J. Sylhet Agril. Univ. 3(2):291-298, 2016 **ISSN: 2308-1597**

CORRELATION ANALYSIS BETWEEN YIELD AND YIELD CONTRIBUTING CHARACTERS OF EIGHTEEN RACES OF SILKWORM

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Abstract

The investigation was conducted to evaluate the performances of rearing of eighteen races of silkworm, *Bombyx mori* L. Characters viz., weight of mature larva, number of cocoon kg^{-1}, yield 100 $dfls^{-1}$ (disease free layings), cocoon weight, shell weight, shell ratio and length of filament were evaluated in a single rearing season. Performances of the race BSR-BN (B1) were reasonably good for no. of cocoon kg^{-1}, cocoon weight and shell ratio. BSR-BN (M) showed the highest rearing performance for shell weight but the BSR-ISK and BSR-BN (P) M were good for yield and length of filament, respectively. On the other hand, the race Nistari (G) was poor for cocoon weight and shell weight and the races Nistid white (P), BSR-BN (B1), Nistari (P), BSR-I (M) and BSR-IK (M) showed poor rearing performances for weight of mature larvae, shell weight, shell ratio, length of filament and yield 100 $dfls^{-1}$ respectively in this investigation. Analysis of correlation conducted on the results of the experiment indicated that the characters of the races were correlated with yield non-significantly. Negative correlation between yield 100 $dfls^{-1}$ and no. of cocoon kg^{-1} showed higher yield improvement which would be a good combination for an improved method of silk production.

***Keywords*:** *Bombyx mori* L., rearing performances, yield, correlation, silk production.

Introduction

Sericulture or silk farming is the rearing of silkworms for the production of raw silk. Silk was first produced in China as early as the Neolithic period (Vainker, 2004). In the seventeenth century sericulture and silk spread overland from China to India (Krishnaswami *et al*., 1973). Sericulture is a branch of agriculture, the raising of silkworms for their cocoons, which are the raw materials used in the manufacture of silk. Although there are several commercial species of silkworms, *Bombyx mori* is the most widely used and intensively studied silkworm. Silkworm is reared in Bangladesh particularly in the district of Rajshahi and Nawabganj where silkworm is cultivated extensively as a major source of earning for many of the rural people. Production processes in sericulture include cultivation of mulberries, the leaves of which are the only food for the larvae of the silkworm moth, production of silkworm eggs, incubation and hatching of the eggs, rearing of the silkworms, and primary processing of cocoons including killing and drying. Bangladesh Sericulture Research and Training Institute (BSRTI) achieved a number of success that include development of appropriate technology for mulberry cultivation, high yielding mulberry and silkworm varieties, quality silkworm egg production, improvement of mulberry leaves with foliar application of urea and micronutrients for quality cocoon production, selection of draught resistant and water logging mulberry varieties and development of low cost and ecofriendly disinfectants.

In silkworm breeding, numerous traits are considered for improving them to increase the profit of silk producers and other sections of sericulture industry. Reproductive traits are considered important for egg producers. Yield is the multiplicative end product of many factors which jointly or singly influence it. The selection of best genotypes depends on a number of characters. Therefore, a clear understanding and knowledge of association and contribution of various yield components is essential for any selection program aimed at yield improvement. The degree of association or relationship between two variables is measured by correlation coefficient (r). The correlation coefficient may be positive or negative. Positive correlation indicates that the two variables are varying in the same

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direction. In other words, if one variable increases, the other variable also increases. In negative correlation, the two variables vary in opposite direction, i.e., if one variable increases the other decreases. There is very intimate correlation between some of the characters in silkworm and an excellent character may bring down the merit of another character, if not given due consideration at the appropriate developmental stage.

The study was undertaken to analyze correlation between the yield and some yield contributing characters of eighteen races of silk worm *B. mori* on the basis of single season rearing performance to study the relationship between yield and different yield contributing characters of silkworm for silk production under the context of Bangladesh.

