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Analysis of four yield contributing character of different races of silkworm (*Bombyx mori* L.)

Lubatul Arbia, Dilruba Afrin, Amit Hasan, Rumana Ferdous Bint-A-Rahman and Apurba Kumar Roy

Abstract
In the present study, an evaluation of four quantitative characters viz. Yield/100 dfls, SR%, Denier, and Reel ability of Cocoons produced by Silkworm through analysis of variance was carried out. Eighteen varieties of mulberry silkworm, *Bombyx mori* L. were used in this analysis viz., Nistid white(P), ISK, D× C, BN(P), BN-(P)m, BN(M)M, N(I)M, N(I) K(M), N(I)K(P), N(I)K(P)L, NN7B-P, NN7B-M, MBY-0115 (P), BSR 3 Yellow(p), BSR-3 Yellow (m), BSR-10 yellow(m), BSR-1 white(m) and BSR-1 white(p). Analysis of variances conducted on the results indicated that the varieties differ significantly ($P < 0.01$) in respect of some characters studied to identify the existence of real differences among the varieties through analytical observation. The good performing varieties were ISK, D×C, BN (P), BN-(M)M, N (I)M, N(I) K(P), N(I) K(P) EL, NN7B(M), BSR-1White-(M), BSR-1White-(P) in most cases. But the most superior variety was N (I) M, because it showed the highest performances in both cases of denier and reel ability which were the most expected characters in this investigation. The other eight varieties showed poor performances. From the finding of the present investigation, it is recommended that the varieties ISK, D×C, BN(P), BN-(M)M, N (I)M, N(I)K(P), N(I)K(P) EL, NN7B(M), BSR-1White-(M), BSR-1White-(P) could be exploited for commercial silk production following rearing technique.

Keywords: Silk, silkworm, *Bombyx mori***,** yield

Introduction
Silk is one kind of natural protein fiber which composed by fibroin, an insoluble protein [1]. Fibroins are composed of a number of simple amino acid sequences organized in reiterated arrays [2]. Silk has been used for the textile manufacturing process, which largely produced by moth caterpillars. The well-known silk is extracted from the cocoons of the larvae of the mulberry silkworm (*Bombyx mori*), this process is termed as sericulture [3]. According to the International Sericulture Commission, there are four types of natural silk exist in the world, which is commercially popular. Among them, mulberry silk is the popular one, which contributed 90% of the total silk production. Remaining three commercially important silks fall into the category of non-mulberry silk namely: Eri silk, Tasar silk, and Muga silk. In Africa and Asia, there are other types of non-mulberry silk present as wild silk such as Anaphe silk, Fagara silk, Coan silk, Mussel silk and Spider silk [4]. Silkworm (*Bombyx mori*) breeding plans to develop high yielding stocks which contains larger cocoons with high silk content, high fecundity and high rate of hatching [5]. In sericulture, silkworm breeds play various important roles, such as in occupation arena through the sustainable cocoon yield with superior quality silk production. In the beginning, pure lines were used for the production of silk which was overtaken by the introduction of hybrid lines. From that time, hybrid lines of silkworm are playing a significant role in the sericulture industry due to its commercial purposes [6, 7]. Since almost a century ago, American corn and Japanese scientists find out the advantages of hybrid vigor of the silkworm, thus also play a valuable role in commercial sectors. In case of the domesticated silkworm, commercial utilization of hybrid vigor of silkworm open a new door through the enhancement of silk production [8]. Hybrid vigor is an essential tool in enhancing cocoon production, evaluation and maintenance of inbred lines and finds out the promising hybrids for commercial exploitation [9]. The main objective of silkworm breeding is to produce new genotypes with more flexibilities to different climates and to select sustainable silkworm hybrids for commercial exploitations. Scientists are making constants efforts in the synthesis of high-quality varieties to meet the demand of sericulture farmer and silk breeders. In the changing scenario of world, for the developing country like Bangladesh, there is a great need to develop potentials silkworm hybrids of higher quality and quantity to sustain the sericulture industry since the polyvoltine silkworm are well adapted for tropical Climate [10].

The present study has been an attempt to identify the significant differences among races and replication of silkworm through statistical analysis as well as find out the superior varieties for the production of silk commercial level.

