The Effect of Four Mulberry Varieties on Performance of *Bombyx mori* L. (Lepidoptera, Bombycidae)

Fazli Subhan, Irshad Ahmad, Salim Jan and Maqsood Shah

1Department of Entomology, University of Agriculture, Peshawar, Khyber Pakhtunkhwa, Pakistan
2Department of Microbiology and Biotechnology, Sarhad University of Science and Information Technology (SUIT), Peshawar, Khyber Pakhtunkhwa, Pakistan

**Abstract:** Silkworm larvae were reared on the leaves of four mulberry varieties i.e. *Morus alba*, *M. rubra*, *M. latifolia* and *M. nigra*. The varieties were evaluated for nutritional potential on the growth and cocoon characters of silkworm. The results revealed that larval growth by weight, single cocoon weight, shell weight and shell percentage were greatly influenced by the nutritive value of different mulberry leaves. The maximum and minimum body weights were found (25.50 g) and (20.50 g) in *M. alba* respectively. The effect of mulberry species on larval and pupal mortality was non-significant. The percent defective cocoons (3.32%) and good cocoons (96.68%) were found in *M. nigra*. The maximum effective and good cocoon was found in *M. alba* (6.73%) and (96.68%), respectively. The maximum single cocoon weight of 1.34 g was recorded in *M. nigra* while minimum was 1.035 g in *M. rubra*. The larvae fed on *M. nigra* showed maximum single shell weight of 0.55 g. The minimum single shell weight of 0.242 g was recorded in *M. rubra*. Maximum shell ratio of 26.49% was recorded in *M. nigra* while minimum shell ratio 23.43% was recorded in *M. alba*. Protein and carbohydrates were found in mulberry leaves (17.25-21.06%) and (35.47-37.25%), respectively. The maximum carbohydrate (37.25%) and protein (21.06%) were found in *M. nigra*. Generally the larvae fed on *M. nigra* leaves gained more body weight and gave better cocoon characters. These variations could be attributed to the nature of nutritive value in tested species.

**Key words:** Sericulture • Larval growth • Cocoon characters

**INTRODUCTION**

Sericulture is the science of rearing silkworm for the commercial production of raw silk and includes all the operation, which are required for the production of silk fiber. The historical background of sericulture shows that silk was discovered first in China and then spread to other parts of the world. The earliest authentic reference to silk is found in the chronicles of Chou-king (2200 B.C.), where silk figured pro-eminently in public ceremonies as symbol of homage to the emperors. Silk industry originated in the province of Chou-Tong (China) and the secret was jealously guarded by the Chinese for about 3000 years. When commercial relation were established between China, Persia and other countries, the export of raw silk and silk goods assumed great importance. By the first century B.C. markets as far away as southern Europe began to receive silk fabrics made in the East [1].

Sericulture is practiced in 35 countries of the world. The main production regions lie in the tropical and subtropical areas between 20-40 degrees north latitude. It was about the start of the Christian era that sericulture spread to India and Azad Kashmir (1951), KhaberPakhtunKhwa (1952), Baluchistan (1951) and last of all in Sind in (1976) [2].
Mulberry belongs to Family Moraceae and Genus *Morus*. There are 35 species of *Morus* and more than 1000 varieties of mulberry, which are being cultivated and classified into three types *Morus*obeycis K. Morusalba L. and *Moruslatifolia* L. [3].

Silkworm, *Bombyx mori* L. belongs to family Bombycidae (order Lepidopetra). The adult moths are creamy white in color with several faint brownish lines. Adult due to feed, rarely fly and usually live only for a few days. Each female lays 300-500 eggs. The eggs hatch in about 12 days. Larvae have a short anal horn and feed principally on leaves of mulberry. When used for commercial purpose pupae are killed before the emergence of adults. Each cocoon is composed of single thread of about 914 meter long [4].

Mulberry leaves are rich in protein and amino acids. It is known that there is high correlation between leaf protein level and production efficiency of cocoon shell, which means cocoon shell weight to the total amount of mulberry leaves consumed by the silkworm [5]. Therefore, increase in protein level may lead to improvement in productivity of cocoons and silk.

