EFFECT OF DIFFERENT MULBERRY CULTIVATION FORMS ON ECONOMIC CHARACTERS OF SILKWORM, *BOMBYX MORI* L.

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Abstract

Effect of bush, low cut and tree mulberry leaves was estimated on growth and economic cocoon characters of eight silkworm (*Bombyx mori)* strains. The results revealed that different mulberry cultivation forms significantly influenced silkworm growth and cocoon characters. Maximum (3.11g) per larva body weight gain, absolute body weight (3.06g) increment, daily body weight (0.23g) increment and growth rate (34.78%) was recorded on low cut while minimum body weight (1.86g) gain, absolute body weight (1.81g) increment, daily body weight (0.15g) increment, and growth rate (30.12%) on bush. Similarly, the highest (1.14g) single cocoon weight, single cocoon shell weight (0.26g) and cocoon shell ratio (25.47%) was on low cut. In addition, effect of mulberry cultivation forms, racial difference among silkworm strains was also observed. Maximum growth rate, single cocoon weight, single cocoon shell weight and cocoon shell ratio was recorded in 206-MKD, 206-MKD, 206-PO, and C-102, respectively. Chemical analysis of leaf showed varied nutritive value with cultivation forms. Moisture (70.55%) and total protein (25.13%) contents were highest in low cut. On the other hand, more total carbohydrates (60.81%) and minerals (15.15%) were found in tree followed by bush. However, no single cultivation form gave all the nutrients at the highest level. High growth rates, single cocoon & cocoon shell weight and cocoon shell ratio on low cut reflected positive effect of high moisture and protein contents. Based on these findings it is recommended that silkworm (*B. mori*) should be reared on low cut mulberry leaves for better growth and silk production.

Key words: Silkworm, *Bombyx mori*, Mulberry, *Morus alba,* Cultivation forms, Growth, Cocoon character, Strains

Introduction

Needless to say, nutrition is one of the most important determinants of silkworm growth. Whereas, growth in terms of larval body weight is a building block leading to productivity of better silk yield. Higher the larval body weights; heaver will be cocoon (Ashfaq *et al.*, 1995). Furthermore, silkworm (*B. mori*) is a domesticated insect with very narrow range of food selection, almost limited to mulberry leaves (*Morus spp.*) which necessitate nutritious mulberry leaves for better growth and silk production.

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Richness of the food rests principally upon chemical composition of mulberry leaves (Zaman *et al.*, 1996). However, chemical composition of leaf is subjected to many factors. For example, genome (Sujathamma and Dandin, 2000), degree of maturity of leaf on the plant (Askari and Sharan, 1982; Qader *et al.*, 1992), mulberry cultivation form (Qader *et al.*, 1995), pruning system (Kumar and Benchamin, 1990), mulberry variety (Karimullah *et al.*, 1989; Hafiz, 1992; Bose and Bindroo, 2001), mulberry growing region (Kumar and Srivastava, 2002), etc.

In Pakistan, attempts were made to maximize leaf yield through cultivation of mulberry under different agronomic practices and training conditions (Ahmad and Hafiz, 1990). But work on nutritional impact of different mulberry cultivation forms *vis-à-vis* silkworm growth and economic cocoon characters is scanty. Present study therefore, was under taken with the aim at finding effect of different mulberry cultivation forms on silkworm growth and commercial attributes of cocoon.

Materials and Methods

Three forms of mulberry (*Morus alba* PFI-I) cultivation, *viz*. bush (cut at ground level), Low cut (cut at 50cm above ground level) and tree (no cut at all) were selected for evaluating their influence on silkworm (*Bombyx mori*) growth and cocoon characters. There were eight promising bivoltine silkworm strains for the trial, i.e. J-99, J-101, 205-MKD, 206-MKD (Japanese origin), C-102, 206-PO, 207-PO and 208-PO (Chinese origin).

Silk seed were hatched at 25±2°C and 75±5% relative humidity. All the neonates and first moulteers were fed leaves from low cut. Before the first feed after 2nd moult 270 disease free silkworm larvae (dfsl) were selected for each strain at random from stock culture, weighed and reared on assorted mulberry leaves. Leaves were plucked daily at 1000 hours and served five times i.e. at, 1000, 1400, 1800, 2200 0600 hours in wooden trays (30x20x2.5 sq. cms). Full-grown larvae were again weighed on 13th day of start of assorted feeding. Various growth indices like weight gained, absolute body weight ($W_t - W_0$) increment, daily body weight ($W_t - W_0$) t^{-1} increment, growth rate $100(\ln W_t - \ln W_0)\, t^{-1}$, etc were calculated. Where, W_0= weight of larva before the first feeding in 3rd instar, W_t = weight at the end of experiment, t= feeding duration. Cocoon characters like cocoon weight, cocoon shell weight and cocoon shell ratio was measured on 7th day after spinning.