Materials and Methods

Eighteen genotypes viz., Nistid white(P), ISK, D× C, BN(P), BN-(P)m, BN(M)M, N(I)M, N(I) K(M), N(I)K(P), N(I)K(P)L, NN7B-P, NN7B-M, MBY-0115(P), BSR 3 Yellow(p), BSR-3 Yellow (m), BSR-10 yellow(m), BSR-1 white(m) and BSR-1 white(p) of the silkworm *Bombyx mori* L., obtained from the Germplasm Bank of Bangladesh Sericulture Research and Training Institute (BSRTI), Rajshahi, were selected for this study.

A. Silkworm rearing

Silkworms were reared under germ free condition. To prevent disease and maintain good sanitation the rearing room and appliances were disinfected with 5% formaldehyde solution. The eggs were incubated in carefully disinfected rearing house by maintaining 80-85% relative humidity and 25% temperature. A black pin-like spot appeared on the eggs two days before hatching and on next 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 [11]. Uniformly developed eggs were selected, packed and covered with a black cloth to ensure uniform hatching. Newly hatched larvae were brushed on properly chopped fresh mulberry leaves. The newly hatched larvae are very active. They constantly use to move until they find mulberry leaves for feeding. For the present experiment, fresh and succulent leaves were harvested from the mulberry garden of the zoological Department Rajshahi University for feeding the silkworm larvae. The recommended size of the chopped leaves was prepared for feeding early three instars [12]. The fourth and final instar larvae were fed with whole mature leaves. At all stages, the worms were feed four times a day at an interval of six hours, i.e. at 4am, 10am, 4pm and 10pm. After that, bed cleaning process was done properly. During the present study, bed spacing was also carefully maintained and recorded using recommended pathway [13]. Then, mature worm were collected from rearing bed and placed on the bamboo-made mountages called 'chandrakis'. Cocoon were harvested after 4-5 days of mounting. After 10-14 days of spinning the adult comes out by dissolving one end of the shell as moth. After 45 minutes to one hour, they become fully active and were prepared for mating. When emergence of moth appeared, the fresh moth were allowed to mate. Coupling normally took place between 16-18 hours of emergence and each couples was then placed on a clean rough paper and covered with aluminum lid. After 3-4 hours of coupling, the moths were separated. When egg laying was finished, the female were subjected to go under the microscopic examination. The eggs thus produce are now called disease free laying (dfls). For the current investigation five disease free laying (dfls) for each of the eighteen varieties were collected from the Germplasm Bank of BSRTI, Rajshahi. The eggs were then preserved in an incubator set at 40±10°C for synchronization of the hatching date. The eggs were released from the incubator. Therefore, the experimental populations are available from all the varieties at a time. After synchronization, the eggs of different varieties were incubated at room temperature and relative humidity. At the pin head stage i.e. 48 hours before hatching, the eggs were disinfected with bleaching powder solution for five minutes (Jolly, 1983). Immediately after washing and drying, the eggs were transferred to the rearing room. For each variety five dfls were brushed on mass bed. Selection of larvae and larval count were conducted at the beginning of 4th instar. For each variety 50 larvae were selected and transferred on the rearing tray (30 cm. 520 cm. 57.5 cm.) For each variety three such rearing trays were taken, and each of these rearing tray was considered as a replication in this experiment. Therefore, there were in total 30 rearing trays (10 varieties and 3 replications) which were arranged randomly on the rearing almirah. The experiment was conducted in commercial rearing season (June-July).

B. Collection of data

The following economic traits were considered for the investigation and the procedure of data collection as follows-

1. Total number of eggs laid per female (TEL): The total number of eggs laid by the individual female moth was counted. A mean of eighteen layings for each replication was used for statistical analysis.

2. Egg hatching percentage (%): For computing the hatching percentage, the total number of eggs hatched in a laying was counted. Hatching percentage was then calculated by the following formula.

$$\text{EHP} = \frac{\text{Total no.of eggs hacthing in a layer}}{\text{Total no.of eggs in a laying}} \times 100$$

3. Percentage of dead eggs: For computing the percentage of dead eggs, the total number of dead eggs in a laying was counted. Percentage of dead eggs was then worked out by the following formula.

$$\text{DP} = \frac{\text{Total no.of dead eggs in a laying}}{\text{Total no.of eggs in a laying}} \times 100$$

4. Percentage of blue eggs: For computing the percentage of blue eggs, the total number of blue eggs in a laying was counted. Percentage of blue eggs was then worked out by the following formula.

$$\text{BP} = \frac{\text{Total no.of blue eggs in a laying}}{\text{Total no.of eggs in a laying}} \times 100$$

5. Weight of mature larva (g): The weight of mature larva was taken at the end of 5th instars, i.e. one day before spinning. Individual weight of these larva was taken in gram by an electronic balance. A mean of eighteen observations for each replication was used for statistical analysis.

