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IMPACT OF FEEDING SELECTED MULBERRY GERMPLASM VARIETIES ON SILKWORM *BOMBYX MORI* L. THROUGH BIOASSAY TECHNIQUES FOR COMMERCIAL EXPLOITATION

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ABSTRACT

A critical evaluation study comprising five mulberry varieties viz., S_{1708}, MS_5, C_{10}, C_6 and M_5 was conducted for their leaf quality through silkworm moulting and rearing using crossbreed ($PMxNB_4D_2$) silkworms. Results revealed that, in moulting tests, silkworm larvae reared on S_{1708} mulberry leaves recorded highest larval weight (25.03mg) and moulting ratio (84.96%) and lowest larval weight (17.04mg) and moulting ratio (71.06%) recorded in silkworms reared on C_6 leaves during II moult. Silkworms reared on S_{1708} leaves recorded highest larval weight (39.08mg), cocoon weight (1.90g), shell weight (0.41g), shell percentage (21.66%), filament length (957.57mts), reelability (86.88%), renditta (6.06), denier (2.08) and E.R.R (88.31%), whereas lower larval weight (26.20g), cocoon weight (1.30g), shell weight (0.19g), shell percentage (16.18%), filament length (722.60mts), reelability (56.12%), renditta (8.30), denier (2.62) and E.R.R (78.86%) were observed in C_6 mulberry leaves. It is clear from the results that, mulberry variety S_{1708} turns out to be superior in bioassay tests compared to other varieties studied.

Keywords: Mulberry Varieties, Feeding, Moulting, Rearing, Cocoon Characters

INTRODUCTION

About 92.20% of the silk produced in the world is obtained from mulberry silkworm *Bombyx mori* L. reared solely on mulberry leaves (*Morus* spp.). It is well-established fact that in sericulture, more than 60% of the total cost of cocoon production goes towards mulberry production alone. Hence, in recent years maximum attention has been given for the improvement of mulberry in terms of both quality and quantity. Silkworm (*Bombyx mori* L.) is essentially monophagous insect feeds solely on mulberry leaves (*Morus*spp.). Leaf quality is an important parameter used for evaluation of varieties aimed at selection of superior varieties for rearing performance (Yokoyama, 1963; Bongale *et al*., 1997). Growth and development of silkworm *Bombyx mori* L. is known to vary depending on the quality and quantity of mulberry leaf used as food source, which in turn indicated by commercial characteristics of cocoon crop (Opender Koul *et al*., 1979; Thangamani and Vivekanandan, 1984; Bari *et al*., 1989; Nagaraju, 2002). Superiority of different mulberry varieties used as food for silkworm larvae greatly affects the economy of sericulture industry (Das and Sikdar, 1970). Nutritive value of mulberry (*Morus* spp.) leaf is a key factor besides environment and technology adoption for better growth and development of the silkworms and cocoon production (Purohit and Pavankumar, 1996). It is a confirmed fact that, leaf quality differs among mulberry varieties which in turn responsible for the difference in silkworm rearing performances (Bongale *et al*., 1997). Leaves of superior quality enhance the chances of good cocoon crop (Ravikumar, 1988). In the present study an attempt has been made to evaluate

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better performing mulberry variety through silkworm rearing for Kolar district, one of the premier and traditional sericulture belt in Karnataka, accounts for 40% of total raw silk production.

MATERIALS AND METHODS

Study Site

Mulberry plants grown in garden and silkworm rearing experiments were conducted in rearing house at Bethamangala, Bangarpet taluk in Kolar district, Karnataka.

Study Material

In the present experiment mulberry varieties viz., S_{1708}, MS_5, C_6, C_{10} and M_5were used. M_5 mulberry variety is used as a check variety. Selected mulberry varieties cuttings were procured from Central Sericultural Germplasm Resources Centre (CSGRC), Hosur, Tamil Nadu, India and disease free cross breed ($PMxNB_4D_2$) silkworm egg layings obtained from National Silkworm Seed Project (NSSP), Bangalore, Karnataka were used. Experiment was conducted in RBD method with 4 replications/ variety. Two years old plants were used for silkworm rearing from time to time in different seasons viz., summer, rainy and winter and the average values were tabulated in tables.

