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RESEARCH ARTICLE

COMPARATIVE PERFORMANCE OF COCOON AND ASSOCIATED TRAITS IN BIVOLTINE SILKWORM (*BOMBYX MORI* L.) GENOTYPES DURING DIFFERENT SEASONS

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ABSTRACT

Twelve bivoltine silkworm *Bombyx mori* L. genotypes viz., SKAU-R-1, SKAU-R-6, SKUAST-28, SKUAST-31, CSR_2, CSR_4, CSR_{18}, CSR_{19}, NB_4D_2, SH_6, DUN_6 and DUN_{22} were studied for their performance during spring and summer seasons of 2012 and 2013. The data generated in respect of different traits was pooled separately and analyzed statistically. The results revealed that during spring, significantly higher estimates for larval weight, cocoon weight, shell weight, shell ratio and filament length were registered by SKAU-R-1. However, during summer significantly higher estimates for larval weight, cocoon weight, shell weight, shell ratio and filament length were recorded for SKAU-R-6. Significantly highest yield by number was recorded for SKAU-R-1 during both the seasons. The results of the study revealed that SKUAR-1 and SKUAR-6, performed significantly higher for all the traits under study in both spring and summer seasons. The study also revealed that irrespective of seasons the values for these traits were marginally higher in spring than summer season. Thus, SKUAR-1 and SKUAR-6 have potential to be used in future breeding programmes to boost bivoltine silk production under temperate climatic conditions of Kashmir.

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INTRODUCTION

Sericulture has also an important place in the economy of Jammu and Kashmir as more than 30,000 rural families which belong to economically backward sections of the society are generating their employment through this vocation (*J&K Economic Survey,* 2014-15). The state presents an ideal and fertile land for the growth and development of bivoltine sericulture. Being one of the traditional and eco-friendly agro-based labor intensive industries of the state, helps in improving the economic conditions of landless farmers by providing subsidiary employment (Malik, 2009) and supplementing the income of rural farmers especially the economically weaker section of the society (Qadri *et al*., 2010). From the past several years, sericulture has shown signs of recovery in the valley of Jammu and Kashmir. The overall numbers of silk farmers, silk production and other realms associated with the sericulture sector of the State have shown steady recovery during this short span of time (Chouhan *et al.,* 2016).

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Traditional breeding methods employed during the last few decades has resulted in the development of many productive silkworm breeds which have contributed significantly in maximizing the silk production in India in general and Jammu and Kashmir state in particular (Dhar *et al*., 2011). Of late, major thrust has been given for quality rather than quantity of silk produced. Efforts made in this direction during the 90's have lead to the evolution of highly productive CSR bivoltine breeds which have the potential to produce international grade silk (Datta, 2000). However, these new breeds continue to suffer badly in adverse conditions of low/high temperature, humidity, poor leaf quality and low management practices prevalent with the small and marginal farmers in Kashmir. Unlike tropics, temperate sericulture being carried out under highly fluctuating environmental conditions and poor leaf quality urgently needs the development of broad based silkworm breeds with genetic plasticity to buffer the adverse situations. Therefore, it is of paramount importance to know the seasonal performance of silkworm genotypes before formulating breeding programme for the development of silkworm breeds. In this context, the present study on the performance of some bivoltine silkworm genotypes was carried out with the aim to identify most promising genotypes suitable for temperate regions during spring and summer seasons.