6. Cocoon weight (G): The average weight (g) of five male and five female cocoons was taken randomly on 6th day after onset of spinning from all the replication in a treatment for a given silk worm line.

$$\text{Cocoon wt. (g)} = \frac{\{\text{wt.of 5 male cocoons} + \text{wt.of 5 female cocoons}\} \times 100}{10}$$

7. Cocoon shell weight (g): The average weight (g) of five male and five female cocoon shells (g) of the same cocoons after removing pupa was taken randomly for the calculation of cocoon weight from all the replication in a treatment for a given silk worm line.

$$\text{COCOON SHELL WT. (G)} = \frac{\{\text{WT.OF (5 MALE+ 5 female) cocoons (G) WITHOUT PUPA}\} \times 100}{10}$$

8. Pupal weight (g): To record the weight of pupae, selected randomly from each replication. Individual weight of these pupae were taken in an electronic balance in gm. For statistical analysis a mean of these pupae were used for each replication.

9. Cocoon shell ratio (%): It is the total content of shell available in the cocoons. It is the average ratio of 5 male and 5 female cocoon shells (g) of the same cocoons to the total cocoon weight and assessed in percentage.

$$\text{Cocoon shell ratio} = \frac{\text{cocoon shell weight} \times 100}{\text{cocoon wt.}}$$

10. Cocoon yield (kg/10000 larvae): It is the total weight of live cocoons expressed in kilograms for unit number of larvae retained after 3rd moult. The weight of all live cocoons was divided by total number of live cocoons in all replications to get average weight of cocoon for a given silk worm line.

$$\text{Cocoon yield} = \frac{\{\text{Avg.of cocoon (kg)} \times \text{number of live cocoon obtained}\} \times 100}{\textit{Larvae retained after 3rd instar} (50)}$$

11. Filament length (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 filaments reeled from 10 cocoons from each replication was used for statistical analysis.

$$\text{Filament length (m)} = \frac{\text{length of raw silk} \times \text{avg.no.of reeled cocoons}}{\text{number of reeling cocoons}}$$

12. Denier (g/9000m): Denier a unit of measure for the linear mass density of fibers, is defined as the mass in grams per 9000 meters. The denier is based on a natural reference: a single strand of silk is approximately one denier; a 9000-meter strand of silk weighs about one gram. The denier system of measurement is used on two- and single-filament fibers. Some common calculations are as follows:

1 denier = 1 gram per 9000 meters
= 0.111 milligrams per meter

In practice, measuring 9000 meters is both time-consuming and unrealistic. Generally a sample of 900 meters is weighed, and the result is multiplied by ten to obtain the denier weight.

13. Reel ability (%): Reel ability is defined as the fitness of cocoons for economically feasible reeling. Reel ability is greatly affected by careful action during cocoon spinning, drying, storage, pre-processing, reeling machine efficiency and operator skill. Number of reeled cocoons were divided by number of ends feeding and then multiply with 100 for getting percentage.

$$\text{Reel ability (\%)} = \frac{\text{number of reeled cocoons} \times 100}{\text{number of ends feeding}}$$

C. Analysis of data

The collected data were analyzed successfully following statistical technique:

Calculation of variance

$$\text{Variance, } \sigma^2 = \frac{\sum(x-\bar{x})^2}{n-1}$$

Calculation of Standard Deviation (SD)

$$\text{Standard Deviation (SD)} = \sqrt{\frac{\sum(x-\bar{x})^2}{n-1}}$$

Calculation of Standard Error (SE)

$$\text{Standard Error (SE)} = \frac{SD}{\sqrt{n}}$$

Steps for analysis of variance (ANOVA)

a. Correction Factor (CF) = $\frac{(GT)^2}{n}$

b. (Total sum of Square) $SS_T = \sum x^2{}_i - CF$

c. (Replication sum of Square) $SS_r = \frac{\sum x_a}{n_a} + \frac{\sum x_b}{n_b} + \ldots\ldots + \frac{\sum x_g}{n_g} - CF$

d. (Error sum of square) $SS_{Error} = SS_T = SS_r$

e. Degrees of freedom: df = number of observation – 1

f. Mean variance: MS = $\frac{SS}{df}$

g. F test: $\frac{MST}{MSE}$

Statistical analysis

All experiment were performed at least three times. Data represent the means and standard errors (Mean± SE) from at least three replicates of a representative experiment. The data were calculated using Microsoft Excel 2010 Software.