Materials and Methods

The research work was conducted at BSRTI in Rajshahi on 18 different races of silkworm namely, Nistari, Nistari (M), Nistari (P), Nistari (L), Nistari (G), BSR-BN (B_1), BSR-BN (B_2), BSR-I (J), Nistari (M) B, Nistid white (P), BSR-ISK, BSR-BN (P), BSR-BN (P) M, BSR-BN (M), BSR-I (M), BSR-IK (M), BSR-IK (P) and BSR-IK (P) EL. These races were collected from the Germplasm Bank of BSRTI, Rajshahi. The rearing of silkworm was conducted for a good harvest of quality cocoon crop at silkworm research laboratory of the BSRTI. The rearing was conducted in a randomized block design with standard rearing techniques suggested by Krishnaswami (1978). To prevent diseases and to maintain good sanitation, the rearing room and other rearing appliances were disinfected with a 5% formaldehyde solution following the procedure suggested by Ullah and Narasimhanna (1978). Then the eggs were incubated at 25±1°C with a humidity 80%± 5% at normal daylight and dark in the night. A black pin-like spot appeared on the egg two days before hatching and on the following day it turned completely blue called body pigmentation of the egg. The eggs at this stage were disinfected with 2% formaldehyde solution for five minutes recommended by Jolly (1983) and transferred to the rearing house. The process of transferring of the newly hatched silkworms to rearing tray is called brushing which was performed with a feather following the brushing technique of Ullah and Narashimhanna (1978). Cocoons were harvested after 4 to 5 days of mounting. After that, male and female pupae were segregated and the fresh moths were allowed to mate after emergence. When the egg-laying was completed the females were subjected to microscopic examination. The eggs produced were called disease free layings (dfls) and they were utilized for experiment. After the formation and maturation of cocoons, data of different characters were collected intensively wherever necessary.

Collection of data

***Weight of mature larvae (g)*:** The weight of mature larva was taken at the end from each rearing-bed. Individual weight of these larvae was taken in gram on an electronic balance. A mean of 10 observations for each replication was used for statistical analysis.

***No. of Cocoon kg^{-1}*:** The number of cocoon was computed on the basis of predetermined total no. of cocoon and total weight of cocoon by using following formula-

$$\text{No. of cocoon} = \frac{\text{Total no. of cocoon}}{\text{Total wt. of cocoon}} \times 1000$$

***Cocoon weight (g)*:** Cocoons were selected randomly from each replication. Individual weight of 10 cocoons was taken in gram. A mean of 10 cocoon weights was used for analysis.

***Shell weight (g)*:** To observe the shell weight cocoons were cut at one end to isolate shell from pupa. Shell weight was then measured from the cocoons selected for cocoon weight. Individual shell weight for 10 shells was recorded in gram. A mean of 10 shell weights was used for statistical analysis.

***Shell ratio (SR%)*:** The shell ratio for male and female was computed on the basis of the predetermined shell weight and cocoon weight by using the following formula-

$$\text{Shell ratio} = \frac{\text{Shell weight}}{\text{Cocoon weight}} \times 100$$

***Length of filament (m)*:** Ten cocoons from each replication were selected randomly which were dried before reeling. Reeling of these cocoons were conducted with an individual cocoon reeling machine and the filament length was recorded in meters. Mean length of filament reeled from 10 cocoons from each replication was used for statistical analysis.

***Yield 100 dfls^{-1}(kg)*:** During cocoon assessment, total cocoon weight for each replication of the continued breeding lines was taken by top loading balance. Recorded production weight was used for calculation of yield 100 dfls^{-1} and an average for two replications was used for statistical analysis.

Data analysis: The collected data were analyzed successfully by following statistical technique-

1. The average for each replication was calculated separately for each character.
2. The coefficient of correlation of each character with yield was computed separately and t-test were performed using following formulae-

a) $$r = \frac{\sum xy - \frac{\sum x . \sum y}{n}}{\sqrt{\sum x^2 - \frac{(\sum x)^2}{n}} \cdot \sqrt{\sum y^2 - \frac{(\sum y)^2}{n}}}$$

b) $$t = r\sqrt{\frac{n-2}{1-r^2}}$$

Results and Discussion

Data were collected on six quantitative traits of *B. mori*, viz., yield 100 dfls^{-1}, weight of mature larvae, number of cocoon kg^{-1}, cocoon weight, shell weight, shell ratio (SR%) and length of filament in a single rearing season in two replications. An average rearing performance of seven characters of 18 races of silkworm in two replications are summarized in Table 1.

***Yield 100 dfls^{-1}(kg)*:** The average yield 100 dfls^{-1} for a single rearing season was recorded ranging from 43 to 54.5 kg (Table 1 and Fig. 1). The highest value was found in the race BSR-ISK. The lowest value was found in the race BSR-BN (M) and BSR-IK (M) for this trait.

