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RESEARCH ARTICLE

Varietal influence of mulberry on silkworm, *Bombyx mori* L. growth and development

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Abstract

The present study was conducted to evaluate the best mulberry verity suitable for larval growth and economic characteristics of cocoon produced by silkworm, *Bombyx mori*. Five mulberry varieties namely, AR-14, TR-10, BR-2, S-1 and S-1635 were selected to feed on CSR2 x CSR4 silkworm race to find out varietal influence on silkworm growth and development. Further, four replications were maintained and 100 silkworm larvae were reared in each replication. Different larval parameters viz. larval duration, larval weight, larval length and larval width were measured at different stages of silkworm. Soon after, harvested the cocoon and same were used to find out cocoon weight, shell weight, shell percentage and other characters like pupal weight and effective rate of rearing were measured. Results showed significant differences among different mulberry varieties on larval growth and cocoon characteristics. The best performance was observed by feeding S-1635 variety in respect of larval duration (4.06 day), weight of 10 mature larvae (34.54 g), cocoon weight (1.68 g), shell weight (0.343 g) and pupal weight (1.353 g) followed by BR-2 and AR-14 mulberry varieties. The deprived performance was recorded by feeding S-1 and S-146 varieties. Therefore, it was concluded that S-1635 is the best influenced mulberry variety among selected varieties.

Introduction

The silkworm, *Bombyx mori* L. is an important economically beneficial insect and survives only on mulberry leaves (Morus spp.). The quality of mulberry leaves play an important role in the nutrition of silkworm and in turn cocoon/silk production for the success of sericulture industry (Choudhury et al., 1991). The growth and development of silkworm larvae and economical characteristics of cocoon is influenced largely by quality leaves of mulberry. It is well known fact that quantity and quality of mulberry leaves affects growth rate, development, body weight, survival rate of larvae as well as influencing the subsequent fecundity, longevity, movement and competitive ability of the adults (Parra and Panizii, 1991). Three important factors viz., good variety of mulberry, suitable agronomical practices and plant protection measures determine the quality of leaves. The quality of mulberry leaves closely related to the mulberry plant varieties, environmental condition and cultivation practices. Mulberry leaf quality is determined by its chemical contents (protein, carbohydrate, minerals, water and chlorophyll contents etc). Leaf quality is also an important parameter used for evaluation of genotypes aimed at selection of superior variety for rearing performance (Bongale et al., 1997). Varieties having higher yield containing better nutritional elements are always desirable to feed silkworm. Moreover, performance of any variety with respect to yield and quality of leaves also varies with agro-climatic conditions. Some varieties of mulberry appeared to be superior to others varieties in respect of feed conversion efficiencies (Raman et al., 1995).

Larval growth of silkworm is influenced by the nutrition level of leaves of different cultivars of mulberry which is ultimately reflected in the economic traits namely larval weight, cocoon and shell weight, effective rate of rearing (ERR) by number and weight etc., influencing yield and quality. It has also been demonstrated that the dietary nutritional management has a direct influence on quality and quantity of silk production in *Bombyx mori* L. (Murugan and George, 1998).

Machii and Katagiri (1991) emphasized that the duration of the larval development of *Bombyx mori* L. differs with the mulberry varieties. Leaf quality is an important parameter used for evaluation of genotypes aimed at selection of superior varieties for rearing performance. It is a confirmed fact that leaf quality differs among mulberry varieties and specific components of the mulberry leaves which are responsible for the difference in rearing performances of the silkworm (Aruga, 1994; Machii and Katagiri, 1990; Minamizawa, 1997; Sarkar and Fujita, 1994). Better the quality of mulberry leaves greater are the possibilities of obtaining good cocoon crops. Quality of mulberry leaves alone contributes 38.20 percent for quality cocoon production (Rathanamma et al., 2005). Therefore, it is well known fact that, the development and growth of silkworm as well as the cocoon and raw silk quality entirely depends upon the quality of mulberry leaves.

Even though, different mulberry varieties cultivating and utilizing in Indian subtropical state for the silkworm rearing, the information about the ideal mulberry variety suitable for the bivoltine silkworm rearing is still not known. In order to fill this gap, an effort has been made to know the varietal influence of mulberry on bivoltine silkworm rearing performance and their influence cocoon yield.

Materials and methods

Five improved mulberry varieties namely, AR-14, TR-10, BR-2, S-1 and S-1635 were selected to feed on bivoltine silkworm race (CSR_2 X CSR_4). 20 DFL's (Diseased Free Layings) were procured from National Silkworm Seed Production Centre, Dehradun, Uttrakhand. The silkworm rearing was conducted as per the recommendations made by Krishnaswami (1978 a, b and c). After 2nd moult larvae were separated from main rearing trays to maintain four replications, 100 larvae were maintained in each replication at temperature 26±1^{0}C and 80±5% relative humidity.

