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Studies on varietal performance of Morus on growth and economic parameters of mulberry silkworm *Bombyx mori* Linn

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Abstract
The experiment was conducted in the Entomology Laboratory of Research Station, Govt. P.G.D.C. Campierganj, Gorakhpur, during September-October, in Completely Randomized Design with six treatments and three replications. Larvae of Silkworm hybrid MYX × CSR2 were fed on mulberry varieties like *Morus alba* (white mulberry), Morus rubra (Red mulberry), Morus nigra (Black mulberry) & Morus macroura (Himalayan mulberry), S-1635 and mixture of all varieties leaf like observations on the dimensions of different instars of silkworm *Bombyx mori* L. were recorded. Mulberry variety mixed different Morus leaf was recorded as best variety for growth and development of silkworm during final instars with maximum larval length (68.88 mm), larvae breadth (9.71 mm) and larval weight (3.24 gm) and economic trait of larval character like pupal weight (1.54 gm), Cocoon weight (2.10 gm), shell weight (0.63 g), cocoon shell ratio (31) and silk filament length (1198 m). Variety was also observed promising so far growth and development of silkworm larvae is concerned, while minimum larval length, breadth, weight and economic trait was observed when larvae fed on mixture of all varieties. The mean weight of larvae, pupae, cocoon economic character and shell as well as cocoon shell ratio and larval fibroin and sericin protein content of *Bombyx mori* were increased when fed with mixed varietal Morus. In addition, the filament length of secretion of salivary gland produced by this silkworm in response to mixed Morus showed significant increase with respect to the other five varieties of mulberry leaf. Positive correlation was observed in filament length against fibroin and sericin protein content. The overall performance of *Bombyx mori* in terms of growth and economic parameters was significantly improved with mixed Morus and this variety has the potential to enhance the commercial qualities of silk production. Therefore, it is suggested to be used in sericulture for higher yield of silk thread production to rearers.

Keywords: *Bombyx mori*, mulberry variety, growth performance, filament length, larval protein content

Introduction
The mulberry silkworm *Bombyx mori* L. belonging to the family Bombycid are of common use in sericulture. They feed solely on leaves of mulberry (*Morus alba* L). Therefore, the quality and quantity of mulberry leaf have an intimate relation with the health of silkworm and quality of silk production. “Natural Silk” a dry salivary secretion is produced when a fully grown silkworm larva spins its cocoon for pupation. It's known as the "Golden Fiber" or "Golden Queen" of textiles, and it's revered all over the world for its lustrous sheen. Its products are delightfully light, soft but sturdy, silky, and universally praised by leading fashion designers across the world for their elegance, colour dyeing affinity, thermal tolerance, and water absorbency. Silk as a wearable fiber was first discovered by the Chinese emperor Xi Ling Shi in 2,640 B.C., and Chinese kept its culture and weaving secrets for 2,500 years (Gangopadhyay; 2008) [4]. Sericulture is the science of rearing of silkworms and production of silk. Silk is the most elegant textile in the world with natural sheen, light weight, soft touch, glamour, and highly durable. Successful qualitative and quantitative cocoon production is influenced by a no. of factors such as mulberry leaf (38.2 percent), climate (37.0 percent), silkworm breed (4.2 percent), rearing procedures (9.3 percent), silkworm seed (3.1 percent), and other factors (8.2 percent). Humans have immensely benefited from silk produced by silkworms and subsequently researchers have always been