Results

The rearing performance of eighteen varieties of silkworm, *Bombyx mori* have been evaluated in respect of thirteen quantitative traits, viz. total no. of eggs laid by female, hatching percentage, no. of dead eggs, no. of blue eggs, weight of mature larvae, cocoon weight, shell weight, pupal weight, cocoon shell ratio, cocoon yield, length of filament, denier and reel ability in a single rearing season. Four traits among thirteen were used for present research purposes, but it was needed to calculate all those thirteen traits for collecting the data for the analysis. The results of the four different characters studied are described as follows:

A. Yield/100 (dfls)

Regarding to this character, the highest value (54.50) was obtained for the variety ISK. On the other hand, the lowest value was found in BSR-3 yellow-(p) variety that was 35.00. N (1) K (p) and N (1) K (P) EL, these two variety gave same value for this character that was 54.00 which also very close to the highest value. Besides these two D×C and BN (P) varieties gave value of 52.50 and 52.00 respectively. The results related to this character presented in Table-1A and graphically presented in Fig-1.

Table 1A: Yield/100 (dfls) of different silkworm varieties

Variety	Replication		Total	Mean	± SE
	R_1	R_2			
Nistid white (p)	44	46	90	45.00	0.19
ISK	56	53	109	54.50	0.28
D×C	53	52	105	52.50	0.09
BN(P)	52	52	104	52.00	0.00
BN-(P)M	45	44	89	44.50	0.09
BN-(m)M	42	44	86	43.00	0.19
N(I)M	48	46	94	47.00	0.19
N(I)K(m)	43	43	86	43.00	0.00
N(I)K(p)	51	57	108	54.00	0.56
N(I)K(p)EL	58	50	108	54.00	0.75
NN7B-(p)	52	50	102	51.00	0.19
NN7B-(m)	50	48	98	49.00	0.19
MBY-0115(p)	48	48	96	48.00	0.00
BSR-3Yellow-(p)	35	35	70	35.00	0.00
BSR-3yellow-(m)	40	42	82	41.00	0.19
BSR-10yellow(r)	34	37	71	35.50	0.28
BSR-1white-(m)	50	53	103	51.50	0.28
BSR-1white-(p)	48	45	93	46.50	0.28

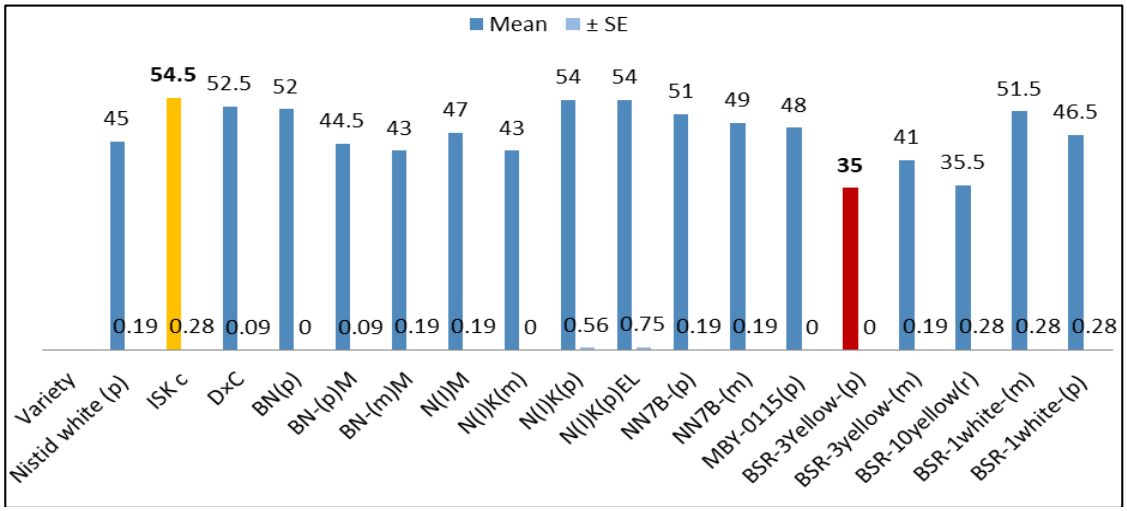

Fig 1: Mean ± SE of yield comparison among varieties.