***Weight of mature larvae (g)*:** The range of average weight of mature larvae for a single rearing season was recorded from 25 to 28.25 g (Table 1 and Fig. 2). The highest value was observed in the race BSR-I (J) and BSR-I K (P). The lowest value was observed in the race Nistid white (P) for this trait. Coefficient of correlation between yield and weight of mature larvae was calculated and analysis of correlation conducted on the yield 100 dfls^{-1} and weight of mature larvae implied that correlation in respect of these traits was non-significant and the correlation between them was positive (Tables 2 and 3). Cocoon yield 10,000 larvae^{-1} trait by weight was also positively correlated with larval weight at high temperature condition showed by Chandrakanth *et al*. (2016).

Table 1. Average rearing performances of some characters of eighteen races of silkworm

Race	Yield 100 dfls^{-1} (kg)	Weight of mature larvae (g)	No. of cocoon kg^{-1}	Cocoon weight (g)	Shell weight (g)	Shell ratio (%)	Length of filament (m)
Nistari	54	25.25	861.5	1.122	0.131	11.695	409.5
Nistari- (M)	52	26	842	1.1455	0.1375	12.02	380
Nistari- (P)	49.5	29	805.5	1.171	0.135	11.50	415
Nistari- (L)	48.5	26.25	850.5	1.137	0.1385	12.175	406.5
Nistari- (G)	47	27.75	914.5	0.914	0.109	11.92	384.5
BSR- BN (B_1)	52.5	27.5	804.5	1.2425	0.172	13.83	371
BSR- BN (B_2)	46	26	875.5	1.1185	0.131	11.71	358
BSR-I (J)	44.5	28.25	822	1.181	0.1355	11.51	354.5
Nistari- (M) B	45	25.75	868.5	1.103	0.147	13.345	426
Nistid white- (P)	45	25	899	0.9625	0.112	11.65	401.5
BSR- ISK	54.5	26.25	882	1.1105	0.140	12.60	374
BSR-BN (P)	52	27.5	869	1.1245	0.1285	12.765	401.5
BSR-BN (P) M	44.5	26	952.5	0.9995	0.1215	12.15	436
BSR-BN (M)	43	23.5	962	1.0915	0.1415	12.98	343
BSR-I (M)	47	26	900.5	1.0925	0.1355	12.45	330.5
BSR-IK (M)	43	26	843	1.062	0.112	10.565	360.5
BSR-IK (P)	54	28.25	857.5	1.1195	0.131	11.715	383
BSR-IK (P) EL	54	26.75	872.5	1.049	0.128	12.215	373.5

***No. of cocoon kg^{-1}*:** The range of average no. of cocoon kg^{-1} for single rearing season was recorded from 804.5 to 962 (Table 1 and Fig. 3). The highest value was in the race BSR-BN (M) and the lowest was in the race BSR-BN (B_1) for this trait. Coefficient of correlation between yield 100 dfls^{-1} and number of cocoon kg^{-1} was negative and non-significant (Tables 2 and 3). Cocoon yield 10,000 larvae^{-1} by weight was most correlated to pupation rate suggesting that the productivity of the silk cocoon yield kg^{-1} can be improved by increasing thermo-tolerance in silkworm through breeding approach and a positive and significant correlation between cocoon yield 10,000 larvae^{-1} by weight and pupation rate was proved by Singh *et al*. (2011) which is dissimilar with our present work as the qualities of cocoons and fixation of price are usually assessed based on cocoon and shell weights but shell ratio is a better parameter for assessing the cocoon quality for reeling because higher shell percentage leads higher raw silk yield due to their positive correlation.

Table 2. Coefficient of Correlation between yield and yield contributing characters in the silkworm

Character	Wt. of mature larvae (g)	No. of cocoon kg^{-1}	Cocoon weight (g)	Shell weight (g)	Shell ratio (SR%)	Length of filament (m)
Yield 100 dfls^{-1} (kg)	0.3475 ^{NS}	-0.3833 ^{NS}	0.3510 ^{NS}	0.3107 ^{NS}	0.2072 ^{NS}	0.1194 ^{NS}

NS= Non-significant

***Cocoon weight (g)*:** The range of average weight for single rearing season was recorded from 0.914 to 1.2425 g (Table 1 and Fig. 4). The highest value was found in the race BSR-BN (B_1). The lowest was found in the race Nistari (G) for this trait. Coefficient of correlation between yield 100 dfls^{-1} and weight of cocoon was positive and non-significant (Tables 2 and 3). Cocoon yield 10,000 larvae^{-1} by weight was also positively correlated with cocoon weight was reported by Chandrakanth *et al.* (2016). Ghanipoor *et al*. (2008) also observed high positive genetic correlation between cocoon weight and cocoon shell weight in commercial six lines of silkworm that corresponded to results of Satnahali *et al*. (1990).