Feeding period, moulting period, larval duration, larval growth parameters viz., larval weight, larval length, larval width and body gain weight were taken into consideration. The body gain weight of larvae was calculated by following formula.

$$\text{Body gain weight (g)} = \frac{\text{Wt. of larvae after moult (g)} - \text{Wt. of larvae before moult (g)}}{\text{No. of larvae taken}}$$

Cocoon parameters like single cocoon weight, pupal weight, shell weight, shell ratio, effective rate of rearing by number and effective rate of rearing by weight were analyzed with following formula:

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

$$\text{ERR by number} = \frac{\text{Total number of good cocoons harvested (g)}}{\text{Total number of larvae brushed}} \times 100$$

$$\text{ERR by weight} = \frac{\text{Weight of good cocoons harvested (g)}}{\text{Total number of larvae brushed}} \times 100$$

Reeling parameters namely filament length and filament weight was measured by eppruovette and digital balance respectively in each replication. Denier of the filament was calculated as below formula:

$$\text{Denier} = \frac{\text{Weight of silk filament (g)}}{\text{Length of silk filament (m)}} \times 9000$$

Statistical analysis: Statistical analysis: Data collected from all experiments with four replicates were subjected to statistical analysis. Two way Analysis of Variance (ANOVA) was carried out to find out the significant differences between the varieties and concentrations. Multiple Comparison of means were made depending on F-ratio and the critical difference (CD) values based on student t criteria at 5% and 1% level of significance utilizing the standard methods16. Pearson's Correlation Coefficients were also computed using the standard method in Statistics. Computations were made using statistical package under M.S. Excel work sheet.

Result

Five mulberry varieties were evaluated to find out their performance by feeding on the popular bivoltine hybrid silkworm race of CSR2xCSR4. The data was collected 3rd instar onwards and the results are as below.

Feeding period of silkworms with selected mulberry varieties showed significant differences only during 4th instar by consuming S-1635 mulberry variety with more time (93.94 hrs) when compared to 3rd and 5th instar. As per as moulting period is concerned, BR-2 variety showed shortest moulting period during 3rd (36.37 hrs) and 4th (35.37 hrs) moult compared with other mulberry varieties. Larval duration of 4th (4.01 days) and 5th (6.84 days) instar silkworm larvae showed significant differences, shortest larval duration were observed when larvae fed on BR-2 variety whereas 3rd instar larvae were not significant. 5th instar silkworm larvae showed significant differences and recorded highest larval weight (34.54 g/10 larvae) by feeding S-1635 variety. However, larval weight of silkworm at 3rd and 4th instar was not significant. Larval width of 3rd, 4th and 5th instar larvae showed highly significant among mulberry varieties. Maximum larval width was recorded by variety TR-10 (3.47 mm), S-1635 (6.49 mm) and BR-2 (9.75 mm) respectively. Larval length during 3rd and 5th instar larvae was found highly significant, longest length was recorded by feeding variety BR-2 (20.05 & 66.14 mm) while at 4th instar maximum length was noted by variety TR-10 (40.76 mm). The differences among mulberry varieties were not significant at 3rd instar larvae on body gain weight. However, during 4th and 5th instar it was highly significant by consuming variety S-1635 (0.71 g/10) and S-1 (2.61 g/10 larvae) respectively.

Varietal effect of mulberry was studied on cocoon parameters. Results indicated that, highest cocoon weight (1.68 g) was recorded by S-1635 of variety among different mulberry varieties. Influences of mulberry varieties were not significant on cocoon shell weight; however S-1635 and AR-14 varieties were recorded highest shell weight (0.34 g). Variety S-1635 was recorded highest pupal weight (1.35 g). As per as shell ratio is concerned, variety S-1 showed highest value (21.19 %) compared with other mulberry varieties. Effective Rate of Rearing (ERR) by number was not showed any significant results, however S-1635 and TR-10 varieties were recorded highest ERR (95.25). Higher ERR by weight was found in S-1635(160.06 g) when compared with other experimental varieties. The silk filament length was recorded highest in variety AR-14 (941.25 m) when compared with other varieties, while variety BR-2 (0.36 g) showed highest silk filament weight. Further, it is observed that denier of silk produced by variety BR-2 (3.45) were highly significant among mulberry varieties.