Silkworm Moulting

Moulting test conducted up to 2nd moult following standard rearing methods suggested by Krishnaswami (1990) with 4replications/variety and 100larvae/ replication. Healthy tender leaves harvested and fed to young age silkworms up to 2nd moult (Benchamin and Nagaraj, 1987, Chaluvachari and Bongale, 1996). Daily three feedings were given at 7am, 2pm and 10pm from brushing to end of II moult. First appearance of one larva out of moult was considered as commencement of moulting (Benchamin and Anantharaman, 1990). Moulting ratio with respect of all the varieties under evaluation was fixed depending on time duration which recorded more than 50% of the larvae under moult. Larval weight was also recorded.

Silkworm Rearing

Silkworm rearing experiments were conducted at different seasons (rainy: July-August, winter: Nov-Dec, summer: March-April). For each mulberry variety, one egg laying was reared and 4 replications were maintained. After III moult, 100 larvae/replication were maintained (Figure 1).

Color reproduction on the Web only

Figure 1. 5thinstar crossbreed ($PMxNB_4D_2$) silkworms

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Appropriate cellular rearing techniques were adopted and separate rearing trials were conducted for different varieties (Krishnaswami *et al*., 1970b; Benchamin and Nagaraj, 1987; Krishnaswami, 1990). Larvae were fed three times daily (7am, 2pm, 10pm) with healthy, fresh leaves. Young age larvae were fed with tender, succulent and nutritious leaves known to favour growth and development of chawki silkworms, while mature and coarse leaves were fed to late age silkworms till ripening. Cocoons (Figure 2) were collected on 5th day of mounting and assessed for commercial parameters viz., ERR, cocoon weight, shell weight, shell percentage, filament length, reelability, denier and renditta by Sonwalkar (1991) methods.

Figure 2. Crossbreed ($PMxNB_4D_2$) silkworm cocoons

Statistical Analysis

Data collected on various parameters were tabulated and subjected to critical statistical analysis by adopting 'Method of Analysis of Variance' appropriate to the experiment (Sundar Raj *et al*., 1972; Singh and Choudhary, 1979).

RESULTS AND DISCUSSIONS

Studies on the influence of different mulberry varieties on silkworms' behavior and cocoon traits were studied in tropical conditions of India (Iwanari and Ohno 1969; Krishnaswami *et al*., 1970a; Krishnaswami *et al*., 1971; Das and Vijayaraghavan 1990). It was also emphasized that, mulberry leaf quality has direct effect on food consumption ratio, larval growth, digestive coefficient and food absorption (Paul *et al*., 1992). Silkworm moulting results were summarized in table 1.

Table 1. Moulting performance of crossbreed silkworms on selected mulberry varieties

Mulberry Varieties	*I Moult*		*II Moult*	
	Single larval weight(mg)	*Moulting ratio (%)*	*Single larval weight(mg)*	*Moulting ratio (%)*
S_{1708}	4.64	75.87	25.03	84.96
MS_5	2.94	70.65	20.37	76.16
C_{10}	2.80	69.16	20.04	75.06
C_6	2.68	67.08	17.04	71.06
M_5	3.66	72.81	22.59	80.78
CD @ 5%	0.01	0.03	0.03	0.03

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Significant differences were observed in larval weight and moulting ratio. Silkworms reared on S_{1708} leaves revealed highest larval weight and moulting ratio and lowest larval weight and moulting ratio were observed in C_6 leaves during I moult. In II moult, high larval weight and moulting ratio was observed in silkworms reared on S_{1708} leaves and lowest larval weight and moulting ratio was recorded in C_6 leaves. It is evident that tender, succulent and nutritious leaves are known to favour good growth and development of young age silkworms whereas progressively mature leaves with less moisture content are required for late age silkworms (Krishnaswami, 1990).