Different species of mulberry may have compositional differences and might lead to varying effects on growth and silk production [6]. The growth rate of silkworm larvae and subsequent silk production depend mainly on the nutrient contents of mulberry leaves. It was reported that about 70% of the silk protein produced by the silkworm is directly derived from the protein contents of mulberry leaves. The nutritive values of mulberry leaves vary due to species and leaf maturity of the plant [7].

**MATERIALS AND METHODS**

We studied the effect of leaves of different mulberry specie on larval growth and cocoon characters of silkworm, *Bombyx mori* L. The experiment was conducted at Pakistan Forest Institute Peshawar.

**Silk Worm Rearing:** The F1 hybrid silk seed was kept in the incubator (disinfected with 2% Formalin) at temperature of 25-27°C and relative humidity of 70-80%. Brushing of newly hatched larvae were carried out after 10-12 days with the help of disinfected hen feather.

Larvae were fed five times a day with equal intervals i.e. 6.00 a.m. to 10.00 p.m. After each feeding the trays were covered by vinyle sheets up to 3rd instar to retain enough moisture inside the microclimate of tray and prevent the leaves from drying.

During 1st and 2nd instar larvae were fed with 1st and 2nd leaves starting from the tip of the branch and chopped double size to that of larvae. During 3rd instar they were fed with 1/4th cut larvae, while 4th and 5th instar were fed with half cut and full leaves, respectively but cleaning was carried out two times in 2nd instar, 3 times in 3rd and daily during 4th and 5th instars. Bed cleaning nets with meshes of various sizes were used.

Wooden trays sizes of 20 X 32 cm² were used for the young stage silkworm (1st to 3rd instar and for feeding the 4th and 5th instar larvae, the wooden tray for 60 X 70 cm² was used. During molting or sleeping stage the worms were not fed. At cocoon spinning stage the ripened worms were shifted to cocoon spinning bed called mounting beds. Four replications were made for each treatment by following completely randomized design and 100 larvae were reared in each replication. The larvae of each replication were fed with leaves of different mulberry species i.e. *M.alba, M.rubra, M.latifolia*and *M.nigra*.

The larvae were reared under identical conditions of temperature (25± 1°C) and relative humidity (70 to 80 ± 5%) during the rearing period.

The following observations were recorded in this experiment.

- Weight of ten larvae, randomly selected from each replication was taken in each treatment of fifth instar.
- Percent larval mortality was found out for each sample taken in four replications consisting of 100 larvae per replication for fifth larval instar.
- Percent pupal mortality was found out as mortality of pupae per total cocoon + cocoons
- Percent Defective Cocoon was calculated as follows:

Percent Defective Cocoon= Defective cocoon /Total cocoon X 100

Percent Good Cocoon was calculated as follows:

Percent Good cocoon= Good cocoon /Total cocoon X 100

- Single cocoon Weight: On the harvest day of cocoons, representative samples of 10 cocoons were dissected and pupae and exuviae were gently removed and the cocoons shells were weighted again in order to determine their average cocoons shell weight.
- Single Shell Weight: after recording the weight each of the 10 cocoons were dissected and pupae and
exuviae were gently removed and the cocoons shells were weight again in order to determine their average cocoon shell weight.

- Cocoon Shell Ratio was calculated as follows:

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\text{Cocoon shell ratio} = \frac{\text{Cocoon Shell Weight}}{\text{Cocoon Weight}} \times 100
\]

**Proximate Chemical Analysis:** The leaves of different mulberry species were sampled in the morning and weight immediately. The samples were oven dried until constant weight. The oven dried samples were grounded to a mesh size of 2 mm and stored in an airtight container for further nutrient analysis. Protein content was determined [8]. The Nitrogen-free-extract can be found by difference. The proteins are the building material to produce silk substance. The carbohydrate plays a vital role in larval growth and cocoons characters as well. Therefore, the relationship was determined between cocoon characters and the chemical composition of different mulberry species to find out their effect, especially their protein content on shell ratio.

**RESULTS**

**Larval Weight:** Data on body weight was taken on 6th day of fifth instar, which shows that the mean values of body weight of larvae fed mulberry species varied from 20.5 to 25.5g (Fig. 1). Statistical analysis indicates that the affect of different mulberry species on larval weight was significant. The maximum mean body weight of larvae fed the leaves of *M.nigra* was (25.5g) and *M.latifolia* (24.9g). While the species *M. alba* (21.8g) and *M.rubra* (20.5g) were non significant among themselves.

