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Studies on improvement of quantitative traits of silkworm, *Bombyx mori* L. during autumn season under temperate climatic conditions of Kashmir

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Abstract

The present investigation was carried out to improve the selected quantitative traits under uniform laboratory conditions utilizing twenty five breeding lines (BL) of silkworm *Bombyx mori* L. during autumn season, 2017 in temperate climatic conditions of Kashmir. The breeding lines were reared over five generations and data were recorded as per the standard procedure for the calculation of all the quantitative traits namely, Fecundity (no.), hatching percentage, yield by number & weight (kg)/ 10,000 larvae brushed, single cocoon weight (g), single shell weight (g), shell ratio (%) and pupation rate (%). The data generated were subjected to the multiple trait evaluation index and among all the breeding lines, eighteen lines *viz.*, L-1, L-2, L-3, L-4, L-6, L-7, L-11, L-12, L-14, L-15, L-16, L-7, L-18, L-19, L-20, L-21, L-22 and L-24 exhibited better performance with >50 evaluation index values, L-4 & L-9 observed moderate and L-8, L-10, L-13, L-23 & L-25 recorded least evaluation index during autumn season.

Based on the results obtained from the study, the traits differences were observed between the twenty five breeding lines to be considered as the variable effects among the lines during autumn season. It is found that, the 18 lines with >50 evaluation index values have shown significant influence on the expression of quantitative traits and have economical importance under the study. Hence, obtained results from the study will conveniently be utilized for selecting best breeding lines for evolving suitable breeds during autumn season in temperate region of the Kashmir and will be helpful in the field of silkworm breeding and genetics programmes.

Keywords: Autumn season, *Bombyx mori*, Improvement, Multi-traits EI, Temperate region

1. Introduction

Jammu and Kashmir is a traditional sericulture state, which enjoys temperate climate congenial for bivoltine silkworms rearing during spring season (April-May). The commercial rearing in Kashmir is mainly conducted during spring season and only 10-15% farmers conduct second rearing during summer or autumn season. Till date limited number of silkworm breeds / hybrids has been developed for the spring season under temperate climatic conditions of Kashmir [34, 7, 14, 16]. Whereas, during summer 10-15 percent farmers take up sericulture in temperate regions of Kashmir [26], few attempts have also been made for identification of hybrids for summer or autumn season [4, 15, 22]. Over the years attempts were made to commercialize the second cocoon crop (autumn season) in the state, but has not been established on large scale so far, as the average yield is still around 25kg/100DFLs, which is not economically viable. Autumn crop is in practice since 1965 in North West India, which still needs to be established in full. As there is scope for second crop at commercial level during autumn season [4, 15], it is true to say that, non availability of desirable region/season specific silkworm breeds is also a constraint for popularization of the autumn crop. Department of Sericulture, J&K Government has expressed its concern that on commercial scale during autumn season, many popular productive silkworm breeds imported from other parts of the country frequently fail to yield consistent cocoon crop.

Breeding for autumn specific silkworm genotypes for temperate climatic conditions remained a challenge before silkworm breeders in North India. Under North Indian sub-tropical conditions, autumn rearing is entailed with high temperature and high humidity at initial stage of silkworm rearing. In addition, 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 desired autumn specific breeds/hybrids. The sericulturally advanced countries like China and Japan have succeeded in increasing the unit production of silk by evolving highly productive season/region specific bivoltine silkworm breeds suitable to their local conditions [35] and to gain the heterosis many breeders attempted for short listing of region and season specific of silkworm bivoltine races/breeds/hybrids in temperate belt of Kashmir [16, 13, 22, 19, 28].