Silkworm Moulting

Degree and uniformity of moulting varies with quality of mulberry leaves fed. Superior quality leaves favours higher moulting, better growth rate and weight of silkworms (Benchamin and Anantha Raman 1990). Bongale and Chaluvachari (1995) opined that, lower larval weight and moulting ratio in Mysore local variety were associated with lower leaf moisture content and moisture retention ability. Chaluvachari and Bongale (1996) reported that S_{41} variety with higher protein and lower sugar content encouraged high larval weight and low moulting ratio. Mishra *et al*., (1996) recorded 89.16% and 92.82% moulting ratio in $PMxNB_4D_2$ and $NB_{18}xNB_7$ races respectively with S_{54} mulberry genotype. Sujathamma *et al*., (1999) reported that, when CB and BV larvae fed on Tr_{10} and MR_2 mulberry varieties shown higher moulting ratio and larval weight. Mallikarjunappa *et al*., (2000) observed the superiority of S_{30}, S_{36} and Vishwa mulberry genotypes over M_5 genotype in moulting ratio and larval weight. Yogananda Murthy *et al*. (2013) reported that, mulberry varieties S_{1708}, Tr_8 and Tr_{12} were superior among the ten varieties examined for bivoltine silkworms in moulting tests. Veerapura Narayanappa Yogananda Murthy*et al*., (2013) observed that, among six mulberry germplasm varieties viz., Tr_8, Tr_{12}, Tr_{20}, *Matigara black*, *Morus nigra* and M_5, in moulting test, crossbreed silkworms reared on Tr_8 mulberry leaves recorded highest values and lowest values recorded in silkworms reared on *Morus nigra* leaves both in I and II moult respectively.

Silkworm Rearing

Silkworm rearing results were presented in table 2. Significant differences were observed in larval parameters and commercial cocoon characters. Ten 5^{th} instar larval weight was significantly higher in silkworms reared on S_{1708} leaves and lower larval weight was recorded in silkworms reared on C_6 leaves.

Table 2. Rearing performance of crossbreed silkworms on selected mulberry varieties

Mulberry varieties	Ten 5^{th} instar-larval weight (g)	Single cocoon weight(g)	Single shell weight(g)	Shell weight (%)	Filament length (mts)	Relability (%)	Renditta	Denier	E.R.R (%)
S_{1708}	39.08	1.90	0.41	21.66	957.57	86.88	6.06	2.08	88.31
MS_5	28.52	1.43	0.25	17.12	745.61	57.50	8.04	2.44	81.77
C_{10}	27.88	1.38	0.22	16.68	736.00	56.64	8.26	2.52	80.60
C_6	26.20	1.30	0.19	16.18	722.60	56.12	8.30	2.62	78.86
M_5	32.16	1.54	0.30	19.59	830.86	97.50	7.58	2.38	84.56
CD @ 5%	0.36	0.05	0.01	0.37	19.01	7.06	0.09	0.02	0.14

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Single cocoon weight was higher in cocoons of silkworms reared on S_{1708} leaves. However, significantly lower cocoon weight was registered in silkworms reared on C_6 leaves. Both shell weight and shell percentage were significantly high in cocoons of silkworms reared on S_{1708} leaves while cocoons obtained from silkworms reared on C_6 leaves recorded lower shell weight and shell weight percentage respectively. Filament length and reelability percentage was significantly high in cocoons obtained from silkworms reared on S_{1708} leaves.