The analysis of variance was conducted on different varieties of silkworm for this character to find whether those varieties differ significantly or not. It was found that varieties showed significant difference at 5% significance level while replication showed no significant differences.
The result of ANOVA is shown in Table-1B below:

Table 1B: ANOVA of Yield/100 (dfls) of different silkworm varieties

Source	df	SS	MS	F	Table value of F	
					5%	1%
Rep	1	0.444	0.444	0.0938$^{(NS)}$	4.45	8.3997
Variety	17	1210.889	71.229	15.0317**	2.23	3.21
Error	17	80.556	4.739			
Total	35	1291.889				

*, ** Significant at 5% and 1% level respectively, ^{NS} = Non-Significant.

B. Shell ratio (%)

The results of this character are presented in Table-2A and Fig-2. The highest mean value was 13.15 that was showed by the variety BSR-10yellow(r) while the second highest value (12.98) gave by BN-(M) M and variety BSR-3yellow-(m) also gave very close value (12.97) to the second highest value. The lowest value was found in N (I) K (M) variety that was 10.57.

Table 2A: Shell ratio (%) of different silkworm varieties

Variety	Replication		Total	Mean	± SE
	R_1	R_2			
Nistid white (p)	11.18	12.12	23.3	11.65	0.09
ISK	12.48	12.72	25.2	12.60	0.02
D×C	12	11.87	23.87	11.94	0.01
BN(p)	12.53	13	25.53	12.77	0.04
BN-(p)M	12.2	12.1	24.3	12.15	0.01
BN-(m)M	13.04	12.92	25.96	12.98	0.01
N(I)M	12.97	11.93	24.9	12.45	0.10
N(I)K(m)	10.58	10.55	21.13	10.57	0.00
N(I)K(p)	11.98	11.45	23.43	11.72	0.05
N(I)K(p)EL	11.81	12.62	24.43	12.22	0.08
NN7B-(p)	12.03	11.99	24.02	12.01	0.00
NN7B-(m)	11.18	11.26	22.44	11.22	0.01
MBY-0115(p)	11.52	11.9	23.42	11.71	0.04
BSR-3Yellow-(p)	12.34	11.88	24.22	12.11	0.04
BSR-3yellow-(m)	13.21	12.72	25.93	12.97	0.05
BSR-10yellow(r)	13.04	13.25	26.29	13.15	0.02
BSR-1white-(m)	12.03	11.64	23.67	11.84	0.04
BSR-1white-(p)	11.12	11.69	22.81	11.41	0.05

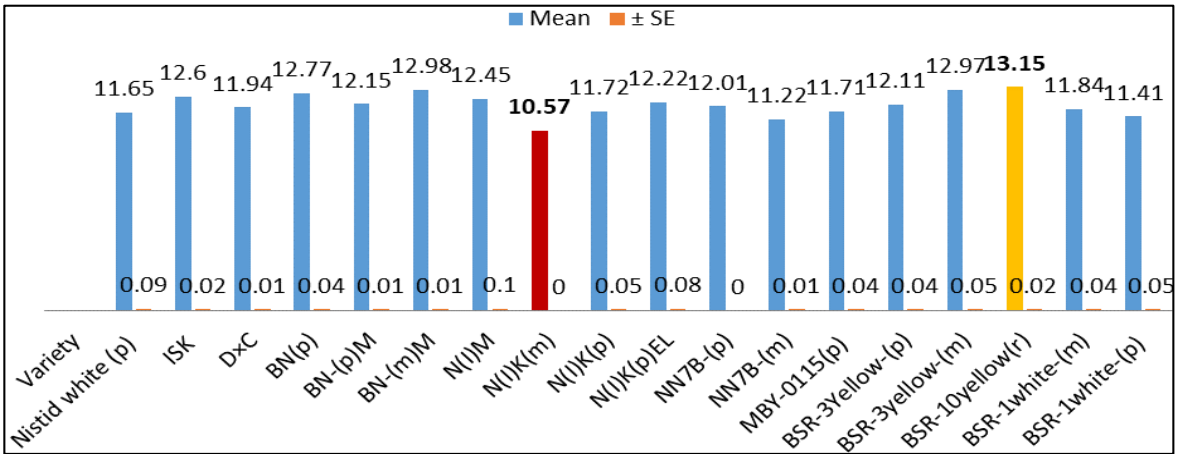

Fig 2: Mean ± SE of shell ratio (%) comparison among varieties

The analysis of variance was conducted on different varieties of silkworm for this character to find whether those varieties differ significantly or not regarding to this trait. The results of ANOVA showed that the varieties differ significantly in respect to this character but replication showed no significant differences. The result of ANOVA is shown in Table-2B below:

Table 2B: ANOVA of shell ratio (%) of different silkworm varieties

Source	df	SS	MS	F	Table value of F	
					5%	1%
Rep	1	0.004	0.004	0.0298	$4.45^{(NS)}$	8.3997
Variety	17	15.319	0.901	7.0586	2.23^{**}	3.21
Error	17	2.170	0.128			
Total	35	2.493				

*, ** Significant at 5% and 1% level respectively, ^{NS} = Non-Significant.