Leaves of all the three mulberry cultivation forms were chemically analyzed for percentage of moisture content, nitrogen, protein, carbohydrates and minerals following the methods of AOAC (1980). The trials were carried out in factorial design with three replications in the Silkworm Pathology Laboratory, Pakistan Forest Institute, Peshawar. Mean data of various parameters were statistically analyzed applying two-way analysis of variance (ANOVA) test and difference among individual treatments was effectuated by least significant difference (LSD) test.

Results

Growth indices

The mean measurements of different growth parameters of eight silkworm strains obtained after feeding on bush, low cut and tree mulberry leaves are presented in Table 1. Overall effect of mulberry leaves cultivated under three conditions was highly significant in body weight gain, absolute & daily increment in body weight and growth rate on 13th day of assorted feeding. Similarly, strains showed overall highly significant variation in growth indices as well as within the same source of food.

Maximum and minimum larval body weight (larva $^{-1}$) was 2.39gms (205-MKD), 3.11gms (J-101), 2.63gms (205-MKD) and 1.86gms (207-PO), 2.57gms (207-PO) 2.08gms (207-PO) on bush, low cut and tree, respectively. Moreover, Low cut gave significantly more return in the form of body weight than that of bush and tree in all strains. Maximum (3.11g larva^{-1}) on low cut was 18.23% and 30.2% more than what the maximum was on tree and bush, respectively. Although there was difference in body weight gain on bush and tree mulberry but that was statistically non-significant. Effect of bush, low cut and tree on absolute and daily increment in larval body weight was almost replica of body weight gain. The highest absolute increment in body weight was 3.06g larva^{-1} on low cut. This was 18.59% and 31.08% higher than the highest of tree and bush leaves. Nearly same scale of percentage difference among cultivation forms was found in daily body weight increment.

In case of growth rate, impact of bush, low cut, and tree mulberry leaves was statistically non-significant on J-101, C-102, and 206-PO. The difference of the highest 34.78% growth rate on low cut with that of tree and bush was non-significant. The growth rate among test silkworm strains varied significantly on bushy leaves. However, their growth rate was non-significant among themselves on low cut and tree.

Cocoon characters

Data of the average economic cocoon characters recorded after feeding leaves from three forms of mulberry cultivation are displayed in Table 2. Overall influence of bush, low cut and tree leaves was highly significant on cocoon weight, cocoon shell weight and cocoon shell ratio. Maximum single cocoon weight (1.14g) in 206-MKD and minimum (0.90g) in 206-PO was observed in low cut and bush mulberry, respectively. Nevertheless this nutritive effect was non-significant on cocoon weight of 205-MKD, C-102 and 208-PO. The weightiest cocoons recorded on bush and tree mulberry leaves were 8.17% and 11.19% lighter than their counter part on low cut. Racial difference among silkworm strains was also highly significant. The cocoon was comparatively heavier on low cut than that of tree and bush in all silkworm strains. Japanese strains spun superior cocoons than Chinese one.

Cocoon shell weight varied significantly on three sources of mulberry leaves. The heaviest single cocoon shell of 0.26g (206-PO) was on low cut while lightest 0.19g (207-PO & J-101) on bush & tree. Maximum single cocoon shell weight was in 208-PO (bush), 206-PO (low cut) and 208-PO & 205-MKD (tree). On the other hand 207-PO (bush), 207-PO (low cut) and J-101 (tree) had minimum single shell weight. All the strains gave comparatively heavy cocoon shell weight on low cut than bush and tree except 208-PO.

The difference between the heaviest cocoon shell on low cut and bushy leaves was marginal (1.19%) but both of them have had conspicuous increase over tree (24.27%).

There was nominal difference in cocoon shell ratio when larvae were fed on bush, low cut and tree mulberry leaves except C-102 and 208-PO. Maximum (25.47%) and minimum (19.29%) cocoon shell ratio was calculated in C-102 and J-101 on low cut and tree, respectively. Maximum cocoon shell ratio recorded on low cut was moderately better than that of bush (6.95%) and tree (15.41%). The strains significantly varied among themselves on low cut and tree mulberry leaves but this variation was non-significant on bushy leaves.

Chemical composition of mulberry leaf

Nutritional composition of mulberry leaves growing under bush, low cut and tree conditions was analyzed for moisture content, total protein, total carbohydrates and minerals contents. The results are presented in Table 3.