***Shell weight (g)*:** The range of average weight for single rearing season was recorded from 0.1415 to 0.109 g (Table 1 and Fig. 5). The highest value was found in the race BSR-BN (M) and the lowest was in the race Nistari (G) for this trait. Coefficient of correlation between yield 100 dfls^{-1} and shell weight was positive and non-significant (Tables 2 and 3). Similar result was also observed by Chandrakanth *et al*. (2016) where cocoon yield 10,000 larvae^{-1}

by weight was positively correlated with cocoon shell weight. Petkov (1987) also studied genetic specification in some of new silkworm varieties and expressed correlation between cocoon shell weight and cocoon shell percentage.

Table 3. Types of correlated characters in the production of silk in the silkworm

Correlation between	Correlation	Coefficient of correlation (r)	t value
Yield and weight of mature larvae	Positive	0.3475	1.4824 ^{NS}
Yield and Cocoon kg^{-1}	Negative	-0.3833	-1.6599 ^{NS}
Yield and Single Cocoon weight	positive	0.3510	1.4994 ^{NS}
Yield and Shell weight	positive	0.3107	1.3075 ^{NS}
Yield and Shell ratio (SR %)	Positive	0.2072	0.8472 ^{NS}
Yield and Length of filament	Positive	0.1194	0.4811 ^{NS}