C. Denier

The highest mean value (2.71) was obtained for the variety N (I) M and the second highest value was found in BN-(M) M that was 2.69. On the other hand, the lowest value was found in BSR-3 yellow-(p) variety that was 1.78. ISK and N (1) K P) EL, these two variety gave same value for this character That was 2.48. Besides these, BN (P) gave value of 2.49. The results related to this character presented in Table-3A and Fig-3.

Table 3A: Denier of different silkworm varieties

Variety	Replication		Total	Mean	± SE
	R_1	R_2			
Nistid white (p)	2.21	2.18	4.39	2.20	0.00
ISK	2.47	2.48	4.95	2.48	0.00
D×C	2.23	2.19	4.42	2.21	0.00
BN(p)	2.46	2.51	4.97	2.49	0.00
BN-(p)M	2.18	2.12	4.3	2.15	0.01
BN-(m)M	2.77	2.61	5.38	2.69	0.02
N(I)M	2.76	2.65	5.41	2.71	0.01
N(I)K(m)	2.25	2.15	4.4	2.20	0.01
N(I)K(p)	2.36	2.23	4.59	2.30	0.01
N(I)K(p)EL	2.53	2.42	4.95	2.48	0.01
NN7B-(p)	2.1	1.96	4.06	2.03	0.01
NN7B-(m)	2	1.92	3.92	1.96	0.01
MBY-0115(p)	2.33	2.25	4.58	2.29	0.01
BSR-3Yellow-(p)	1.79	1.77	3.56	1.78	0.00
BSR-3yellow-(m)	1.86	1.95	3.81	1.91	0.01
BSR-10yellow(r)	1.98	1.88	3.86	1.93	0.01
BSR-1white-(m)	2.1	2.09	4.19	2.10	0.00
BSR-1white-(p)	1.8	1.72	3.52	1.76	0.01

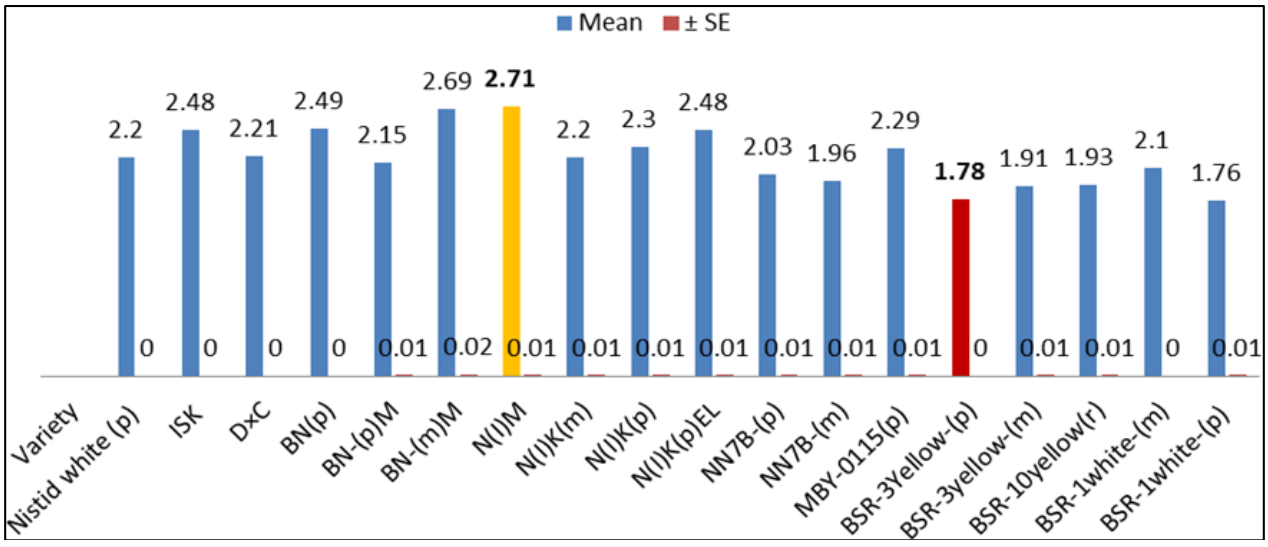

Fig 3: Mean ± SE of denier comparison among varieties

The analysis of variance was conducted on different varieties of silkworm for this character to find whether those varieties differ significantly or not. It was found that varieties showed significant difference at 5% significance level and replication showed significant differences at 1%. The result of ANOVA is shown in Table-3B below:

Table 3B: ANOVA of denier of different silkworm varieties

Source	df	SS	MS	F	Table value of F	
					5%	1%
Rep	1	0.034	0.034	15.1205	$4.45^{(NS)}$	8.3997
Variety	17	2.750	0.162	72.7595	2.23^{**}	3.21
Error	17	0.038	0.002			
Total	35	2.821				

*, ** Significant at 5% and 1% level respectively, ^{NS} = Non-Significant.

D. Reel ability (%)

The results of this character are presented in Table-4A and Fig-4. The highest mean value was 100.00 that was showed by 12 varieties among 18 while the second highest value (91.67) gave 3 other varieties. The lowest value was found in BN (p) and BSR-3yellow-(p) variety that was 83.33.

Table 4A: Reel ability of different silkworm varieties

Variety	Replication		Total	Mean	± SE
	R_1	R_2			
Nistid white (p)	83.33	90.9	174.23	87.12	0.71
ISK	100	100	200	100.00	0.00
D×C	100	100	200	100.00	0.00
BN(p)	83.33	83.33	166.66	83.33	0.00
BN-(p)M	83.33	100	183.33	91.67	1.57
BN-(m)M	100	100	200	100.00	0.00
N(I)M	100	100	200	100.00	0.00
N(I)K(m)	100	100	200	100.00	0.00
N(I)K(p)	100	83.33	183.33	91.67	1.57
N(I)K(p)EL	100	100	200	100.00	0.00
NN7B-(p)	100	100	200	100.00	0.00
NN7B-(m)	100	100	200	100.00	0.00
MBY-0115(p)	100	100	200	100.00	0.00
BSR-3Yellow-(p)	83.33	83.33	166.66	83.33	0.00
BSR-3yellow-(m)	100	100	200	100.00	0.00
BSR-10yellow(r)	100	83.33	183.33	91.67	1.57
BSR-1white-(m)	100	100	200	100.00	0.00
BSR-1white-(p)	100	100	200	100.00	0.00