Lower filament length and lower reelability was recorded in cocoons harvested from silkworms reared on C_6 leaves. Significantly lower renditta was recorded in the cocoons procured from silkworms reared on S_{1708} leaves, while higher renditta was found in the cocoons recovered from silkworms reared on C_6 leaves. Finer denier was recorded in cocoons procured from silkworms reared on S_{1708} leaves while cocoons procured from silkworms reared on C_6 leaves produced coarser denier. Effective rate of rearing was significantly higher in silkworms reared on S_{1708} leaves and lower effective rate of rearing was recorded in silkworms reared on C_6 leaves. Krishnaswami *et al*., (1970b) observed that Berhampore variety was better than Kosen and Mandalaya with regard to effective rate of rearing and cocoon weight. Verma and Kushwaha (1970) reported that, mulberry variety Catteneo was found best in silkworm rearing trials compared to $Burmose_2$, Tsukasakhu and Local mulberry varieties. Govindan *et al*., (1987) observed that, cocoon weight obtained with S_{41} and S_{54} was higher than that obtained with S_{36} while Mysore local and $Kanva_2$ registered lowest. Venugopala Pillai *et al*., (1987) reported that mulberry variety S_{54} encouraged higher values in larval span, larval weight, single cocoon weight and coon yield. Tayade *et al*., (1988) reported that mulberry variety S_{54} was found superior followed S_{41} and $Kanva_2$ for feeding silkworms. Dar *et al*., (1988) observed that feeding of Ichinose leaves resulted in higher cocoon characters compared to other two varieties. Fotadar *et al*., (1989) observed that silkworms fed with $Kokuso_{27}$ variety leaves revealed best results among other varieties studied. Sathyanarayana Raju *et al*., (1990) stated that mulberry variety S_{30} showed better performance than S_{36}, S_{41} and K_2 for commercial characters of bivoltine cocoons. Saratchandra *et al*., (1992) revealed that, mulberry variety S_{36} was found superior in silkworm rearing trials and recorded highest cocoon yield, ERR and shell percentage. Changalarayappa and Chinnaswamy (1999), Vage and Ashoka (1999) reported that, silkworm breeds ($PMxNB_4D_2$) and (NB_4D_2) performed well when reared on M_5 mulberry variety. Rahman *et al*., (1999), Chakrovorty and Borgohain (2000), Santoshagowda V. Patil (2002) were reported that, mulberry variety S_{1635} was found superior in silkworm rearing trials with good commercial cocoon characters compared to all other varieties examined. Rachotaiah *et al*., (2000) noticed that, mulberry variety RFS_{175} was found superior in silkworm rearing trials with maximum cocoon production. Sujathamma *et al*., (2001) observed that, mulberry varieties Tr_{10} and MR_2 were found superior as they secured maximum scores for silkworm races CB ($PMxNB_4D_2$) and BV (NB_4D_2) in rearing tests. Definite relationship between larval weight and economic characteristics such as cocoon weight and shell weight in various strains were reported. Adolkar *et al*., (2007), Giridhar and Reddy (1991), Seidavi (2011) reported that, silkworm rearing performance differed significantly when subjected to same conditions, some of them performed better and poor performance by some races. Present study confirms the same as S_{1708} mulberry variety gives better results in pre-cocoon and post-cocoon characters compared to other varieties tested. Gangawar (2010) reported that, among eight mulberry varieties i.e. S_1, S_{146}, S_{1635}, AR_{12}, AR_{14}, TR_{10}, BR_2 and K_2 evaluated for nutritional potential by rearing experiments, silkworms fed on BR_2 variety showed high larval weight, cocoon weight, shell weight and silk percentage in comparison with other varieties. Yogananda Murthy *et al*., (2013) observed that, mulberry varieties S_{1708}, Tr_8 and Tr_{12} were superior among ten varieties examined with

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bivoltine silkworms for growth and development of silkworms and commercial cocoon parameters. Veerapura Narayanappa Yogananda Murthy*et al*., (2013) opined that, among six mulberry germplasm varieties viz., Tr_8, Tr_{12}, Tr_{20}, *Matigara black*, *Morus nigra* and M_5 observed for leaf quality, crossbreed silkworms reared on Tr_8 mulberry leaves proved significantly better and lower values observed in silkworms reared on *Morus nigra* leaves. Ogunleye and Johnson (2012) evaluated three silkworm races namely EC_1, EJ_1 and EJ_2 for their growth and productivity by feeding them with S_{36} mulberry leaves and reported that, EJ_2 silkworms showed a higher and consistent growth rates compared to other silkworm races. Cocoon weight and shell weight are the most important characters evaluated for productivity (Gaviria *et al*., 2006). Shell percentage indicates the amount of raw silk reeled from given quantity of fresh cocoons and shell percentage varies according to silkworm age and breed. According to FAO (1999), total silk filament length is ranging from 600m-1500m out of which only 80% is reelable. In the present study, silk filament length of cocoons falls within this range and cocoons recovered from silkworms reared on S_{1708} mulberry leaves produced longest filaments length and lowest denier.

CONCLUSIONS

In 1980s, mulberry varieties like S_{36}, S_{41}, S_{46}, S_{54} etc., and in late 1990s varieties like S_1, S_{146}, S_{1635}, AR_{12}, AR_{14}, TR_{10}, BR_2 etc., were evaluated for nutritional potential and silkworm rearing. In recent years more new mulberry varieties like S_{1708}, MS_5, C_6, C_{10}, were evolved and screened to know their nutritional quality of leaves. Mulberry being the sole food plant of silkworm *Bombyx mori* L. and nutritional quality of leaves evaluated through moulting and bioassay tests is a standard recommended practice. Present results revealed that, moulting and rearing performance of silkworms proved better with S_{1708} mulberry variety and cocoons harvested showed significantly good economic cocoon characters such as silk filament with finer denier and lower renditta compared to other varieties. Results thus obtained are presented in this paper which is self-explanatory. Information generated will help silkworm breeders and rearers at field level to use these new mulberry varieties for high yield, healthy silk worms growth and development and good commercial cocoons parameters for sustainable growth and development of sericulture industry.