MATERIALS AND METHODS

Twelve potential bivoltine mulberry silkworm genotypes namely; SKAU-R-1, SKAU-R-6, SKUAST-28, SKUAST-31, CSR_2, CSR_4, CSR_{18}, CSR_{19}, NB_4D_2, SH_6, DUN_6 and DUN_{22} formed basis for this study (Table 1). The disease free laying's (DFL's) of these selected silkworm genotypes were obtained from the Germplasm Bank of Temperate Sericulture Research Institute (TSRI), Sher-e-Kashmir university of Agricultural Sciences and Technology of Kashmir-India (SKUAST-K) Mirgund, Central Sericultural Germplasm Resources Centre (CSGRC) Hosour, Tamilnadu, India and Central Sericultural Research and Training Institute (CSR&TI) CSB, Pampore, Srinagar Kashmir. The eggs were incubated at 25±1 ^{0}C temperature and 75-80% relative humidity for about 10-12 days till their hatching. The larvae of all the selected bivoltine breeds were reared under standard package of practices (Krishnaswami, 1978). The silkworms were fed with mulberry leaves harvested from the popular mulberry varieties viz; Goshoerami and Ichinose maintained in Mulberry Farm of TSRI, SKUAST-K, Mirgund. The experiment was laid out in Completely Randomized Block Design with three replications for each treatment. Each replication comprised of 250 silkworms of uniform age and size retained after third moult. During the rearing period, larvae and cocoons were assessed for different parameters viz; larval weight, single cocoon weight, single shell weight, shell ratio, filament length during spring and summer seasons (2012 and 2103). The data pertaining to the following parameters was recorded replication-wise for all the treatments and subjected to statistical analysis. The characters studied and observational procedures adopted are given under the following headings.

Weight of ten mature larvae (g Larva^{-10})

It denotes healthiness and robustness of the larvae. It is the measure of ten randomly selected larvae weighed one day before spinning. Ten mature larvae were selected randomly from each replicate of each treatment and weighed separately.

Single cocoon weight (g)

This is the average weight of a cocoon in grams derived by calculating the weight of a random sample of 10 cocoons. Ten cocoons from each replicate of each treatment were selected randomly and weighed to determine the average cocoon weight.

Single shell weight (g)

This trait represents the total quantity of silk in a cocoon. It is the average individual shell weight in grams of 10 cocoons selected for assessment of cocoon weight. The cocoons used for determining the average single cocoon weight were cut open and weighed to obtain shell weight.

Shell ratio (%)

It is the ratio of the shell weight to the cocoon weight. It is calculated in percentage from a random sample of 10 to 25 cocoons from each laying. It was calculated as,

$$\text{Shell ratio (\%)} = \frac{\text{Single Shell wt.}}{\text{Single cocoon wt.}} \times 100$$

Filament length

It is the length of the silk filament in meters reeled from a single cocoon. The mean value of the filament length is obtained by reeling ten cocoons collected at random from each laying. Ten randomly selected cocoons from each treatment and replicate were reeled to determine the average filament length.

RESULTS AND DISCUSSION

The performance of silkworm genotypes under optimal rearing conditions (25 ±1°C) and humidity (70 ± 5 %) is presented in Table 2-3. The comparative performance of genotypes during spring and summer seasons of 2012 and 2013 is presented in Table 3. Larval weight is one of the important parameter which determines not only the health of the larvae, but also the quality of the cocoons spun (Nguku *et. al*., 2007). Present study revealed that there was significant variation in larval weight of different genotypes of silkworm in both the seasons. SKAU-R-1, SKAU-R-6, and SKUAST-31 recorded higher larval weight of about 50.19g, 49.47g and 49.17g respectively in spring season (Table-2) while in summer SKAU-R-6, SKAU-R-1, NB_4D_2 and SKUAST-31 recorded the higher larval weight of 45.17g,43.65g, 43.36g and 42.70g (Table-3) over the other genotypes evaluated. The difference in the larval weight among the genotypes studied could be attributed to the racial character, difference in degree of assimilation that differ from one genotype to another and the quality and quantity of food consumed by the larvae which has a direct bearing on the performance on the growth and development of larvae. It is well known that the environmental conditions prevailing in different seasons affects the growth and development as well as expression of economic traits in different genotypes of silkworms. Current studies revealed that genotypes under study have good genetic variability and thus significant variation in larval weight was recorded. The present findings are in conformity with the findings of Masrat *et al*., (2014) who have reported higher larval weight of 52.46g in SKAU-R-1, 49.53g in SKAU-R-6 and 49.56g in SKUAST-31. Pal and Moorthy (2011) have also reported highest larval weight of 3.53g in NB14, 3.24g in SK4C and 2.43g in CSR_{19}. Higher larval weight in SKAU-R-1, SKAU-R-6, SKUAST-31 and NB_4D_2 reflected that these genotypes have the potential to be used in breeding programmes. Cocoon weight, shell weight and shell ratio are the major traits evaluated for productivity in sericulture (Gaviria *et al*., 2006). These traits are highly heritable and are significantly important as these determine the quality, quantity and efficiency of the reeling process (Singh *et. al*., 2011). Cocoon weight is an important commercial characteristic used to determine approximately the amount of raw silk that can be obtained. In the present study, SKAU-R-1 registered the highest cocoon weight of 2.09g while SH_6 recorded minimum cocoon weight of 1.84g during spring season (Table-3). In summer, SKAU-R-6 recorded the highest cocoon weight of about 1.76g and SKUAST-28 was found to register a minimum cocoon weight of 1.70g during the same season (Table-3). However, the cocoon weight of all the genotypes evaluated was relatively lower in summer season than spring which could be attributed to nutrient deficient mulberry leaf available in summer season thereby affecting the cocoon weight.