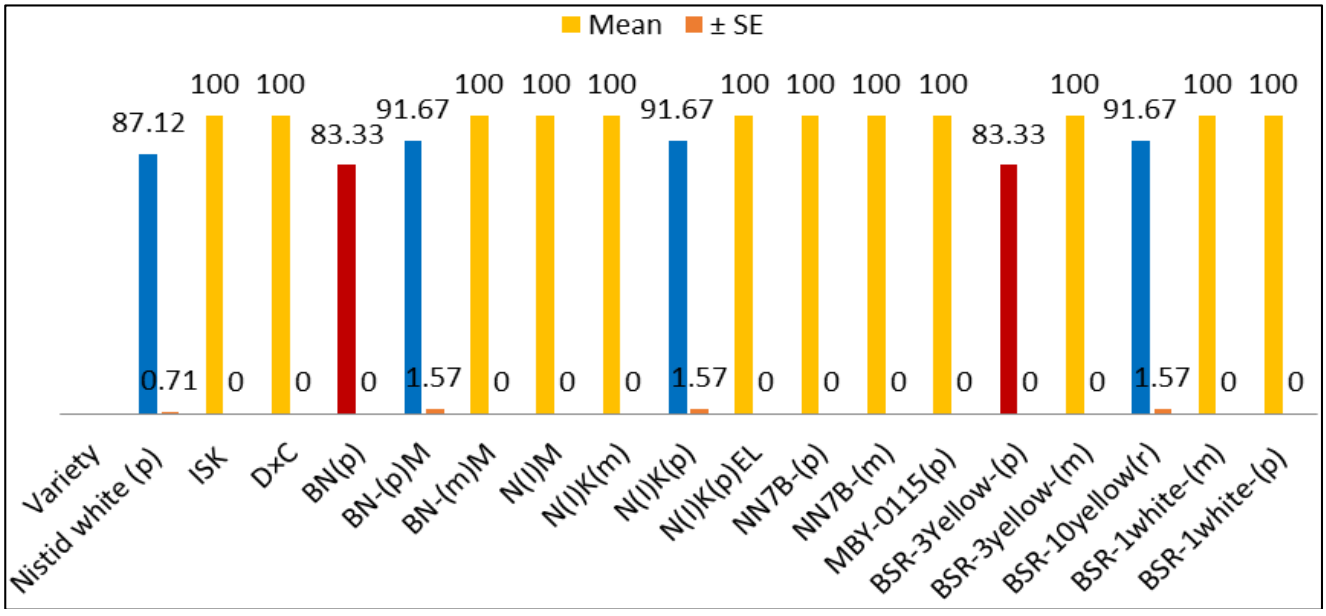

Fig 4: Mean ± SE of reel ability (%) comparison among varieties

The analysis of variance was conducted on different varieties of silkworm for this character to find whether those varieties differ significantly or not regarding to this trait. The results of ANOVA showed that the varieties differ significantly at 5% level in respect to this character but replication showed no significant differences. The result of ANOVA is shown in Table-4B below:

Table 4B: ANOVA of reel ability of different silkworm varieties

Source	df	SS	MS	F	Table value of F	
					5%	1%
Rep	1	2.300	2.300	0.0882	$4.45^{(NS)}$	8.3997
Variety	17	1296.689	76.276	2.9258	2.23^{*}	3.21
Error	17	443.185	26.070			
Total	35	1742.175				

*, ** Significant at 5% and 1% level respectively, ^{NS} = Non-Significant.

Discussion

The present investigation conducted on the rearing performances of 18 varieties of mulberry silkworm, *Bombyx mori* L. Varities of *Bombyx mori* viz., Nistid white (M), ISK, D×C, BN (P), BN-(P)M, BN-(M)M, N (I)M, N(I))K(M), N(I) K(P), N(I) K(P) EL, NN7B-(P), NN7B(M), MBY-0115(P), BSR-3Yellow-(P), BSR-3Yellow-(M), BSR-10Yellow-(M), BSR-1White-(M) and BSR-1White-(P). Over a period of single rearing season indicated that the population means estimated for different characters differed significantly in different varieties. Low to high mean performances were recorded and that was not confined to any particular genotype. Similar results on genotype-environment interaction was also reported in silkworm by a number of workers [14]. Yield performance is the first considering character among all. The highest mean value was obtained from ISK-c which is supported by the result of the other scientists [15]. They have also conducted that similar type of experiment on different silkworm varieties and got same result. Moreover, in the present investigation, ANOVA was conducted to find whether those selected varieties and their replications differ significantly or not in respect of yield. It was found that varieties' difference was significant regarding that character while the replication of those varieties had no difference statistically. Nguku *et al*. (2009) found similar type of result while they were working on six different silkworms especially mulberry. Considering the shell ratio percentage character, it was found that the variety BSR-10yellow(r) gave the highest result while the second highest value (12.98) was given by BN-(m) M. These results are supported by the study of Amardev *et al*. (2012) as they got similar type of result in their own experiments. Moreover, Nguku (2009) and Istiaque (2011) also got more or less similar result. So it can be said that the result of this present investigation regarding to shell ratio % is consistent with other investigators around the world. ANOVA result showed that varieties difference was significant regarding that character while the replication of those varieties has no statistically significant difference [16, 17]. Denier is a very important character while we consider the overall performance of silk production in sericulture. In this present study it was found that the highest value was 2.71 while the lowest one was 1.78. It clearly differs significantly. The ANOVA result also showed that significant difference existed in different varieties of silkworm while considering that important character. N(I)M variety gave the highest result which is supported by the result of Reddy *et al*. (2012) and Thapa *et al*. (2005) [18]. But that character showed statistically significant difference within replications. Reel ability is one of the considered important characters of this study. There are several reports available on this character in several journals that mean it's an immense important character related to silk production. In this present investigation, it was found that most of the varieties gave same result. That type of result also found by Umesh (2009), Jones (2009) and Niranjana (2001). But The ANOVA result showed the significant difference among different varieties at 5% significance level while replication of same variety had no any statistically significant difference [19, 20, 21].

Conclusion

In this research work, eighteen varieties of silkworm (*Bombyx mori*) were investigated and among all the varieties, ten varieties viz., ISK, D×C, BN(P), BN-(M)M, N(I)M, N(I)K(P), N(I)K(P)EL, NN7B(M), BSR-1White-(M), BSR-1White-(P) showed good performance in most of the cases. The performance of remaining eight varieties were not up to the mark. Form the findings of the present investigation it was recommended that, the good performing varieties could be commercially exploited in the field after large scale laboratory and field trials.

Conflict of interest

The authors declare that there are no conflict of interest regarding the publication of this paper.

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