**Larval Mortality:** Data relating percent larval mortality are given in Fig. 1. The mean value of mortality was maximum for larvae fed on *M.alba* (3.00) followed by *M.rubra* (3.25) and *M. latifolia* (3.00) and *M. nigra* (2.00). Statistical analysis shows that mulberry species had no significant effect on larval mortality of silkworm.

**Pupal Mortality:** Data relating percent pupal mortality are given in Fig. 1. It was recorded that the means value of pupal mortality was maximum for larvae fed on *M. rubra* (3.00) followed by *M.alba* (2.75), *M. latifolia* (2.25%) and *M.nigra* (1.25). Statistical analysis shows that mulberry species had no significant effect on pupal mortality of silkworm.

**Defective Cocoon:** It is clear from Fig. 2 that the maximum percent defective cocoons were calculated in *M.alba* (6.73%) which is statistically at par with *M.rubra* (5.43%). Minimum defective cocoon was found in *M.nigra* (3.32%) which is statistically similar to *M. latifolia* (4.64%).

**Good Cocoon:** The percent good cocoon was 93.27, 94.57, 95.36 and 96.68% for *M.rubra, M. alba, M. latifolia* and *M.nigra*, respectively (Fig.2). Statistical analysis indicates that the effect of different mulberry species on good cocoon was significant. The maximum good cocoon was recorded in *M.nigra* followed by *M. latifolia* and *M.rubra* (94.57%) were non significant among themselves.

**Single Cocoon Weight:** The results in Fig. 3 show that there was a significant difference among different treatments. The maximum cocoon weight (1.34g) was recorded in *M.nigra* followed by *M. latifolia* (1.23g), *M.alba* (1.10g) and *M.rubra*(1.03). However *M.alba* is statistically similar to *M.rubra*.
Fig. 3: Cocoon characters of silkworm reared on different mulberry species.

Fig. 4: Relationship between cocoon characters and chemical composition of leaves of different mulberry species.

**Single Shell Weight:** Results shown in Fig. 3 indicated that there were significant differences among different treatments. The maximum shell weight (0.355g) was recorded in *M. nigra* followed by *M. latifolia* (0.305), *M. alba* (0.262g) and *M. rubra* (0.242g). However, *M. alba* is statistically at par with *M. rubra*.

**Shell Ratio:** Cocoon shell ratio expressed in percentage is given in Fig. 3. Data indicates significant difference was observed among different treatments. The maximum shell ratio (26.49%) was recorded in *M. nigra* followed by *M. latifolia* (25.01), *M. alba* (23.78%) and *M. rubra* (23.43%). However, *M. alba* is statistically at par with *M. rubra*.

**Percent Protein:** Result shown in Fig. 4 indicated that there were significant differences among the protein content of different treatments. The highest protein (21.06%) was observed in *M. nigra* followed by *M. latifolia* (19.00%) and *M. rubra* (18.85%), while the lowest were found in *M. alba* (17.25%). The latter three species were non-significant among themselves.

**Percent Carbohydrate:** Results shown in Fig. 4 indicated that there were significant differences among different treatments. The highest carbohydrate (7.25%) was observed in *M. nigra* followed by *M. latifolia* (36.55%) and *M. alba* (35.47%). The minimum percent carbohydrate was in *M. rubra* (34.10%).

It is clear from the comparison Fig. 4 that highest protein (21.06%) and carbohydrate (37.25%) gave highest shell ratio (26.49%) in *M. nigra*. The lowest protein content of (17.25%) gave shell ratio of (23.78%) in *M. alba*.

**DISCUSSION**

Larval weight varied between 20.5g/10 larvae to 25.5g/10 larvae in the present study. The maximum and minimum mean larval weight was recorded in *M. alba* (25.5g/10 larvae) and *M. rubra* (20.5g/10 larvae) respectively. These findings are in accordance with those obtained by Qader et al. [11], who studied maximum larval weight (30.96g/10 larvae) in Urboshi which differed significantly from Nistari (15.45g/10 larvae) fed with tender and mature coarse leaves, respectively throughout larval period. These results indicate that the mulberry species used in food for silkworm weight has an average body weight of eight/10 larvae for the fifth instar is 25.42g fed on *M. laevigata* and 16.32g when fed on *M. alba* [6]. It was found that weight gained by the leaves fed on *M. leavigata* was highest and it was lowest on *M. alba* [14].