Table 1: Growth indices of silkworm strains fed with mulberry leaves cultivated under different conditions

Strains	Weight gained on 13th day of feeding (g larva^{-1})			Absolute increment in weight (g larva^{-1})			Daily increment in weight (g larva^{-1} day^{-1})			Growth rate (% day^{-1})		
	Bush	Low cut	Tree	Bush	Low cut	Tree	Bush	Low cut	Tree	Bush	Low cut	Tree
			∀Δ			∀Δ			∀Δ			∀n.s
J-99	2.03 cd (b)	2.82 bc (a)	2.24 cde (b)	1.98 bc (b)	2.77 ab (a)	2.20 bc (b)	0.17 cd (c)	0.23 bc (a)	0.18 cde (b)	31.08 ab (b)	34.23 n.s (a)	32.89 n.s (ab)
J-101	2.37 ab (b)	3.11 a (a)	2.48 ab (b)	2.33 a (b)	3.06 a (a)	2.43 ab (b)	0.19 ab (b)	0.26 a (a)	0.20 ab (b)	33.19 a	34.44	32.50 **(n.s)**
205-MKD	2.39a (c)	2.88 b (a)	2.63 a (b)	2.34 a (b)	2.83 ab (a)	2.58 a (ab)	0.20 a (c)	0.24 b (a)	0.22 a (b)	31.43 ab (b)	34.24 (a)	32.82 (ab)
206-MKD	2.13 c (c)	2.98 ab (a)	2.41 abc (b)	2.07 abc (b)	2.93 a (a)	2.36 abc (b)	0.17 c (c)	0.24 ab (a)	0.20 abc (b)	30.12 b (b)	34.78 (a)	32.49 (ab)
C-102	2.18 abc (b)	2.95 ab (a)	2.31bcd (b)	2.13 ab (b)	2.90 a (a)	2.26 bcd (b)	0.18 abc (b)	0.24 ab (a)	0.19 bcd (b)	31.77 b	33.58	32.30 **(n.s)**
206-PO	2.16 bc (b)	2.60 cd (a)	2.12 de (b)	2.11 abc (b)	2.55 bc (a)	2.07 c (b)	0.18 bc (b)	0.21 cd (a)	0.17 de (b)	31.63 ab	33.42	31.31 **(n.s)**
207-PO	1.86 d (b)	2.51 d (a)	2.08 e (b)	1.81 c (b)	2.46 c (a)	2.03 d (b)	0.15 d (c)	0.21 d (a)	0.17 e (b)	30.57 ab (b)	34.14 (a)	32.1 (ab)
208-PO	2.19 abc (b)	2.83 bc (a)	2.03 e (b)	2.14 ab (b)	2.78 ab (a)	1.99 d (b)	0.18 abc (b)	0.23 b (a)	0.17 e (b)	31.55 ab (b)	34.57 (a)	32.11 (ab)

∀ - Overall effect of mulberry cultivation forms was significant at 99% level. Δ - Overall difference among silkworm strains was significant at 99% level. – Figures in a column sharing same alphabets are non-significant among themselves. – Figures sharing same parenthesized alphabets in a 3-column row are non-significant among themselves (effect of mulberry cultivation forms for the given growth parameter of a silkworm strain), **n.s** - non-significant

Table 2: Economic cocoon characters of different silkworm strains reared on three mulberry cultivation forms

Strains	Cocoon weight (g cocoon^{-1})			Cocoon shell weight (g cocoon shell^{-1})			Cocoon shell ratio (%)		
	Bush	Low cut	Tree	Bush	Low cut	Tree	Bush	Low cut	Tree
			∀Δ		∀Δ				∀Δ
J-99	0.92 bc (b)	1.13 a (a)	0.96 abc (b)	0.21 b (b)	0.25 a (a)	0.22 a (b)	22.39 ^{ns}	23.26 ab	21.62 ab (**ns**)
J-101	1.03 a (b)	1.12 ab (a)	0.99 ab (b)	0.22 b (b)	0.24 ab (a)	0.19 b (c)	21.62	21.64 bc	19.29 b (**ns**)
205-MKD	1.06 a (a)	1.07 ab	1.03 a (**ns**)	0.22 b (ab)	0.23 bc (a)	0.21 ab (b)	21.58	21.14 bc	20.07 ab (**ns**)
206-MKD	1.04 a (b)	1.14 a (a)	0.987 ab(b)	0.21 bc (b)	0.25 ab (a)	0.20 ab (b)	21.75	20.21 c	20.53 ab (**ns**)
C-102	0.99 ab	0.98 c	0.92 bc (**ns**)	0.25 a (a)	0.23 bc (a)	0.20 b (b)	23.81	25.47 a (a)	21.46 ab (b)
206-PO	0.90 c (b)	1.09 ab (a)	0.94 bc (b)	0.21 b (b)	0.26 a (a)	0.20 ab (b)	23.56	23.46 ab	21.84 a (**ns**)
207-PO	0.92 bc (ab)	0.98 c (a)	0.90 c (b)	0.19 c (b)	0.22 c (a)	0.20 b (b)	22.44	20.87 c	22.07 a (**ns**)
208-PO	1.01 a (a)	1.05 bc	0.99 ab (**ns**)	0.25 a (a)	0.24 ab (a)	0.21 ab (b)	23.32 (a)	25.18 a (a)	20.74 ab (b)

∀ - Overall effect of mulberry cultivation forms was significant at 99% level. Δ - Overall difference among silkworm strains was significant at 99% level. – Figures in a column sharing same alphabets are non-significant among themselves.
– Figures sharing same parenthesized alphabets in a 3-column are non-significant among themselves (effect of mulberry cultivation forms for the given character of cocoon of a silkworm strain), **n.s** - non-significant.