NS= Non-significant

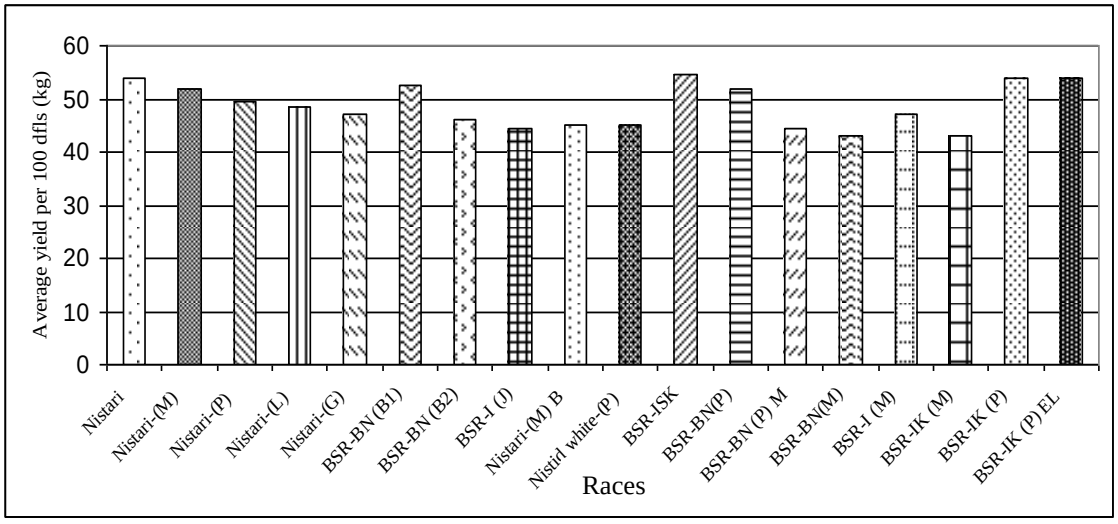

Fig. 1. Average yield 100 dfls^{-1} (kg) of eighteen races of silkworm, *B mori*

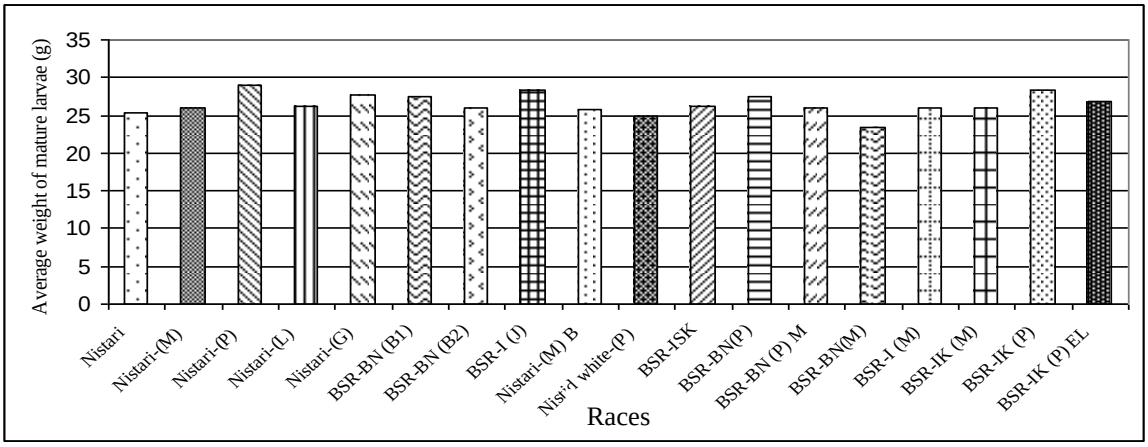

Fig. 2. Average weight of mature larvae (g) of eighteen races of silkworm, *B mori*

***Shell ratio (SR%)*:** The range of average ratio for single rearing season was recorded from 11.50 to 13.83% (Table 1 and Fig. 6). The highest value was recorded in the race BSR-BN (B_1). The lowest was recorded in the race Nistari (P) for this trait. Coefficient of correlation between yield 100 dfls^{-1} and shell ratio was positive and non-significant (Tables 2 and 3). Shell percent of silkworm and the yield 100 dfls^{-1} are the most important characters and are directly related with the production of silk. Positive correlation of shell percent with yield 100 dfls^{-1} was also

observed by Sonwalkar (2001) and Chandrakanth *et al*. (2016). Chanda *et al*. (2013) observed negative correlation of shell percent with yield 100 dfls^{-1}.

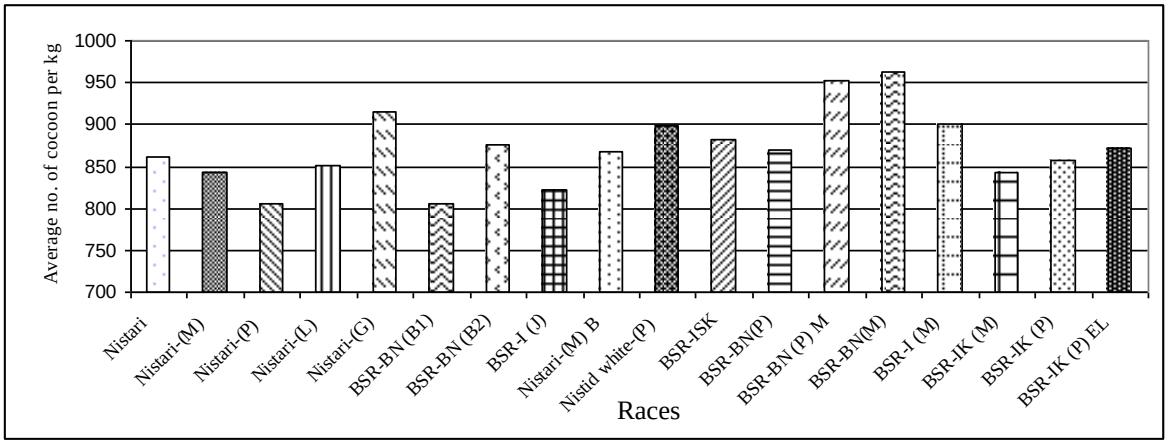

Fig. 3. Average no. of cocoon kg^{-1} of eighteen races of silkworm, *B mori*

***Length of filament (m)*:** The range of average length for single rearing season was recorded from 330.5 to 436 m (Table 1 and Fig. 7). The highest value was found in the race BSR-BN (P) M but the lowest was found in the race BSR-I (M) for this trait. Coefficient of correlation between yield and length of filament was positive and non-significant (Tables 2 and 3). Positive correlation between yield 100 dfls^{-1} and filament length recorded in this study was similar with the observation of Sekharappa *et al*. (1999). Chanda*et al*. (2013) also observed that yield 100 dfls^{-1} was highly correlated with length of filament.