However, it is important that, desired level of success in silkworm breeding depends on the selection of initial breeding materials followed by their effective utilization in different combinations to create genetic variability for selection. Though silkworm cocoon crop during spring season is well stabilised, the cocoon productivity is far below the national average (cocoon productivity level is around 60 kg per 100 DFLs of silkworm seed). The cocoon productivity during autumn season is much below the economic feasibility level. Therefore, to ensure the stable crops, it is very pertinent that breeds which can be reared successfully under poor rearing conditions of the farmers need to be developed. However, few reports available in regard to autumn season in China succeeded in evolving silkworm breeds suitable for summer and autumn rearings [31, 29, 6, 2, 37]. Apart, Japan also studied in regard to the seasons (summer and autumn) and evolved a good numbers of breeds and exploited commercially [21, 8, 3, 36] and few attempt were also made in India for success of autumn crop at temperate zone of Kashmir [4, 15, 16]. Hence, it is prime importance to study in detail as to why the autumn crop has not gained momentum so far, even though autumn crop is considered as second largest crop after the spring. Hence, in the present investigation, the authors have utilized twenty five breeding lines to understand the genetic differences during autumn season through biometrical tool of evaluation index under temperate climatic belt of Kashmir Valley.

2. Materials and Methods

The twenty five (25) bivoltine breeding lines of F5 generations comprising different combinations of bivoltine silkworm *Bombyx mori* were selected for the present investigation. Parental seed of the above said line's races/breeds were collected from the Germplasm Bank of 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 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. The layings of F5 generation of 25 breeding lines with control (SH6XNB4D2) were prepared during summer season, 2017 and rearing was conducted in autumn season, 2017 by adopting the methods described by Tazima [33] and Krishnaswami [9]. After incubation of eggs at 25 ± 1 temperatures and relative humidity of 80 ± 5%, three layings of each of the 25 breeding lines were selected for the experiment. The silkworm larvae were fed with suitable quality mulberry leaves for both young and late ages. For assessing the comparative performance of the 25 breeding line's was done for selected economic characters such as, fecundity, hatching percentage, yield by number / 10,000 larvae brushed, yield by weight/ 10,000 larvae brushed, single cocoon weight, single shell weight, shell percentage and pupation rate.

The data generated was subjected to evaluation by Evaluation Index method developed by Mano *et al.*, 1993 [18] 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 particular breeding line

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

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

10: Standard Unit &

50: Fixed Value.

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

3. Results and Discussion

The data pertaining to rearing performance for mean values of the eight economic traits in regard to twenty five bivoltine breeding lines during autumn season along with the statistical test are presented in Table-1. The results in regard to the traits fecundity (no.) and hatching percentage of 532 no. and 98.87% were higher in line-24 & line-23 and least (515 no. & 97.76) was depicted in line-3, line-9 and line-14 respectively (Fig.1). The maximum yield/10,000 larvae brushed by number (9667) and by weight (14.91kg) were recorded in line-21 & line-14 and were found significantly superior than remaining lines. The trait single cocoon weight (g) was found greater (1.588g) in line-1 (Fig.2) and single shell weight of 0.310g was noticed in case of line-18 superior than other lines of the study. Further, the data pertaining to the trait shell ratio was recorded maximum (19.83%) in line-3 and minimum of 17.12% was observed in line-8 (Fig.3). The pupation rate of 91.72 in Line-18 was found highest in comparison to other breeding lines studied. The results from Table-1 clearly depicts that the breeding lines which exhibited superior performance will serve as base material for further selection as breeding resource material. The further performance of these lines not only depends on the quantitative traits but also on their adaptability under diverse environmental conditions during 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/live stock animals are very well documented by several breeders *viz.*, [24, 27, 5, 10, 32, 25, 1, 30]. Further, several attempts were made in temperate zone [34, 7, 31, 12, 11, 14, 22, 20, 19, 28] and also few reports carried out in regards to autumn season for short listing of the breeds/races/hybrids for commercialization of second crop in temperate region of Kashmir [15, 16, 17, 23].

Further, the data pertaining to multi-traits evaluation index for F5 generation during autumn season was presented in Table-2 and same was represented as graph in Fig.4 (mean index values of all the traits). The 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 57.31observed in line-18 (1st rank) and followed by line-20 (55.80), line-22 (55.19), line-7 (54.31), line-24 (54.21), line-19 (54.09), line-12 (53.44), line-4 (53.19), line-21 (53.03), line-1 (52.67), line-15 (52.39), line-16 (52.32), line-3 (51.98), line-6 (51.54), line-14 (51.27), line-17 (51.12), line-11 (50.17), line-2 (50.09) and remaining lines exhibited <50 index values, which is economically not viable. The present findings, evaluated on the basis of multi-traits E.I clearly demonstrated that, the eighteen breeding lines explained above expressed more favourable under autumn season. Further, based on the E.I values of all the eighteen genotypes revealed different values for E.I and it is needless to say that, the 18 lines with >50 evaluation index values have shown significant influence on the expression of 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 suitable breeds during autumn season in temperate climatic conditions of the Kashmir Valley.