REFERENCES

[1] Adolkar, V.V., Raina, S.K. & Kimbu, D.M. (2007). Evaluation of various mulberry Morus spp. (Moraceae) cultivars for the rearing of the bivoltine hybrid race Shaanshi BV-333 of the silkworm *Bombyx mori*(Lepidoptera: Bombycidae). *Int. J. Trop. Insect Sci., 27*(1), 6-14.

[2] Bari, M.A., Qaiyyum, M.A. & Ahmed, S.U. (1989). Correlation studies in mulberry (*Morus alba* L.). *Indian J. Seri., 28*(1), 11-16.

[3] Benchamin, K.V. & Nagaraj, C.S. (1987).Silkworm rearing techniques. In: *Appropriate sericulture techniques*. Ed. by Jolly, M.S. Chapter-4, ICTRTS, India.pp.63-106.

[4] Benchamin, K.V. & Anantharaman, K.V. (1990).Standardisation of moulting test to evaluate mulberry leaf quality under tropical conditions.*Indian J. Seric., 29*(2), 255-262.

[5] Bongale, U.D. & Chaluvachari. (1995). Evaluation of eight mulberry germplasm varieties by leaf biochemical and bio-assay moulting studies. *Sericologia, 35*(1), 83-94.

ISSN: 2186-8476, ISSN: 2186-8468 Print
Vol. 2 No. 4 December 2013

[6] Bongale, U.D., Chaluvachari, Mallikarjunappa, R.S., Narahari Rao, B.V., Anantharaman, M.N. & Dandin, S.B. (1997). Leaf nutritive quality associated with maturity levels in fourteen important varieties of mulberry (*Morus* spp.). *Sericologia, 37*(1), 71-81.

[7] Chakravorty, R. & Borgohain, P.N. (2000).Identification of an improved mulberry variety suitable for north eastern part of India.*Indian J. Seric., 39*(1), 74-75.

[8] Chaluvachari & Bongale, U.D. (1996). Bioassay moulting response of silkworm *Bombyx mori* L. in relation to leaf nutritive constituents in mulberry (*Morus* spp.) genotypes.*Indian J. Seric., 35*(2), 160-162.

[9] Changalarayappa & Chinnaswamy, K.P. (1999). Influence of mulberry varietal feeding sequences on growth and development of silkworm (*Bombyx mori* L.) breeds. *Proc. Natl. Semi.Tropical Seric.*, India. pp. 204-205.

[10] Das, B.C. & Sikdar, A.K. (1970). Evaluation of some improved strains of mulberry by feeding experiment. *Indian J. Seric., 9*(1), 26-30.

[11] Das, P.K. & Vijayaraghavan. (1990). Studies on the effect of different mulberry varieties and seasons on the larval development and cocoon characters of silkworm *Bombyx mori*L. *Indian J. Seric., 29*(1), 44-53.

[12] Dar, H.U., Singh, T.P. & Das, B.C. (1988).Evaluation of mulberry varieties by feeding to *Bombyx mori.Indian J. Seric., 27*(1), 16-22.

[13] FAO, (1999).Silk reeling and testing manual, Agricultural Services.*Bulletin No.136*. Rome, Italy. pp. 65-75.

[14] Fotadar, R.K., Ahsan, M.M., Dhar, K.L. & Bhakuni, B.S. (1989).Evaluation and utilization of genetic variability in mulberry.*Indian J. Seric., 28*(2), 150-158.

[15] Gaviria Dae, Aguilar, H.J., Serrano & Alegria, A.H. (2006). DNA fingerprinting using AFLP markers to search for makers associated with yield attributes in the silkworm *Bombyx mori. J. Insect Sci.*, 6, 1-10.

[16] Gangwar, S.K. (2010). Impact of varietal feeding of eight Mulberry varieties on *Bombyx mori* L. *Agric. Biol. J. N. America, 1*(3), 350-354.

[17] Giridhar, K. & Reddy, N.S. (1991). Effective rate of rearing in bivoltine silkworm *Bombyx mori*breeds on different mulberry *Morus*spp. varieties. *Indian J. Seric., 30*(1), 88-90.