Discussion

The quality of mulberry leaves play an important role for success in the sericulture industry and direct its economics (Choudhury et al., 1991). The present study concluded that during fifth instar, varieties BR-2 and S-1635 showed shortest larval period due to less consumption of food. It is correlated with the earlier findings of Waldbauer (1964) and Sarkar (1994) who also reported the reduced larval period in the fifth instar along with the low intake of food in mulberry variety V-1which is clearly indicated that the varieties with high conversion efficiencies may reduce the larval period and consequently less quantity of the food is needed to support optimal growth of silkworm.

Present study confirmed that BR-2, S-1635 and AR-14 mulberry varieties performed well on larval weight of silkworm and it was also correlated with the findings of Kumar et al.,(1994) and Shankar et al.,(1994) who found similar results with different mulberry varieties. The current research work revealed that BR-2 and AR-14 mulberry varieties were best for larval growth and cocoon parameters of CSR2xCSR4 silkworm race. Present findings was

supported by Gangwar, (2010) who observed that BR-2 and AR-14 varieties were superior on economic characteristics of silkworm, larval weight (Sharma et al., 1986), larval growth (Machii and Katagiri, 1991) and cocoon yield (Sabhat et al., 2011 and Sarkar, 1994).

Economics of reeling and the quality of the reeled product is largely depended on the quality of cocoons used for reeling, and thus it is very important that the cocoon quality must be very good. The present experiment was conducted on five salt tolerance mulberry varieties and among the varieties, S-1635 were performed well on economic characteristics of silkworm larvae and cocoon parameters. Similar results were obtained from the different nutritive tests, among the four saline tolerant genotypes of mulberry in the findings of Kumar and Pandidurai (2011). They investigated that S-1635 is the best genotypic variety, because S-1635 has high nutritive value compared with the other genotypes, also its growth and yield parameters is more convenient compared with other varieties. So, the S-1635 gives good yield and also recommended as a best genotypic feed with high nutritive value for the silkworm larvae.

The results from the present investigation clearly indicated that feeding the silkworms with leaves of S-1635 mulberry variety have showed better performance followed by BR-2 and AR-14. Larval weight, larval length, feeding period, cocoon weight, filament length and ERR by number were shown better results with S-1635 when compared to other mulberry varieties (AR-14, TR-10, BR-2, and S-1). Whereas S-1 variety shown least performance on larval growth and cocoon parameters. Therefore, S-1635 mulberry variety has considered as best variety for bivoltine (CSR2 X CSR4) silkworm rearing in spring season under Uttar Pradesh climatic conditions.

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Table:1 Influence of different mulberry varieties on third instar silkworm larvae

Mulberry Variety	Moulting Period (h)	SD	CV%	Larval duration (days)	SD	CV%	Larval weight (g)	SD	CV%	Larval length (mm)	SD	CV%	Larval width (mm)	SD	CV%	Body weight gain (g)	SD	CV%
AR-14	36.75	0.645	1.756	3.04	0.048	1.576	0.90	0.021	2.326	20.26	0.140	0.691	3.40	0.043	1.257	0.09	0.008	9.072
TR-10	37.63	0.479	1.272	3.09	0.013	0.418	0.96	0.010	0.995	19.02	0.134	0.702	3.47	0.128	3.698	0.09	0.010	10.351
BR-2	36.38	0.479	1.316	3.09	0.010	0.310	0.91	0.013	1.427	20.05	0.151	0.753	3.36	0.073	2.184	0.10	0.008	8.165
S-1	36.63	0.479	1.307	3.15	0.022	0.686	0.90	0.013	1.442	18.39	0.205	1.114	3.15	0.029	0.935	0.09	0.008	9.072
S-1635	37.63	0.479	1.272	3.01	0.019	0.628	0.95	0.010	1.005	19.80	0.070	0.356	3.26	0.032	0.970	0.10	0.008	8.165
F value	5.20			16.60			22.72			113.95			12.15			1.47		
Inference	HS			HS			HS			HS			HS			NS		
CD @ 5%	0.78			0.04			0.021			0.221			0.108			-		
CD @ 1%	1.08			0.05			0.029			0.305			0.149			-		

Table:2 Influence of different mulberry varieties on fourth instar silkworm larvae