4. Conclusion

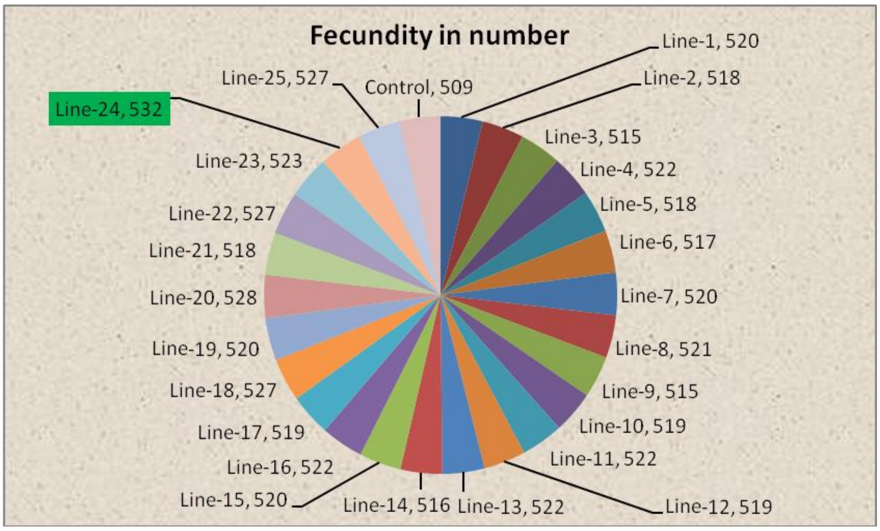
Perusal of the data through multi traits evaluation index reveals that out of 25 breeding lines, 18 breeding lines were exhibited >50 index value *viz*., line-18 (1st rank) with index value of 57.31 and followed by line-20 (55.80), line-22 (55.19), line-7 (54.31), line-24 (54.21), line-19 (54.09), line-12 (53.44), line-4 (53.19), line-21 (53.03), line-1 (52.67), line-15 (52.39), line-16 (52.32), line-3 (51.98), line-6 (51.54), line-14 (51.27), line-17 (51.12), line-11 (50.17) and line-2 (50.09) were economically viable at F5 generation during autumn season 2017. The 18 lines with index values of >50 have performed well in all the parameters during the autumn season when compared with the control. Hence, obtained results from the study will conveniently be utilized for selecting best breeding lines for evolving suitable breeds during autumn season in temperate region of the Kashmir and will be helpful in the field of silkworm breeding and genetics programmes.

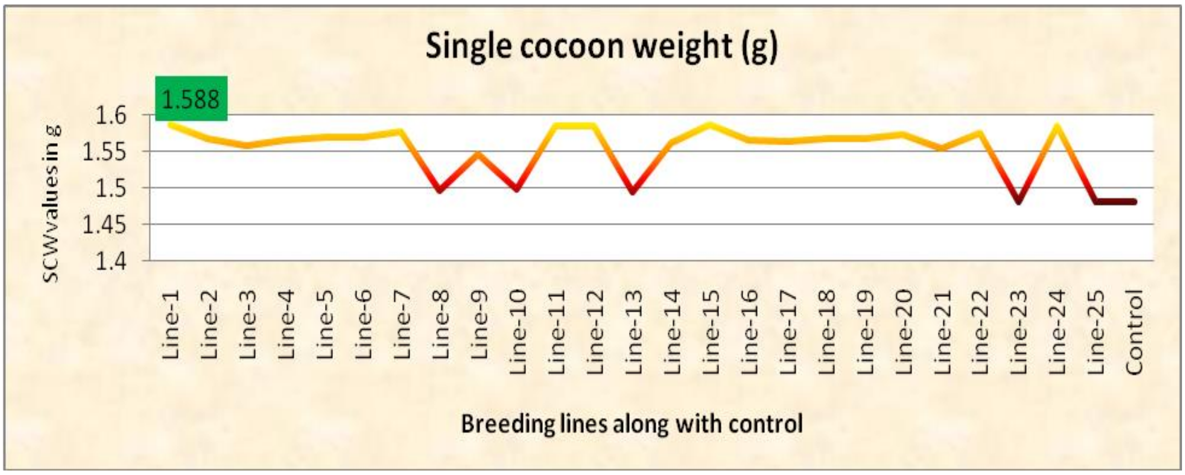
Table 1: Rearing performance of selected traits in F5 generation of silkworm bivoltine breeding lines during autumn season, 2017.