[18] Govindan, R., Magadum, S.B., Bhemanna, C. & Narayanaswamy, T.K. (1987). Influence of mulberry varieties on cocoon weight, ovariole length, ovariole egg number and fecundity in silkworm *Bombyx mori* L. *Sericologia, 27*(1), 25-30.

[19] Iwanari, Y. & Ohno, Y. (1969). Rearing experiments of silkworms on the artificial diets composed mainly of the mulberry leaf powder harvested on the late autumnal and thereafter season. *J. Seric. Sci. Japan*, 38, 307-315.

[20] Krishnaswami, S. Roy, D. & Mukherjee, S.K. (1970a).Yield and nutritive value of mulberry leaves as influenced by planting system, spacing and frequency of pruning.*Indian J. Seric., 9*(1), 38-42.

[21] Krishnaswami, S., Noamani, K.R. & Asan, M. (1970b). Studies on the quality of mulberry leaves and silkworm cocoon crop production, Part I, Quality difference due to varieties. *Indian J. Seric., 9*(1), 87-93.

ISSN: 2186-8476, ISSN: 2186-8468 Print
Vol. 2 No. 4 December 2013

[22] Krishnaswami, S., Kumararaj, S., Vijayaraghavan, K. & Kasiviswanathan, K. (1971). Silkworm feeding trials for evaluating the quality of mulberry leaves as influenced by variety, spacing and nitrogen fertilization. *Indian J. Seric.*, 10, 79-90.

[23] Krishnaswami, S. (1990).Improved method of rearing young age (chawki) silkworms.*Bulletin No.2,* CSB, India. pp. 1-24.

[24] Mallikarjunappa, R.S., Venkateshaiah, H.V., Bongale, U.D., Chandrakala, M.V. & Chaluvachari. (2000). Evaluation of improved mulberry genotypes for production of leaf suitable for young age silkworm rearing, with annual 12 leaf harvest schedule. *Indian J. Seric., 39*(2), 122-126.

[25] Matsumara. (1951). On the functional difference of digestive amylase of different strains of the silkworm *Bombyx mori* L. *Bull. Seric. Exp. Sta. Japan*, 13, 513-519.

[26] Mishra, R.K., Choudhury, P.C., Mathur, V.B. & Ghosh, A. (1996). Studies on the development of package of cultivation for mulberry garden exclusively for young age silkworm rearing. *Indian J. Seric.*, 35, 10-18.

[27] Nagaraju, J. (2002). Application of genetic principles in improving silk production.*Current Science, 83*(4), 409-415.

[28] Ogunleye, R.F. & Johnson, O. (2012). Determination and comparison of performance and production properties in three strains of silkworm *Bombyx mori*L fed with a variety of mulberry plant. *Int. Res. J. Biotech., 3*(5), 76-80.

[29] Opender Koul, Tikku, K., Saxena, B.P. & Atal, C.K. (1979). Growth and silk production in *Bombyx mori* L. fed on three different varieties of mulberry. *Indian J.Seric., 18*(1),1-5.

[30] Paul, D.C. Rao, G.S. & Deb, D.C. (1992). Impact of dietary moisture on nutritional indices and growth of *Bombyx mori*and concomitant larval duration.*J. Insect Physiol., 38*(3), 229-235.

[31] Purohit, K.M. & Pavankumar, T. (1996). Influence of various agronomical practices in India on the leaf quality in mulberry, A review. *Sericologia, 36*(1), 27-39.

[32] Rachotaiah, M., Narahari Rao, B.V., Prabhuraj, D.K. & Dandin, S.B. (2000). Status of biochemical constituents in four mulberry varieties grown under rainfed condition and their effect on silkworm *Bombyx mori* L.*Natl. Semi.Stra.Seri. Res. Devpt.New Millennium*, India.pp. 41.

[33] Rahman, M.S., Doss, S.G., Vijayan, K. & Roy, B.N. (1999).Performance of the mulberry variety S_{1635} under three systems of planting in West Bengal.*Indian J. Seric., 38*(2), 165-167.

[34] Ravikumar, C. (1988). Western ghat as a bivoltine region prospects, challenges and strategies for its development. *Indian Silk, 26*(9), 39-54.