trying to unveil the factors that can be manipulated to the benefit of the silkworm rearers (Nair KS, *et al*., 2004) [14]. The major factors which determine the productivity and profit ability in sericulture are yield and quality of mulberry leaves (Krishnaswami. S; 1978) [9]. The growth and development of silkworm and the economic characters of cocoon are influenced to a great extent by the nutritional content of mulberry leaf and this in term influences silk production. Several reports are available on the evaluation of mulberry varieties through silkworm rearing performances (Adolkar, *et al*. 2007; Seidavi, A; 2011) [1, 17]**.** The nutritive value of mulberry depends on various factors and one of them is the varietal component of the leaf. Besides, the effect of feeding of different varieties of mulberry on the economic characters of the worm has been studied by a number of workers. On the bases of above facts, the nutritional value of the leaves fed to silkworms has a significant impact and plays an important role on silkworm growth and development such as larval length, breadth and weight and economic traits of silkworm which are influenced by the nutritional status of the leaves supplied to silkworms. Because of the quicker metabolic activity, the worms can mature earlier due to the balanced nutritional quality of the leaves**.** Silkworm larvae of a young age like wet, succulent, and nutritive leaves, ideally the top ones, which allow the young larvae to increase the amount of food they consume (Yokoyama; 1974) [23]. Mulberry varieties are important as they differ in their nutritional value responsible for growth and development of silkworm larva. Mulberry leaves are succulent for silkworms due to their high water content **(**Machii & Katagiri; 1991) [12]. Water has a significant impact on the quality of leaves used as silkworm feeding, and there is a close link between the silkworm's ingestion and digestion of leaves and the most crucial variables for successful silkworm rearing (Ullal & Narasimhanna; 1981) [12]. Silkworm larvae in the first and second instar, in particular, require more water in leaves to thrive. As a result, they require soft, succulent tender leaves that are high in water and fibroin and sericin protein 2nd & 3rd instar larvae; on the other hand, require dark green leaves, which contain less water than tender leaves. For healthy growth and development of silk glands for higher silk production, the 4th and 5th instar larvae require mature leaves with higher protein and carbohydrate content (Quader; 1987) [15]. The early instars of silkworms (1st , 2nd & 3rd) are known to consume 10-15% of the food consumed by the silkworm in its larval stage, whereas the late instars (4th and 5th) feed the bulk of food consumed by the silkworm in its larval stage 80-90% (Krishnaswami *et al*., 1973) [10]. Therefore, this study was undertaken by conducting a test between five different mulberry varietal leaf and local in order to suggest suitable variety for more silk productivity under selective varietal leaf of Morus mix variety & S-1635 mulberry leaf conditions which will be beneficial for the silkworm rearers and more productivity of silk.

Materials and Methods

The experiment entitled “Studies on varietal performance of mulberry on growth and development of silk worm (*Bombyx mori* L.)” was conducted in the Laboratory of Entomology, Govt. P.G.D.C. Campierganj, Gorakhpur, during September-October, 2017 in Completely Randomized Design with nine treatments and three replications. 25 larvae of silkworm hybrid MYX × CSR2 were reared on five cultivars of mulberry i.e. *Morus alba* (white mulberry), Morus rubra (Red mulberry), Morus nigra (Black mulberry) & Morus macroura (Himalayan mulberry), mixture of S-1635all varieties. The fresh mulberry leaves of above four varieties were obtained in required quantity was collected from state sericulture farm, mulberry garden Govt. P.G. college campus. The black boxing was done for uniform development of embryo. The subsequence day, in morning at 9am to 10am eggs were exposed to bright light for about 1 to 2 hours to get synchronized hatching. The leaves were chopped into small pieces of 0.5 cm. and sprinkled over the newly hatched worms for their feeding of 1st instar larvae. The feeding was given four times in a day, at 6am, 11am, 5 pm, and 10 pm. The rearing trays were cleaned daily. During its larval stage, the silkworm molts four times. There are five instars in a silkworm's life cycle. During molting feeding were not given. Molting takes 20 to 30 hours to finish. Worms during molting are more prone to disease infection and to manage illnesses, a bed disinfectant Vijeta @ 200 gm/5 DFLs (Disease free egg laying) were dusted after each molt and feeding was provided an hour afterwards. After that, the bed was cleaned. The mature worms were translucent and creamy in colour. The ripe 5th instar worms stopped eating, crept to the trays edges, and attempted to spin cocoons by raising their head upward. They were picked gently by hand and placed on chandrika for spinning the cocoon. The observations on larval dimensions *viz*., length, breadth, weight and economic character of larvae and cocoon were taken in each instars.