Traits Breeding lines	Fecundity (no.)	Hatching (%)	Yield/10,000 Larvae		Single Cocoon Weight (g)	Single Shell Weight (g)	Shell Ratio (%)	Pupation Rate (%)
			By no.	By wieght (kg)				
Line-1	520	98.03	9573	14.88	1.588	0.309	19.46	91.37
Line-2	518	98.22	9520	14.57	1.568	0.306	19.52	91.37
Line-3	515	98.48	9600	14.64	1.558	0.309	19.83	91.08
Line-4	522	98.25	9613	14.71	1.565	0.308	19.68	91.04
Line-5	518	98.49	9427	14.43	1.569	0.307	19.57	91.34
Line-6	517	98.32	9587	14.72	1.570	0.307	19.55	90.96
Line-7	520	98.07	9653	14.90	1.578	0.309	19.58	91.41
Line-8	521	98.27	9667	14.43	1.497	0.256	17.12	90.07
Line-9	515	98.27	9547	14.43	1.547	0.302	19.52	91.42
Line-10	519	98.09	9480	13.91	1.498	0.257	17.17	89.53
Line-11	522	98.25	9427	14.57	1.585	0.307	19.37	91.51
Line-12	519	98.20	9587	14.87	1.586	0.307	19.36	91.61
Line-13	522	98.11	9573	14.12	1.495	0.258	17.28	89.64
Line-14	516	97.76	9613	14.91	1.562	0.308	19.72	91.65
Line-15	520	97.90	9640	14.77	1.587	0.303	19.09	91.59
Line-16	522	97.78	9627	14.75	1.565	0.307	19.62	91.57
Line-17	519	98.34	9520	14.57	1.563	0.307	19.64	91.48
Line-18	527	98.31	9653	14.80	1.568	0.310	19.77	91.72
Line-19	520	98.55	9600	14.73	1.567	0.304	19.40	91.55
Line-20	528	98.39	9640	14.77	1.573	0.298	18.94	91.70
Line-21	518	98.22	9667	14.68	1.554	0.307	19.76	91.29
Line-22	527	98.54	9600	14.76	1.576	0.304	19.29	91.01
Line-23	523	98.87	9600	13.89	1.481	0.260	17.55	89.85
Line-24	532	98.33	9480	14.67	1.586	0.307	19.36	91.35
Line-25	527	98.40	9560	13.89	1.481	0.256	17.28	89.23
Control (SH6XNB4D2)	509	99.12	9547	13.91	1.485	0.293	19.73	91.39
Average	520	98.29	9576	14.55	1.552	0.296	19.08	91.07
Std Dev.	4.701	0.294	67.98	0.332	0.036	0.019	0.922	0.737

Table 2: Multi-traits evaluation index in F5 generation of silkworm bivoltine breeding lines during autumn season, 2017.