The mean value of mortality was maximum for larvae fed on mulberry species *M. rubra* (3.5%) followed by *M. alba* (3.25%), *M. latifolia* (3.00%) and *M. nigra* (2.00%). By above result we may assume that mulberry species do not differ in nutrient value for disease susceptibility. However, no literature could be found in this regard. In general larval mortality was more in spring then autumn. The mean value of mortality was maximum for pupae fed on mulberry species *M. rubra* (3.00%) followed by *M. alba* (2.75%), *M. latifolia* (2.25%) and *M. nigra* (1.25%).

Maximum mean of percent defective cocoon and percent good cocoon were obtained for larvae reared on *M. alba* (6.73%) and *M. nigra* (96.68%) respectively. Percent defective cocoon was 3.32 to 6.73% and the percent good cocoon was 93.26 to 96.68% in the present study. The percent defective cocoons were reported as 4.5% and percent good cocoon 82.75% in case of *M. nigra* [9]. Therefore, these findings are in accordance with those obtained by previous workers.
In the present study, weight of cocoons has been found to be ranging between 1.105 to 1.340 grams. It was found that the cocoon weight varied between 0.4 to 2.0 grams [10]. The cocoon weight recorded in this study is almost in accordance with the previous results. Cocoon weight of 1.34 grams as recorded in case of M. nigra species in the present study whereas [9] reported cocoon weight of this specie to 1.35 gram.

Cocoon shell weight was 0.24 to 0.35 gram and the cocoon shell ratio was 23.43 to 26.49 percent in the present study. The cocoon shell weight of 0.29 and cocoon shell ratio of 25.58 percent in case of PFI (M. nigra). It was found that the weight of cocoon shell varied between 0.46 gram to 0.62 gram and the cocoon shell ratio ranged between 21.5 to 24.70 percent depending upon the species [9]. Therefore, the results of the present study fall within the same range as those of the previous worker. The species M. alba had thus comparatively better effect on shell weight and cocoon shell ratio.

In the present study, protein has been found to ranging between 17.25 to 21.06% and carbohydrate between 35.47 to 37.25%. It was found that the protein varied between 13.25 to 21.04% in different types of mulberry species [11]. Protein (22.5%) and carbohydrate (36.57%) was reported in case of M. nigra. Mulberry species protein and carbohydrate varied between 20.56 to 22.51% and 36.20 to 41.35% respectively [9].

The results of the present study are, therefore, within the range reported by other workers. The proteins are the building material to produce silk substance. Therefore, the relationship was determined between economic cocoon characters and chemical composition of different mulberry species to find out their effect.

It is clear from the above data that highest protein content in M. nigra gave highest shell ratio which was followed by M. latifolia, gave comparatively better cocoon shell ratio. 26.75 and 18.70 to 23.20 percent crude protein in mulberry leaves was reported as against 21.06, 19.00, 18.85 and 17.25 percent in M. nigra, M. latifolia, M. rubra and M. alba respectively [12]. The results are in line with Ito and Tanaka [13] who reported that elevation of dietary protein results in acceleration of growth and silk production.

In general M. nigra proved superior to the rest to test species so for as its larval growth, larval and pupal mortality, good cocoon percentage, cocoon weight, shell weight, cocoon shell ratio, protein and carbohydrate contents were concerned. All these are favorable to the rearers. M. latifolia was second in all the above stated characters.

The present study has shown that food has positive effect on development of silkworms. Some mulberry species gave better economic cocoon characters, protein and carbohydrate content in mulberry leaves, which has a direct bearing on cocoon and silk yield. Mulberry nutrition promotes vigor and resistance in silkworms.

**CONCLUSION**

The mulberry varieties (Morusalba, M. rubra, M. latifolia and M. nigra) have a nutritional potential on the growth and cocoon characters of silkworm. The larval growth by weight, single cocoon weight, shell weight and shell percentage were greatly influenced by the nutritive value of different mulberry leaves.

**REFERENCES**