Results and Discussion

Larval length

Length of 10 larvae feeding on each variety of mulberries was taken and mean was calculated as per standard statistical procedure. Table: 1. showed the results of the silkworm larvae length at various developmental stages fed on various mulberry varieties and mixed varietal mulberry leaf. No significant difference were observed on average length of silkworm larvae feeding with different varieties of mulberry during Ist and IInd instar which varied from 8.77-8.99 mm and 12.01-12.50 mm, respectively. Significant differences in length of silkworm larvae feeding with different mulberry varieties during IIIrd, IVth and Vth instar were recorded. Mulberry mixed variety & S -1635 was the best performer as far as larval length is concerned (24.63 mm-III instar, 40.90 mm-IV instar and 68.88 mm-V instar) and proved to be significantly superior over rest of the varieties. The poor performance was showed by the treatment mixture of leaves of all varieties with lowest 22.11, 40.12 and 67.17mm larval length during IIIrd, IVth and Vth instar, respectively. Mulberry mixed variety & S-1635 was found next best. The findings of (Vidyasagar, G.M *et al*., 2003) [22] are in accordance with present findings as variety M-5 was recorded with maximum length 58.5 mm of final instars larvae and followed by mixed variety & S-1635 (68.88 mm & 68.08) while in present findings mixed varietal leaf & S-1635 was recorded with maximum length.

Table 1: The performance of different varieties of mulberry on the larval length.

S. No	Mulberry varieties	Mean length (mm)				
		1st instar L	2nd instar L	3rd instar L	4th instar L	5th instar L
1-	White Mulberry	8.95	12.01	22.11	40.12	67.40
2-	Red Mulberry	8.81	12.22	23.01	40.20	67.50
3-	Black Mulberry	8.90	12.24	24.21	40.25	67.17
4-	Himalayan Mulberry	8.77	12.40	24.25	40.53	68.50
5-	S-1635 Mulberry	8.98	12.47	24.50	40.70	68.08
6-	Mixed varieties Mulberry	8.99	12.50	24.63	40.90	68.88
--	SEm ±	0.497	0.903	0.109	0.289	0.302

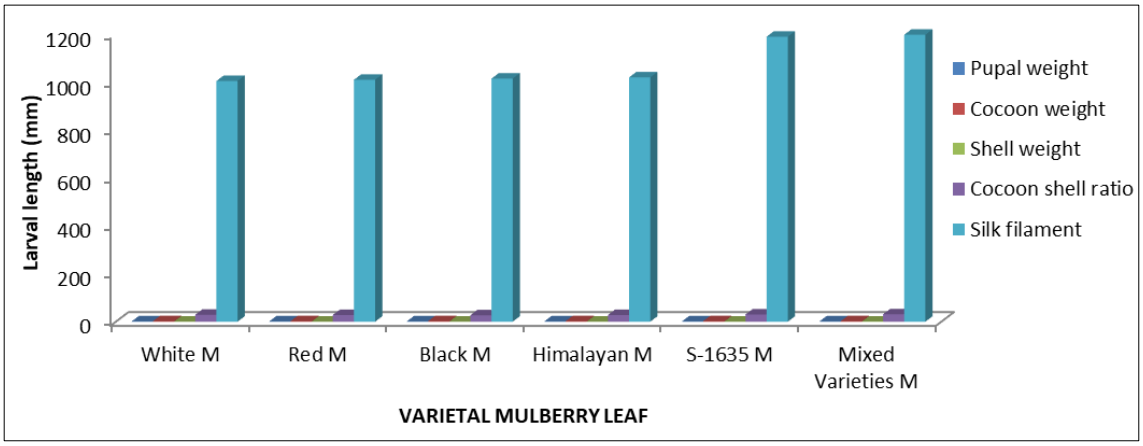

Fig 1: Performance of different varieties of mulberry on the larval length

2. Larval breadth: Larval breadths of different instars fed with different mulberry varieties were taken and found that there was no significant difference in the larval breadths of first and second instar. Significant difference was observed during III, IV and Vth instar larval breadth (Table-2). The maximum larval breadth 04.53 mm in IIIrd , 06.72mm in IVth and 09.71mm in Vth instar were recorded in larvae fed with mulberry mixed variety of mulberry leaf which is significantly superior over other varieties during III instar, while during IV instar and Vth insatr 9.71 mm the mulberry mixed variety was recorded as maximum breadth of larvae. The varieties other mulberry leaf and mixture of all varieties were recorded with less larval breadth and lowest were observed in all varieties in all instars. Findings of (Kumar *et al*., 2014) are in accordance with present findings as maximum larval width was recorded in mixed variety of mulberry. In present findings on larval width mixed variety & S-1635 was recorded with highest, however variety of different other verities of mulberry are not included in present work.