Mulberry Variety	Moulting Period (h)	SD	CV%	Larval duration (days)	SD	CV%	Larval weight (g)	SD	CV%	Larval length (mm)	SD	CV%	Larval width (mm)	SD	CV%	Body weight gain (g/10 larvae)	SD	CV%
AR-14	37.38	0.479	1.281	4.19	0.022	0.530	7.408	0.02	0.23	40.31	0.018	0.045	6.44	0.028	0.428	0.70	0.017	2.431
TR-10	36.38	0.479	1.316	4.18	0.026	0.634	6.760	0.01	0.21	40.76	0.013	0.032	6.32	0.022	0.351	0.62	0.014	2.281
BR-2	35.38	0.479	1.353	4.02	0.019	0.477	7.103	0.02	0.24	40.12	0.021	0.052	6.17	0.017	0.277	0.65	0.026	3.972
S-1	36.63	0.479	1.307	4.12	0.021	0.501	6.518	0.02	0.26	38.97	0.017	0.044	6.28	0.017	0.272	0.61	0.014	2.318
S-1635	38.25	0.645	1.688	4.06	0.043	1.072	7.295	0.01	0.18	40.16	0.026	0.064	6.49	0.026	0.408	0.71	0.008	1.150
F value	17.53			28.47			225.37			460.22			127.26			29.81		
Inference	HS			HS			HS			HS			HS			HS		
CD @ 5%	0.78			0.04			0.024			0.029			0.034			0.025		
CD @ 1%	1.08			0.06			0.033			0.041			0.047			0.035		

Table: 3 Influence of different mulberry varieties on fifth instar silkworm larvae

Mulberry Variety	Larval duration (days)	SD	CV%	Larval weight (g)	SD	CV%	Larval length (mm)	SD	CV%	Larval width (mm)	SD	CV%	Body weight gain (g/10 larvae)	SD	CV%	Pupal weight (g)	SD	CV%
AR-14	7.11	0.017	0.240	33.57	0.986	2.936	64.41	0.204	0.317	9.16	0.056	0.608	2.15	0.050	2.331	1.33	0.014	1.063
TR-10	7.12	0.026	0.369	32.78	0.138	0.420	65.44	0.479	0.733	9.42	0.076	0.808	2.30	0.039	1.688	1.35	0.008	0.605
BR-2	6.84	0.048	0.700	34.38	0.365	1.061	66.14	0.085	0.129	9.75	0.058	0.595	2.37	0.034	1.444	1.23	0.017	1.391
S-1	7.09	0.060	0.842	32.84	0.477	1.453	65.38	0.130	0.198	8.11	0.055	0.675	2.61	0.039	1.487	1.30	0.013	0.997
S-1635	6.96	0.048	0.688	34.54	0.398	1.151	65.33	0.146	0.223	9.52	0.087	0.917	2.45	0.055	2.253	1.35	0.017	1.263
F value	32.477			9.136			24.001			357.293			60.371			53.27		
Inference	HS			HS			HS			HS			HS			**HS**		
CD @ 5%	0.064			0.828			0.379			0.102			0.066			0.02		
CD @ 1%	0.089			1.145			0.525			0.141			0.092			0.03		

Table: 4 Influence of different mulberry varieties on cocoon and silk parameters

Mulberry Variety	Cocoon weight (g)	SD	CV%	Shell weight (g)	SD	CV%	Shell ratio (%)	SD	CV%	ERR by number	SD	CV%	Filament length (m)	SD	CV%	Filament weight (g)	SD	CV%	Denier (g/d)	SD	CV%
AR-14	1.67	0.013	0.775	0.34	0.013	3.674	20.37	0.109	0.534	94.25	1.708	1.812	941.25	5.12	0.54	0.33	0.01	4.29	3.04	0.02	0.56
TR-10	1.65	0.014	0.857	0.31	0.013	4.027	18.61	0.082	0.440	95.25	1.708	1.793	928.50	5.45	0.59	0.31	0.02	6.83	2.97	0.03	0.89
BR-2	1.57	0.013	0.825	0.33	0.017	5.136	21.69	0.124	0.570	95.00	1.414	1.489	912.25	4.19	0.46	0.36	0.02	4.78	3.45	0.04	1.17
S-1	1.61	0.017	1.062	0.34	0.008	2.401	21.19	0.055	0.258	92.25	2.217	2.404	849.25	4.35	0.51	0.31	0.01	4.56	3.24	0.01	0.44
S-1635	1.68	0.022	1.286	0.34	0.022	6.474	19.53	0.058	0.297	95.25	2.500	2.625	877.50	2.38	0.27	0.32	0.02	5.38	3.20	0.02	0.57
F value	34.05			2.76			768.950			1.697			292.12			6.20			222.78		
Inference	**HS**			**NS**			**HS**			**NS**			**HS**			**HS**			**HS**		
CD @ 5%	0.02			-			0.135			-			6.67			0.03			0.04		
CD @ 1%	0.03			-			0.187			-			9.23			0.04			0.05		