Traits Breeding lines	Fecundity (no.)	Hatching (%)	Yield/10,000 Larvae		Single Cocoon Weight (g)	Single Shell Weight (g)	Shell Ratio (%)	Pupation Rate (%)	Mean EI of all the traits	Ranking-wise of breeding lines
			By no.	By wt. (kg)						
Line-1	48.72	41.03	49.42	60.00	59.50	54.50	54.13	54.05	52.67	10
Line-2	44.58	47.59	41.62	50.61	54.50	53.00	54.78	54.05	50.09	18
Line-3	38.36	56.55	53.39	52.73	52.00	54.50	58.15	50.14	51.98	13
Line-4	52.86	48.62	55.30	54.85	53.75	54.00	56.52	49.59	53.19	8
Line-5	44.58	56.90	27.94	46.36	54.75	53.50	55.33	53.65	49.13	19
Line-6	42.51	51.03	51.48	55.15	55.00	53.50	55.11	48.51	51.54	14
Line-7	48.72	42.41	61.19	60.61	57.00	54.50	55.43	54.59	54.31	4
Line-8	50.79	49.31	63.25	46.36	36.75	28.00	28.70	36.49	42.45	21
Line-9	38.36	49.31	45.59	46.36	49.25	51.00	54.78	54.73	48.67	20
Line-10	46.65	43.10	35.74	30.61	37.00	28.50	29.24	29.19	35.00	25
Line-11	52.86	48.62	27.94	50.61	58.75	53.50	53.15	55.95	50.17	17
Line-12	46.65	46.90	51.48	59.70	59.00	53.50	53.04	57.30	53.44	7
Line-13	52.86	43.79	49.42	36.97	36.25	29.00	30.43	30.68	38.67	24
Line-14	40.43	31.72	55.30	60.91	53.00	54.00	56.96	57.84	51.27	15
Line-15	48.72	36.55	59.27	56.67	59.25	51.50	50.11	57.03	52.39	11
Line-16	52.86	32.41	57.36	56.06	53.75	53.50	55.87	56.76	52.32	12
Line-17	46.65	51.72	41.62	50.61	53.25	53.50	56.09	55.54	51.12	16
Line-18	63.21	50.69	61.19	57.58	54.50	55.00	57.50	58.78	57.31	1
Line-19	48.72	58.97	53.39	55.45	54.25	52.00	53.48	56.49	54.09	6
Line-20	65.28	53.45	59.27	56.67	55.75	49.00	48.48	58.51	55.80	2
Line-21	44.58	47.59	63.25	53.94	51.00	53.50	57.39	52.97	53.03	9
Line-22	63.21	58.62	53.39	56.36	56.50	52.00	52.28	49.19	55.19	3
Line-23	54.93	70.00	53.39	30.00	32.75	30.00	33.37	33.51	42.24	22
Line-24	73.56	51.38	35.74	53.64	59.00	53.50	53.04	53.78	54.21	5
Line-25	63.21	53.79	47.51	30.00	32.75	28.00	30.43	25.14	38.85	23
Control (SH6XNB4D2)	64.84	54.70	53.56	42.02	45.11	48.38	50.23	52.37	51.40	15