Table 1. Characteristic features of different silkworm genotypes under study

Genotype	Voltinism	Parental Source	Larval pattern	Cocoon colour	Cocoon shape	Origin/ Evolution	Source
SKAU-R-1	Bivoltine	Shunrei × Shogetsu	Marked	White	Constricted	TSRI, SKUAST-Kashmir-Mirgund	Silkworm Germplasm Bank, TSRI, SKUAST-K, Mirgund
SKAU-R-6		Shogetsu × Hoshu	Plain	White	Slightly oval		
SKUAST-28		Evolved Under Broad Based Germplasm Complex, Comprising 10 Breeds With Marked Larvae (Kamili *et. al*., 2000)	Marked	White	Short dumbell		
SKUAST-31		Evolved Under Broad Based Germplasm Complex, Comprising 10 Breeds With Plain Larvae (Kamili *et. al*., 2000)	Marked	White	Oval		
CSR_2		Shunrei × Shogetsu	Plain bluish	Bright white	Oval	CSR&TI, Mysore-India	Silkworm Germplasm Bank, CSGRC, Hosur-Tamilnadu, India
CSR_4		(BN18×BCS25) × NB_4D_2	Plain bluish	Bright white	Dumbell		
CSR_{18}		B201× BCS12	Plain & marked	Creamish white	Oval		
CSR_{19}		B201× BCS12	Plain & marked	Creamish white	Dumbell		
NB_4D_2		(Kokko × Seihaku) × (N124×C124)	Plain faint bluish	White	Elongated, constricted		
SH_6		Shogetsu × Hoshu	Moderately marked	White	Oval	RSRS, Majira, Dehradun- India	
DUN_6		CC1 × NN6D	Plain	White	Oval	CSR&TI, Pampore-Kashmir	Silkworm Germplasm Bank, CSR&TI,CSB-Pampore
DUN_{22}		(KS × NB_4D_2) (AT × NB_4D_2)	Marked	White	Oval		

Table 2. Mean performance of twelve silkworm genotypes during spring

Genotype	Weight of Ten Mature larvae(g)	Single cocoon weight (g)	Single shell weight (g)	Shell ratio (%)	Filament length (m)
SKAU-R-1	50.19	2.09	0.45	21.45	1197.00
SKAU-R-6	49.47	2.04	0.43	21.14	1168.00
SKUAST-28	48.27	1.84	0.38	20.74	1060.50
SKUAST-31	49.17	1.91	0.40	20.85	1148.00
CSR_2	40.53	1.71	0.34	19.94	898.17
CSR_4	43.48	1.74	0.35	20.07	917.48
CSR_{18}	40.78	1.69	0.34	20.17	928.23
CSR_{19}	39.70	1.67	0.32	19.24	920.17
NB_4D_2	48.87	1.89	0.39	20.70	1121.00
SH_6	42.17	1. 84	0.38	20.60	1098.00
DUN_6	41.18	1.78	0.37	20.69	1019.50
DUN_{22}	40.13	1.76	0.36	20.40	1013.67
Mean	44.5	1.83	0.38	20.5	1040.81
S.D	4.28	0.13	0.04	0.59	107.08
CD $p \leq 0.05$	0.32	0.60	0.61	0.15	23.91