Table 2: The performance of different varieties of mulberry on the larval breadth.

S. No	Mulberry varieties	Mean length (mm)				
		1st instar L	2nd instar L	3rd instar L	4th instar L	5th instar L
1	White Mulberry	1.23	2.27	4.11	6.33	9.44
2	Red Mulberry	1.28	2.28	4.17	6.50	9.50
3	Black Mulberry	1.27	2.30	4.24	6.57	9.55
4	Himalayan Mulberry	1.29	2.32	4.50	6.58	9.59
5	S-1635 Mulberry	1.30	2.34	4.51	6.69	9.62
6	Mixed varieties Mulberry	1.32	2.36	4.53	6.72	9.71
	SEm ±	0.018	0.020	0.029	0.011	0.012

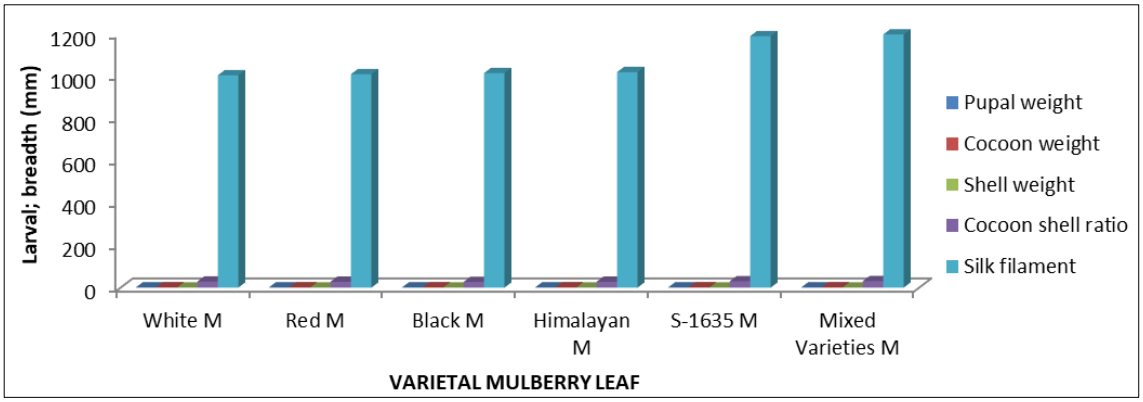

Fig 2: Performance of different varieties of mulberry on the larval breadth (mm)

3. Larval weight: The mean larval weight of silkworm in different developmental stages under different treatments of mulberry varieties feeding is shown in Table-3. Larval weights during two early instars showed no significant difference; whereas significant differences in weight of later stages larvae were observed. Most of the varieties of mulberry were found at maximum larval weight obtained in Ist instar & IInd insatr larvae was (0.010 & 0.046) while IIIrd, IVth & Vth instar larval weight are (0.40, 1.19 & 3.24gm respectively). Minimum 2.90 g larval weight was recorded in mixture of all varieties of Vth instar larvae. The present findings on larval weight are in agreement with findings of (Lalfelpuii *et al*., 2014) [11] who had also reported variety S-1635 as best variety with highest larval weight during fifth instars but present investigation reported that mixed varietal feeding Morus leaf larval development recorded.

Table 3: The performance of different varieties of mulberry on the larval weight.

S. No.	Mulberry varieties	Mean length (gm)				
		1st instar L	2nd instar L	3rd instar L	4th instar L	5th instar L
1	White Mulberry	0.007	0.042	0.36	1.14	2.90
2	Red Mulberry	0.008	0.043	0.37	1.13	2.94
3	Black Mulberry	0.007	0.041	0.38	1.15	2.91
4	Himalayan Mulberry	0.005	0.042	0.37	1.17	3.20
5	S-1635 Mulberry	0.009	0.045	0.39	1.18	3.22
6	Mixed varieties Mulberry	0.010	0.046	0.40	1.19	3.24
	SEm ±	0.0008	0.0004	0.0022	0.0041	0.032

