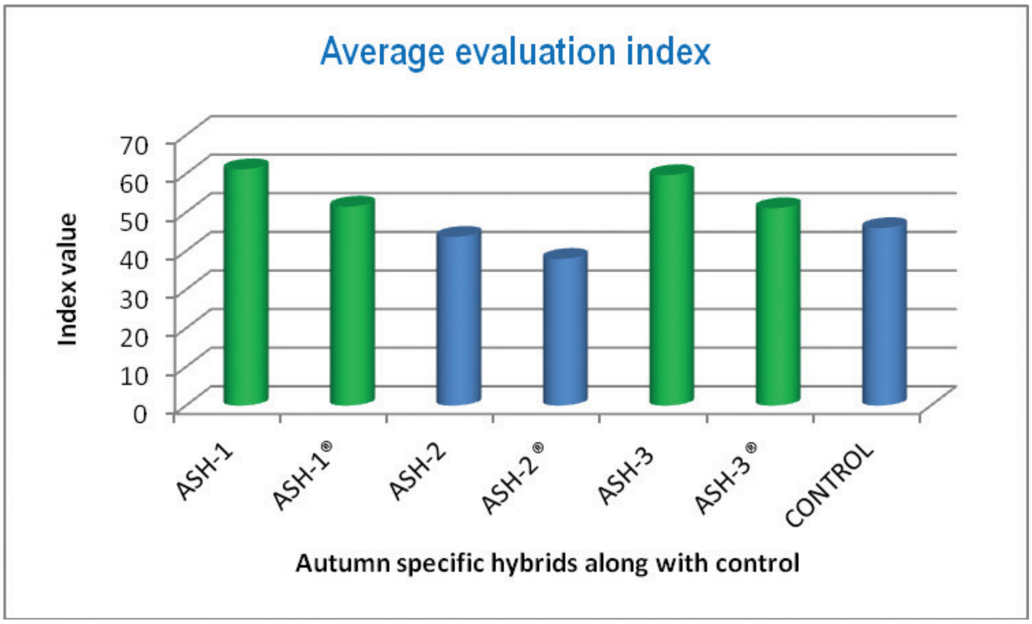

Fig. 2: Multi- traits evaluation index autumn specific hybrids during autumn, 2019.

the data obtained was subjected to the statistical analysis of multi- traits evaluation index, the line-9 (58.16) exhibited highest index value among all autumn specific breeding lines under study. Further, out of 18 lines under the study, total 08 autumn specific breeding lines (line-1, line-5, line-6, line-7, line-9, line-16, line-17, line-18) have recorded the >50 index values, which is considered as economically viable autumn specific breeding lines. The index value with suitable mean of all the traits and SD are presented in the same table.

Further, the data pertaining to the rearing performance of 18 autumn specific breeding lines at F10 generation along with a control is given in Table 2. The data pertaining to the trait, fecundity (558) was the highest in line-11, whereas a 441 (no. fecundity) was recorded the lowest in line-24. The maximum hatching percentage (94.74) was found in line-7 and minimum (90.19) was recorded in line-24. The traits yield by 10,000 larvae by greater number of 9740 cocoons was recorded in line-3 and line-7 and by weight (14.90kg) was exhibited highest in line-7. Regarding SCW (1.74g), SSW (0.37g) and SR (21.30%) were found maximum in line-9, line-5 and line-5 respectively. The traits pertaining to the pupation rate higher was recorded in line-3, line-6, line-9, line-16 and line-18 with 93% and as well filament length of 877 metre was observed in line-9 at F10 generation. The highest index value was recorded by line-7 with 61.02 index value and out of 18 autumn specific breeding lines along with a control under the study, 08 breeding lines exhibited excellent index value by recording >50 index value, which were considered as economically viable autumn specific breeding lines at F10 generation. The index value along with mean of all the traits and standard deviation are presented in the same table.

The data pertaining to the rearing performance of 18 autumn specific breeding lines along with control during autumn season 2019 at F11 generation is presented in the Table 3 along with a control. The highest fecundity (527) was observed in line-3 followed by 520 in line-17, 510 in line-18 among all the autumn specific breeding lines. Hatching percentage was observed the maximum (94.25) in line-3 and minimum of 90.33 was exhibited by line-14. Similarly, cocoon yield/10,000 larvae by number was maximum (9860) in line-7, line-16 and line-18 and yield by weight (kg)/10,000 larvae was maximum 15.20 in line-9. Further, single cocoon weight of 1.74g was recorded highest in line-9, single shell weight of 0.39g was found in four lines (line-5, line-6, line-7 & line-9) and shell ratio (21.06%) was observed highest in line-7. The pupation rate was found around 90% in all lines and maximum of 96% was in line-7. The data obtained during autumn 2019 was subjected to statistical analysis of multi- traits evaluation index, out of 18 autumn specific breeding lines under the study along with a control, 8 lines (line-3, line-5, line-6, line-7, line-9, line-16, line-17 & line-18) exhibited excellent index value by recording >50 index value, which were considered as economically viable hybrids and among all the 18 autumn specific breeding lines, the highest index value (60.41) was recorded by line-9. Besides, values of control for all the parameters along with average values and standard deviation are being shown in the same table.