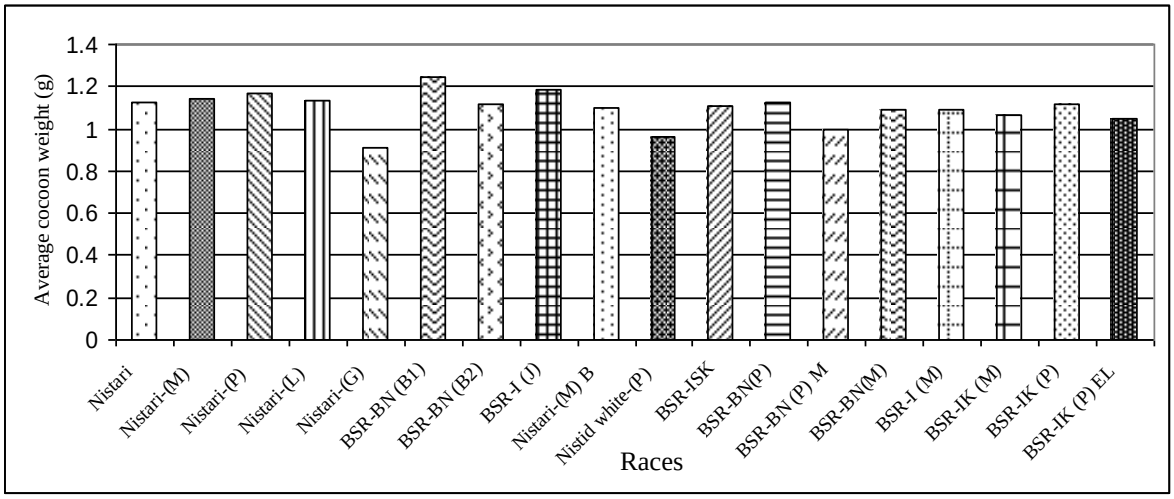

Fig. 4. Average cocoon weight (g) of eighteen races of silkworm, *B mori*

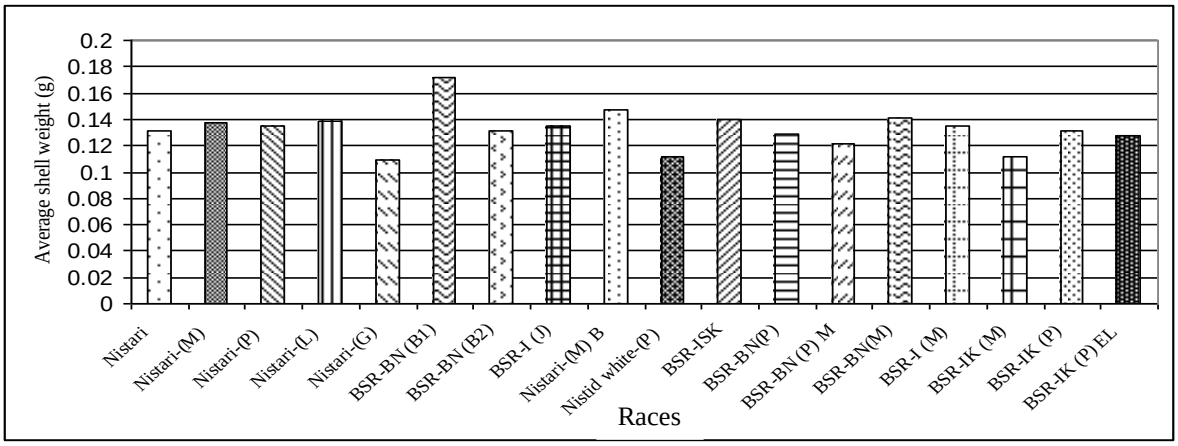

Fig. 5. Average shell weight (g) of eighteen races of silkworm, *B mori*

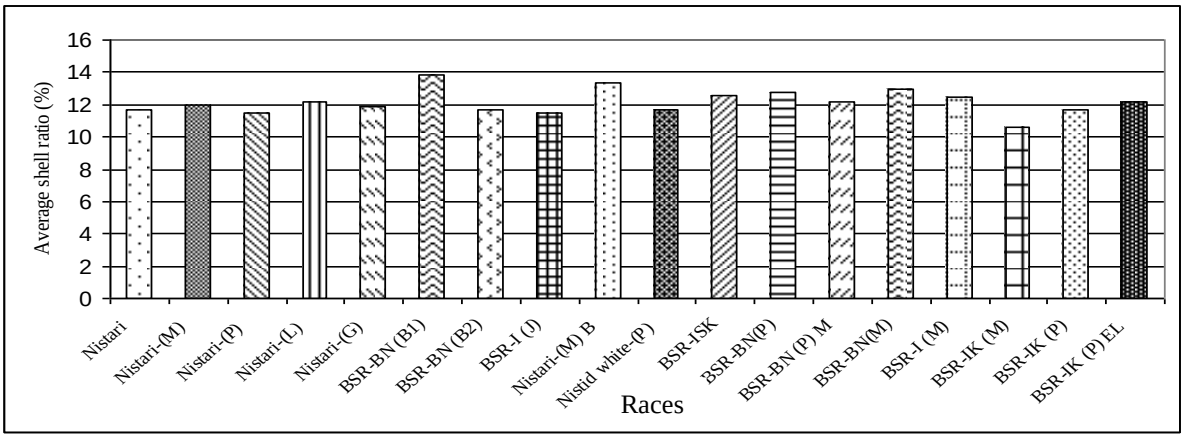

Fig. 6. Average shell ratio (%) of eighteen races of silkworm, *B mori*

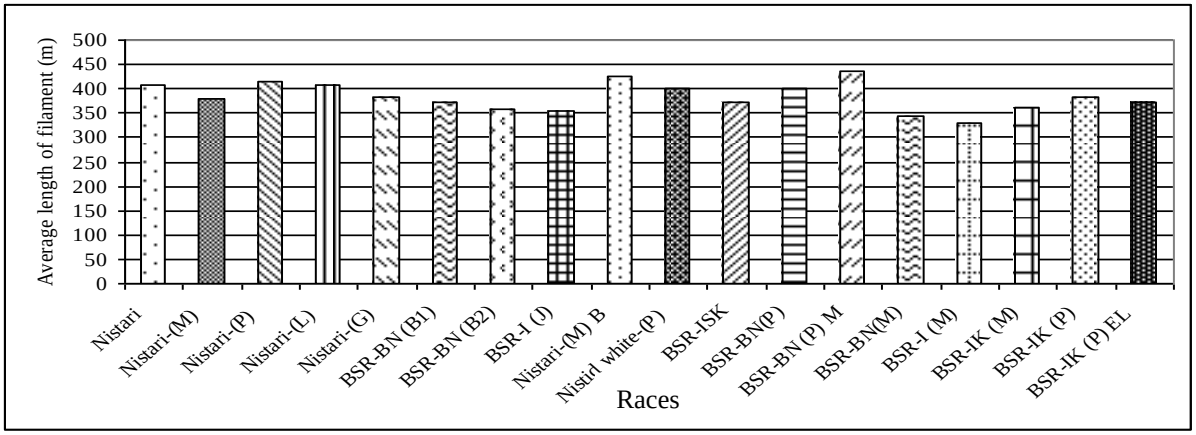

Fig. 7. Average length of filament (m) of eighteen races of silkworm, *B mori*

The above results showed that these characters were affected by a vast effect of genes with common environmental factors in a single rearing season. From above discussion, it would be a suggestion for the breeders to select any of larval weight, cocoon kg^{-1}, single cocoon weight, shell weight, shell ratio, filament length traits of those varieties of *B. mori* to improve the silk production. The knowledge of correlation among various commercial characters is one

of the important parameters in breeding programmes for new breeds of silkworm *B. mori* with better economic characters (Mahesha *et al*., 2013). Umashankara and Subramanya (2002) were estimated for five cocoon productivity traits *viz*. cocoon weight, shell weight, pupal weight, larval weight and shell ratio. They showed that shell weight had higher significance for genotype correlation. So, they suggested that breeders can select of single cocoon weight, shell ratio, larval weight and larval duration traits to improve the silk yield in *B. mori*. In the present research, it was observed that negative correlation between yield 100 $dfls^{-1}$ and no. of cocoon kg^{-1} of eighteen races of silkworm *B. mori* on the basis of single season rearing performance would be a good combination for silk production.

Acknowledgement

The authors gratefully acknowledge to the staff of BSRTI in Rajshahi Division for their help to carry out this study.

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