(Data pooled over same seasons of 2012 and 2013)

Table 3. Mean performance of twelve silkworm genotypes during summer

Genotype	Weight of Ten mature larvae(g)	Single cocoon weight (g)	Single shell weight (g)	Shell ratio (%)	Filament length (m)
SKAU-R-1	43.65	1.74	0.36	20.60	998.23
SKAU-R-6	45.17	1.76	0.38	21.53	1012.60
SKUAST-28	42.23	1.70	0.32	18.76	934.62
SKUAST-31	42.70	1.72	0.33	19.13	987.43
CSR_2	36.20	1.59	0.29	18.30	752.00
CSR_4	38.82	1.62	0.31	19.07	789.00
CSR_{18}	34.70	1.64	0.33	20.08	929.12
CSR_{19}	33.80	1.49	0.28	18.91	878.16
NB_4D_2	43.36	1.74	0.34	19.60	993.36
SH_6	39.87	1.73	0.33	19.12	975.97
DUN_6	38.48	1.67	0.32	19.22	896.61
DUN_{22}	37.40	1.64	0.32	19.45	883.17
Mean	39.70	1.67	0.33	19.48	919.19
S.D	3.74	0.08	0.03	0.88	83.71
CD $p \leq 0.05$	0.71	0.90	0.33	1.43	7.76

(Data pooled over same seasons of 2012 and 2013)

Table 4. Comparative performance of twelve silkworm genotypes during spring and summer seasons(*)

Genotypes	Weight of Ten mature larvae (g)		Single cocoon weight (g)		Single shell weight (g)		Shell ratio (%)		Filament length (m)	
	Spring	Summer	Spring	Summer	Spring	Summer	Spring	Summer	Spring	Summer
SKAU-R-1	50.19	43.65	2.09	1.74	0.45	0.36	21.45	20.60	1197	998
SKAU-R-6	49.47	45.17	2.04	1.76	0.43	0.38	21.14	21.53	1168	1012.
SKUAST-28	48.27	42.23	1.84	1.70	0.38	0.32	20.74	18.76	1060.	934
SKUAST-31	49.17	42.70	1.91	1.72	0.40	0.33	20.85	19.13	1148	987
CSR_2	40.53	36.20	1.71	1.59	0.34	0.29	19.94	18.30	898	752
CSR_4	43.48	38.82	1.74	1.62	0.35	0.31	20.07	19.07	917	789
CSR_{18}	40.78	34.70	1.69	1.64	0.34	0.33	20.17	20.08	928	929
CSR_{19}	39.70	33.80	1.67	1.49	0.32	0.28	19.24	18.91	920	878
NB_4D_2	48.87	43.36	1.89	1.74	0.39	0.34	20.70	19.60	1121	993
SH_6	42.17	39.87	1. 84	1.73	0.38	0.33	20.60	19.12	1098	975
DUN_6	41.18	38.48	1.78	1.67	0.37	0.32	20.69	19.22	1019	896
DUN_{22}	40.13	37.40	1.76	1.64	0.36	0.32	20.40	19.45	1013	883
Mean	44.50	39.70	1.83	1.67	0.38	0.33	20.50	19.48	1040.81	919.19
S.D	4.28	3.74	0.13	0.08	0.04	0.03	0.59	0.88	107.08	83.71
CD $p \leq 0.05$	0.32	0.71	0.60	0.90	0.61	0.33	0.15	1.43	23.91	7.76

*(Data pooled over same seasons of 2012 and 2013)