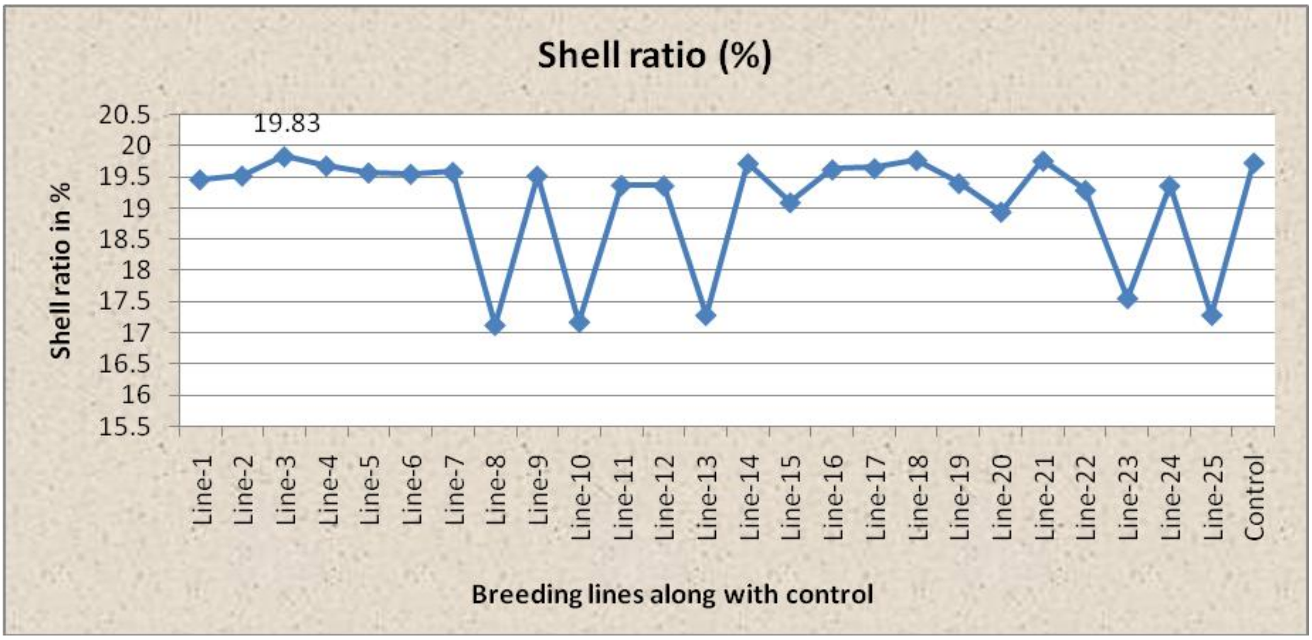


Fig 1-3: Graphical representations of the traits (Fecundity, SCW & SSW) of silkworm breeding lines during autumn season, 2017.

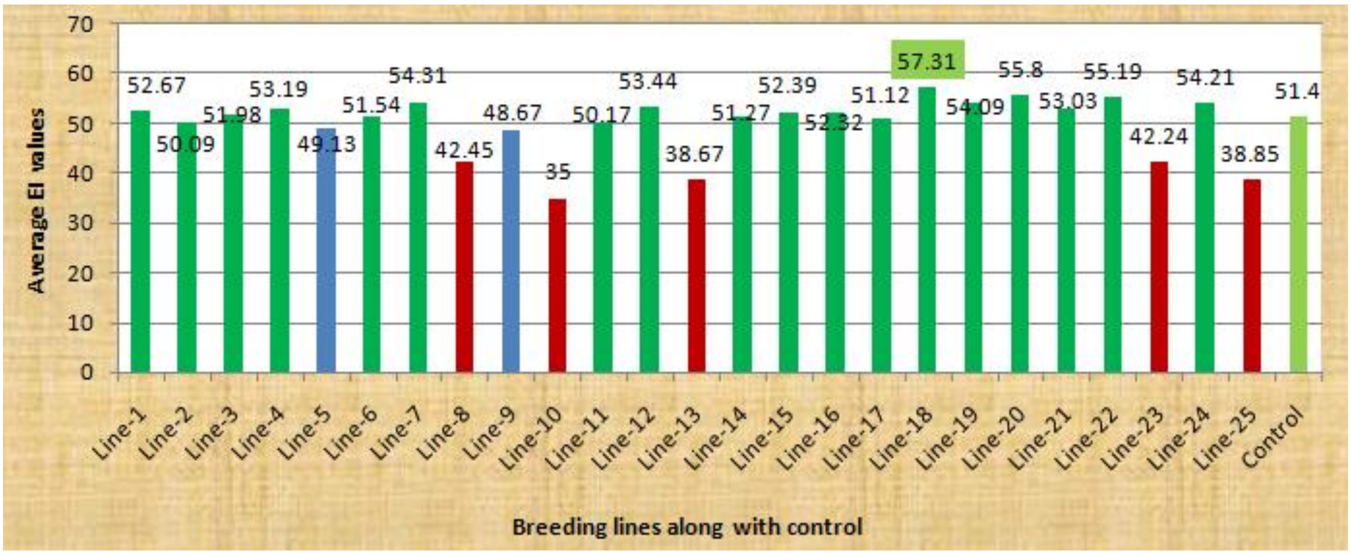


Fig 4: Graphical representation of mean evaluation index of silkworm breeding lines during autumn season, 2017

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