[35] Saratchandra, B., Rajanna, L., Philomena, K.L., Paramesha, C., Ramesh, S.P., Jayappa, T. & Sabitha, M.G. (1992).An evaluation of elite mulberry varieties for yield and quality through bioassay. *Sericologia, 32*(1), 127-134.

[36] Santoshagowda V Patil.(2002). Evaluation of promising genotype S_{1635} under irrigated conditions. *Indian Silk, 41*(2), 7-9.

ISSN: 2186-8476, ISSN: 2186-8468 Print
Vol. 2 No. 4 December 2013

[37] Sathyanarayana Raju, C.H., Pallavi, S.N., Reddy, M.M., Suryanarayana, N., Singhal, B.K. & Sengupta, K. (1990). Evaluation of four new mulberry varieties through silkworm rearing under irrigated condition. *Indian J. Seric., 29*(2), 240-247.

[38] Seidavi, A. (2011). Evaluation of the genetic potential of six native strains of silkworm *Bombyx mori* L. *African J. Agricul. Res., 6*(20), 4816-4823.

[39] Singh, R.K. & Choudhury, B.D. (1979). *Bio-metrical methods in quantitative genetic analysis*. New Delhi: Kalyani Publishers.

[40] Sonwalkar, T.N. (1991). *Handbook of Silk Technology*. New Delhi: Wiley Eastern Limited.

[41] Sujathamma, P., Savithri, G. & Dandin, S.B. (1999).Evaluation of mulberry (Morus spp.) genotypes suitable for chawki rearing.*Proc. Natl. Semi. Tropical Seri*., December, 28-30, Bangalore, India. pp. 132-135.

[42] Sujathamma, P., Dandin, S.B. & Savithri, G. (2001). Quality evaluation of mulberry (*Morus* spp.) genotypes through bioassay under Royalaseema conditions of Andhra Pradesh. *Indian J. Seric., 40*(1), 27-34.

[43] Sundararaj, G.L., Nagaraju, M.N., Venkataramu & Jaganath. (1972). Design and Analysis of field experiments.*Miscellaneous Series 22*, U.A.S, India. pp. 410-440.

[44] Tayade, D.S., Jawale, M.D. & Unchegaonkar, P.K. (1988). Evaluation of some improved strains of mulberry by feeding experiments under Maratawada conditions. *Indian J. Seric., 27*(1), 92-94.

[45] Thangamani, R. & Vivekanandan, M. (1984).Physiological studies and leaf nutrient analysis in the evaluation of best mulberry variety. *Sericologia, 24*, 317-324.

[46] Vage, M.N. & Ashoka, J. (1999). Performance of fifth instar silkworm of $PMxNB_4D_2$ on tender shoot feeding for larval and cocoon yield traits. *Proc. Natl. Semi. Tropical Seri*., December, 28-30, Bangalore, India. pp. 97-99.

[47] Venugopala Pillai, S., Krishnaswami, S. & Kasiviswanathan, K. (1987). Growth studies in silkworm *Bombyx mori* (L.) under tropical conditions II. Influence of agronomical methods of mulberry on the growth, cocoon crop and fecundity of silkworm. *Indian J. Seric., 27*(1), 32-45.

[48] Verma, S.K. & Kushwaha, K.S. (1970). Comparative growth of the silkworm *Bombyx mori*race Bulupolu reared on different mulberry varieties. *Indian J. Agric. Sci., 40*(12), 1079-1107.

[49] Veerapura Narayanappa Yogananda Murthy., Hyadalu Lingappa Ramesh., Gangadharaiah Lokesh., Munirajappa& Bangalore Ramakrishna Dayakar Yadav. (2013). Assessment of six mulberry (*Morus*) germplasm varieties through moulting and bioassay parameters by using cross breed silkworms *Bombyx mori* L. for commercial exploitation in Kolar district, Karnataka. *Int. Res. J. Biological Sci., 2*(9), 69-75.

[50] Yogananda Murthy, V.N., Ramesh, H.L., Munirajappa & Dayakar Yadav, B.R. (2013). Nutritional quality assessment of ten mulberry (*Morus*) germplasm varieties through moulting test, silkworm rearing technique and economical characters of bivoltine silkworms (*Bombyx mori* L) for commercial exploitation. *Int. Res. J. Natural Sci., 1*(2), 11-22.

[51] Yokoyama, T. (1963). Sericulture. *Annual Review of Entomol., 8*, 287-306.