Present findings are in conformity with the reports of Singh *et al.* (2010) who have concluded that environmental factors influence the physiology of insects and also have deleterious effect on economic traits such as cocoon weight and shell weight. The present findings are also in agreement with the findings of Masrat *et al*. (2014) who have reported higher cocoon weights for these genotypes during spring and summer seasons under temperate climatic conditions. The results of the study also corroborate with the results of Kumar and Shamitha (2011) who noticed the deleterious effect of adverse temperature and humidity on economic traits. Shell weight is an important character in determining the silk weight. During spring the mean single cocoon weight among all the genotypes was found significantly higher in SKAU-R-1 (2.09g) and lower in NB_4D_2 (1.89g), while in summer, mean cocoon weight was found significantly higher in SKAU-R-6 (1.76g). However, CSR_{19} registered significantly lowest single cocoon weight of 1.67g and 1.49g during both the seasons, respectively. Present study revealed that shell weight was variable under different sets of environmental conditions. However, SKUAR -1 and SKAU-R-6 registered the highest shell weight and shell ratio during both seasons. During spring, SKAU-R-1 registered highest shell weight and shell ratio of 0.45g and 21.45% respectively where as SKAU-R-6 registered shell weight and shell ratio of 0.43g and 21.14% respectively (Table-2). During summer season these genotype again displayed the superiority in shell weight and registered a highest shell weight of 0.38g (SKAU-R-6) and 0.36g (SKAU-R-1) (Table-3). Highest shell ratio of 21.53% was registered by SKAU-R-6 followed by SKAU-R-1 which registered a shell ratio of 20.60%. This could be attributed to high pupal weights for these genotype. Masrat *et al*., 2014 have also reported higher shell weight and shell ratio in SKAU-R-1 and SKAU-R-6 during both seasons indicating the better adaptability of these genotypes under summer conditions. The results are in conformity with the findings of Basavaraja *et al.* (1998) who have reported that cocoon shell weight shows variability under different environmental conditions. The variations observed in the present findings in shell weight and shell ratio might also be due to racial character.

Filament length is one of the important attributes of the silkworm breed. The silk filament length is different in silkworm breeds under different set of rearing conditions and rearing seasons (Basavaraja *et al*., 1995). In present study, the highest average filament length of 1197.00m was observed in SKAU-R-1, in spring season (Table-2) while as in summer season SKAU-R-6 registered the longest filament length of 1012.60m (Table-3). Longest filament length in SKAU-R-1 and SKAU-R-6 implied the superiority of these genotypes over the other genotypes evaluated. The filament length was relatively higher in spring than summer. The results of the present findings are in conformity with the findings of Masrat Bashir *et al*., (2014) who have identified SKAU-R-1 and SKAU-R-6 as the genotype with higher filament length during spring and summer seasons under temperate climatic conditions of Kashmir. Summarizing all the aspects, it is given to understand that the performance of a genotype or a breed is mainly dependent on the combined action of hereditary potential of its population and the extent to which such potential is permitted to express in the environment and to which it is exposed. The differential expression of different races in different seasons recorded in the present study is in conformity with the observations of several workers (Kumaresan *et al.,* 2000 & 2007; Mukherjee *et al*., 2000 and Pal and Moorthy 2011). This is largely due to the variable gene frequencies at different loci in different silkworm races which make them to respond differently to changing environmental conditions (Kalpana, 1992 and Nanjundaswamy, 1997). Obviously, the present investigation on comparative performance of some potential bivoltine silkworm genotypes during different seasons under temperate climatic condition of Kashmir valley has yielded rich information to identify promising genotypes which can be recommended to initiate future breeding programmes for commercial exploitation in the interest of the industry to push up productivity levels of sericulture in the region.

Conclusion

Based on the performance and better physiological compensatory mechanisms in response to prevailing climatic conditions during spring and summer seasons, eight genotypes viz., SKAU-R-1, SKAU-R-6, SKUAST-28, SKUAST-31, NB_4D_2, SH_6, and DUN_6 seem to be more suitable for rearing in spring and summer seasons than other productive genotypes. However, SKUAR-1 and SKUAR-6 will be more suitable for rearing during spring and summer owing to their best performance in terms of maximum economic traits irrespective of the seasons. These genotypes can be used as breeding material to boost bivoltine silk production in temperate region of India.

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