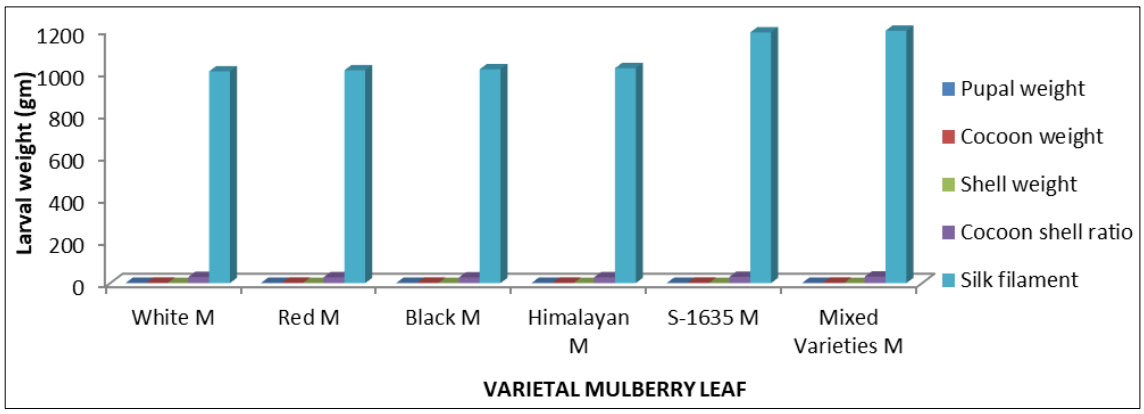

Fig 3: Performance of different varieties of mulberry on the larval weight (gm)

4. Economic parameters of silkworm: Present investigation reported on Table-4 gives the economic parameters of *Bombyx mori* L. treated in different mulberry varieties. It was observed that cocoon weight (2.10 g), pupal weight (1.54 g), shell weight (0.63 g), cocoon shell ratio (31.00) and filament length (1198 m) scores higher in B. mori fed with mixed varietal of mulberry. Plants contain all nutrients required by herbivorous insects but the concentrations and proportions of these nutrients vary greatly among species (Jeyabalan D & Murugan K. 1996) [8]. Digestion in different insects is appropriately adapted to the nutritional composition of host upon which the specific insect feeds (Applebaum, S.W, 1985) [2]. Growth and development of silkworm, B. mori L. are known to vary depending on the quality and quantity of mulberry leaf used as food source, which in tum (reducing the amount of acid in stomach) are indicated by commercial characteristics of cocoon crop (Govindan, R, 1987) [7]. Thangamani and Vivekananda, 1984 [20]; reported the significant influence of different mulberry genotypes on the growth and development of silkworm and cocoon production. Sujathamma *et al*. 2001 [19] evaluated mulberry genotypes in Andhra Pradesh and recommended two varieties (Tr-10 and Mr-2) for commercial cultivation. Bohidar *et al*. 2007 [3] reported effect of different mulberry genotypes on the economic parameters of silkworm in Orissa climate and made suggestion for use of mulberry variety (V1, S36, and DD) for more silk production. Present study also confirms the same as mixed varietal Morus leaf & S1635 mulberry variety gives better results in pre cocoon and post-cocoon characters when compared to other varieties tested. Gangawar, *et al*. 2010 [5] reported that, among eight mulberry varieties i.e. S1, S146, S1635, AR12, AR14, TR10, BR2 and K2 evaluated for nutritional potential by silkworm rearing experiments, silkworm larvae fed on BR2 variety leaves showed higher larval weight and improved economic traits like cocoon weight, shell weight and silk percentage in comparison to other varieties. Cocoon weight and shell weight are the most important characters evaluated for productivity (Gaviria, D.A.E; 2006) [16]. Shell weight percentage indicates the amount of raw silk can be reeled from the given quantity of fresh cocoons and shell weight percentage varies according to age and breed of silkworm. In the present study, silk filament length of cocoons recovered from silkworms reared on different mulberry varieties falls within this range and cocoons recovered from silkworms reared on mulberry mixed variety leaves produced longest filaments length followed by (1198 m) and minimum filament length was observed in local variety (1005 m). The most preferred plant or plant part not only provided the nutritive requirements but also capable of being assimilated and converted into energy and structural substances required for the normal activities and development (Slansky, F. Jr & Scriber, J.M; 1985) [18]. Insects feeding on protein rich host plants will be more successful than those that consume plant material which is