Further, the data in regards to the rearing performance of 18 autumn specific breeding lines of pooled data of F9, F10 and F11 generations during year 2019 along with a control is exhibited in Table 4. The data pertaining to the trait, fecundity 543 (no.) was the highest in line-9, whereas 456 (no. fecundity) was recorded the lowest in line-1. The maximum hatching percentage (96.00) was found in line-16 and minimum (92.13) was recorded in line-24. The traits yield by 10,000 larvae by greater no. of 9820 cocoons was recorded in line-7 and by weight 15.14 kg was exhibited highest in line-7. Regarding SCW (1.74g), SSW (0.36g) and SR (20.93%) were found maximum in line-9, line-9 and line-5 respectively. The traits pertaining to the PR higher was recorded in line-17 with 94.67% and as well filament length 919 m was observed in line-6. The index value along with mean of all the traits and standard deviation are presented in the same table. Further, the data obtained at three generations (F9, F10 and F11) during year 2019 was subjected to statistical analysis of multi- traits evaluation index, the highest index value was recorded by line-9 with 62.18 index value and out of 18 autumn specific breeding lines along with a control under the study, 8 breeding lines *viz.,* line-3 (55.86), line-5 (57.81), line-6 (58.97), line-7 (61.07), line-9 (62.18), line-16 (58.52), line-17 (58.13) and line-18 (59.27) exhibited excellent index value by recording >50 index value, which were considered as economically viable autumn specific breeding lines of pooled data of F9, F10 and F11 generations during three different seasons of year 2019 (Table 5 and Fig.1).

Further, five lines *viz.*, line-5, line-7, line-9, line-17 and line-18 were shortlisted for midterm evaluation at F10 generation. The crossing in oval into dumbbell and vice-versa pattern were carried out and three ASH (autumn specific hybrid) hybrids and their reciprocals *viz.*, ASH-1 (Line-5 × Line-9), ASH-1 (R), ASH-2 (Line-5 × Line -9), ASH-2 (R), ASH-3 & ASH-3 (R) were prepared and evaluated during autumn season 2019. The data regarding rearing performance of 3 hybrids and their reciprocals shortlisted for midterm evaluation during autumn season 2019 along with a control (SH6 × NB4D2) was presented in Table 6 and Fig. 2. The trait in regard to fecundity revealed that, the highest fecundity 514 (no.) was observed in ASH-3 and the lowest of 425 (no.) was recorded in ASH-2 (R). The trait hatching percentage was observed maximum (94.50%) in ASH-3 and a minimum percentage (90.30) was recorded in ASH-2. Similarly, cocoon yield/10,000 larvae by number was maximum (9880) in ASH-3 and yield by weight (kg)/ 10,000 larvae was maximum (14.91) in ASH-1, whereas minimum (13.02) was in ASH-2 (R). Further, SCW, SSW and SR were observed 1.70g, 0.36g and 20.94% the highest in ASH-1 alone. The FL of 942m was recorded highest in ASH-1 and PR was found above 90% in all hybrids and maximum was 95% was exhibited in respected two hybrids (ASH-1 and ASH-3). Besides, the data obtained was subjected to the statistical analysis of multi- traits evaluation index, the hybrid ASH-1 was exhibited highest index value (61.18) among all autumn specific hybrids under study. Further, four out of six autumn specific hybrids (ASH-1, ASH-1R, ASH-3 &

ASH-3R) have recorded the >50 index values (Table 6 and Fig. 2), which were considered as economically viable autumn specific hybrids. The index value with average of all the traits and SD are presented in the same table. The results obtained in the present study are in conformity with the earlier studies through evaluation in different region and season by Buhroo *et al.* (2016), Malik *et al.* (2006 and 2010), Naseema *et al.* (2000), Ahmad *et al.* (2005, 2008a & 2013), Nooruldin *et al.* (2014), Rayar (2007), Thiagarajan *et al*. (1993), Shivakumar and Subramanya (2010), Shivkumar *et al.,* (2018) and (2020), Kumar *et al.* (2018), Ahmad *et al.* (2019), Singh and Murali, (2019) and Singh, (2020).

CONCLUSION

The research finding which was evaluated through multi-traits index, eight breeding lines and four autumn specific hybrids have exhibited more favourable for autumn season in temperate region. Further, based on the E.I values of all the 18 lines and 6 hybrids revealed different values for E.I and it is needless to say that, the 8 lines and 4 hybrids with >50 evaluation index values have shown significant influence on the stable expression of qualitative, quantitative traits and higher productivity during F9, F10 and F11 generations of the year. Therefore, 08 lines *viz*., Line-3, Line-5, Line-6, Line-7, Line-9, Line-16, Line-17 and Line-18 will serve as base material for autumn specific hybrids development and were well stable in terms of expression of traits during autumn season in temperate region of Jammu and Kashmir. Further, outcome identified under the study, which are best performed autumn specific lines during autumn season in temperate region and best combination of promising bivoltine lines will be selected and taken up for identification of autumn specific hybrids for further evaluation in the temperate region of Jammu and Kashmir.

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