Table 3: Chemical composition of mulberry leaf cultivated under different conditions

Leaf Type	Moist. content (%)	Nitrogen (%)	Protein (%)	Carbohydrates (%)	Minerals (%)
Bush	63.91 ** b	3.24 **b	20.23 ** b	60.23 **a	12.99 **b
Low cut	70.55 a	4.03 a	25.13 a	58.04 b	10.26 c
Tree	66.26 ab	2.80 c	17.49 c	60.81 a	15.15 a
CD	4.93	0.11	0.66	1.38	0.71

** Significant at 99% level, - Figures sharing same alphabets in a column are non-significant among themselves.

Maximum (70.55%) moisture content found in low cut and that was significantly higher than bush. It was non-significant between low cut and tree; tree and bush. Likewise, 25.13% total protein was reckoned in low cut followed by bush (20.23%) and tree (17.49%). Contrarily, total carbohydrates (60.81%) and minerals (15.15%) were significantly more in tree leaves followed by bush. However, results revealed that no single form of cultivation had all nutrients in maximum.

Discussion

It is common knowledge that genetic make-up and ecological factors regulate animal growth. Among ecological factors nutrition has paramount importance. In the present study, effect of mulberry cultivation forms as well as racial is found on silkworm growth and cocoon attributes. Performance of different strains on the same food reflects genetic make up variation. Significant differential impact of bush, low cut and tree on silkworm growth and cocoon characters due to cultivation form. These results are in corroboration with Qader *et al.,* (1995) who have reported effect of cultivation forms on *B. mori* growth and cocoon characters. Nutritional analysis of leaf shows that cultivation forms influence nutritive value (Table 3).

Generally, the nutritional status of mulberry leaves which influence the economic characters of silkworm depends upon the levels of moisture content, total protein, total carbohydrates and minerals (Sujathamma and Dandin, 2000; Bose and Dindroo, 2001). Among these nutriments leaf moisture is the most important constituent (Radhakrishna *et al.*, 2000). High moisture improves the palatability and consequently enhances the feeding efficiency of the larvae. In turn the high feeding efficiency increases the growth rate of silkworm (Hemavathi and Bharathi, 2003). In the present study, low cut mulberry leaves have higher moisture content as well as growth indices. This substantiates a positive correlation between leaf moisture and larval growth. This finding is consistent with the results to Paul *et al.,* (1992).

Another vital dietary component of *B. mori* is leaf protein. According to Horie (1978) optimum dietary protein level of 20-25% is required for better growth of silkworm larvae. This study indicates a maximum 25.13% total protein in low cut mulberry leaves that have given impetus to larval growth. Carbohydrates are used for physiological combustion and for synthesis of lipids and amino acids. Silkworm through more intake of food quantum in succulent leaves may overcome their shortage.

Protein contents of mulberry leaves are not only vital for silkworm growth but also for better silk production. All cocoon characters directly rely on protein contents of mulberry leaves. Fukuda, (1960) reported that about 70% of the silk protein produced by silkworm is directly derived from the protein content of mulberry leaves. The outcome of this study depicts that cocoon weight, cocoon shell weight and cocoon shell ratio are high of those silkworm strains which fed on mulberry leaves having high protein percentage (low cut mulberry leaves). These results are consistent with that of Qader *et al.*, (1992 & 1995), Bongale and Krishna (2000).

Conclusion

It is concluded that different mulberry cultivation forms, i.e. bush, low cut and tree mulberry leaves affect nutritional composition of the leaf vis-à-vis economic characters of silkworm (*B. mori*). Besides high moisture and protein contents, silkworm growth and economic cocoon characters were better in all under trial silkworm strains on low cut. In addition, significant racial variation was noticed among silkworm strains. Nutritionally non-of the cultivation form had all nutrients at appropriate level. Therefore, an integrated cultivation form should be adopted to supply all the essential components at proper time and in adequate quantity for better silkworm growth and silk production.

Acknowledgement

The authors are thankful to the Forest Chemist, Pakistan Forest Institute, for chemical analysis of mulberry leaves cultivated of different forms.

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