less rich in protein (Murugan, K, 1998) [13]. It was observed that the larval protein content was highest in mixed variety of mulberry leaf followed by S-1635 varieties, least in local varieties. Mulberry leaves are rich in protein and amino acids, and there is a high correlation between leaf protein levels and the production efficiency of the cocoon shell, i.e., the cocoon shell weight relative to the total amount of mulberry leaves consumed by the silkworm (Machii, H & Katagiri, K; 1991) [12]. It is therefore possible that an increase in the protein level of mulberry leaves may lead to improvements in cocoon productivity. The protein content was positively correlated with the larval, pupal, cocoon and Shell weight while silk filament length with larval, pupal, cocoon and shell weight, cocoon shell ratio and protein.

Table 4: The performance of different varieties of mulberry on the economic parameter of silkworm.

S. No	Mulberry varieties	Mean analysis of economic parameters (gm)				
		Pupal wt.	Cocoon wt.	Shell wt.	Cocoon Shell ratio	Silk filament length (m)
1	White Mulberry	1.49	2.08	0.61	29.00	1005
2	Red Mulberry	1.51	2.09	0.58	28.00	1010
3	Black Mulberry	1.48	2.07	0.56	27.00	1015
4	Himalayan Mulberry	1.52	2.06	0.57	28.00	1020
5	S-1635 Mulberry	1.53	2.09	0.62	30.00	1190
6	Mixed varieties Mulberry	1.54	2.10	0.63	31.00	1198
	SEm ±	1.10	0.08	0.004	0.050	1.730

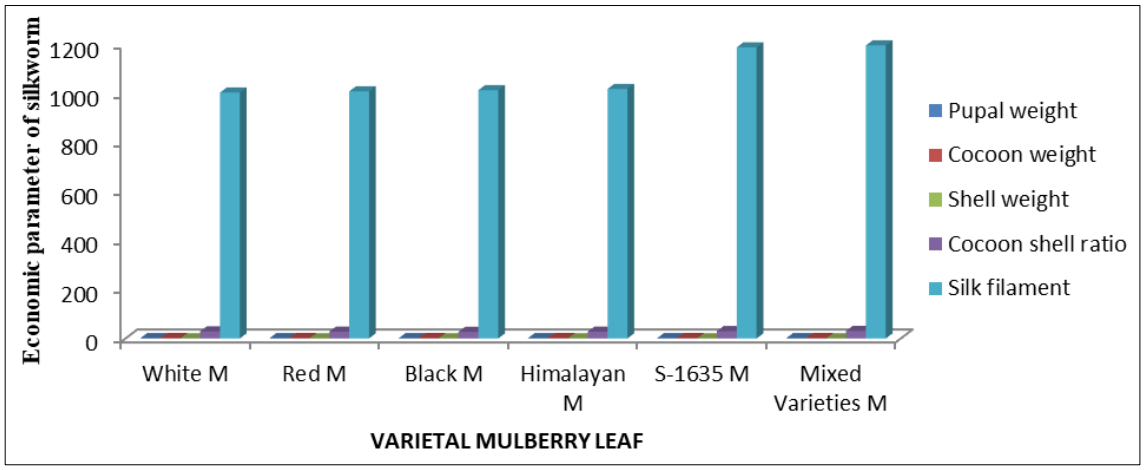

Fig 4: Performence of different varieties of mulberry on the economic parameter of silkworm

Conclusion

Leaves of mixed varietal leaf of Morus mulberry varieties supported good growth and development of silkworm larvae, which is reflected in better commercial cocoon characteristic features. Such mulberry variety can be recommended for more trials at field level by farmers and could be exploited for commercial purpose in all over the world for sustainable growth and development of sericulture industry. The results of the present study indicate that mulberry variety mixed varietal Morus leaf was found best performer in relation to different parameters, larval length, larval breadth, and larval weight and economic trait like pupal weight, cocoon weight, Shell weight, cocoon shell ratio and silk filament length of silkworm larvae and performers to silkworm rearers.

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