RESEARCH PAPER | Biology | Volume : 3 | Issue : 8 | Aug 2013 | ISSN - 2249-555X

Evaluation of Mulberry (Morus) Variety Vishwa for Leaf Yielding Parameters and Phytochemical Analysis under Different Spacing Systems

KEYWORDS: Mulberry, spacing, yield, proteins, total sugars, chlorophyll, moisture

V. N. Yogananda Murthy
Department of Life Sciences, Ganga Kaveri Institute of Science and Management,Dr. Rajkumar Road, Rajajinagar, Bangalore-560021, Karnataka, INDIA.

H. L. Ramesh
Department of Sericulture, Life Sciences, V. V. Pura College of Science, K.R.Road, Bangalore-560004, Karnataka, INDIA.

Munirajappa
Department of Sericulture, Life Sciences, Jnana Bharathi Campus, Bangalore University, Bangalore-560056, Karnataka, INDIA.

ABSTRACT *Present investigation was undertaken to study yield and phytochemical parameters of mulberry variety Vishwa under different spacing systems (2'x1', 2'x2', 3'x3', 4'x4'). Branching pattern differed markedly depending on the spacing where highest number of shoots/plants and longer shoot length/plant found in 4'x4' followed by 3'x3' spacing. Lowest internodal distance observed in 4'x4' spacing and maximum in plants under 2'x2' spacing. Plants under different spacing revealed significant difference in 100 fresh leaves weight. Average leaf yield/plant was highest in 4'x4' spacing whereas leaf yield/unit area was more in 2'x1' spacing followed by 2'x2' and 3'x3' spacing. No change in moisture retention capacity in leaves even after 12hrs under different spacing. Proteins, total sugars and chlorophyll contents were high in plants under 4'x4' spacing. Based on the findings, mulberry variety Vishwa grown under 4'x4' spacing revealed substantial improvement in yield and phytochemical parameters.*

Introduction
Mulberry leaf is the sole food of silkworm Bombyx mori L. due to the presence of morin, β-sitosterol and swallowing factors (Horie, 1995; Babu et al., 2009). Biotic and abiotic factors play a pivotal role in assessing the quality of mulberry leaves since mulberry leaf plays a major role in successful cocoon production. Genus Morus is cross pollinated and highly heterozygous exhibiting considerable taxonomical plasticity. In India, large number of improved varieties has been evolved for commercial purpose in recent years. These varieties registered their superiority over traditional local varieties in exhibiting increased yield with good quality leaves, wide adaptability and resistance to stress condition. Kolar district in Karnataka is the hotspot of sericulture activities provides regular employment throughout the year. Total area under mulberry is around 13,615hacter with cocoon production of 10,749MT and industry provides employment to about 21,276persons (Annual Report, 2012). It has become passion for the sericulturists to establish plantation using high yielding varieties introduced time to time by the research institutes. Vishwa variety is the selected from the Dehradun area of Uttar Pradesh where mulberry grows naturally from open pollinated hybrid seedlings. This variety has good sprouting and rooting ability with fast growth, suitable for 5-6 crops/year. Bushes are of open type, branches simple, vertical, rough with short internodes. Leaves are dark green, simple, smooth, unlobed, alternate or spirally arranged, ovate- broadly ovate, palmately veined and succulent. Leaf yield is about 45,000 kg/ha/year under irrigated conditions with recommended package of practices. In the present investigation, high yielding mulberry variety Vishwa was chosen to test its potentiality under different spacing system in Kolar region of Karnataka. The major objective of mulberry crop improvement is to evolve new elite varieties for high leaf yield, resistance to pests, drought and adoptability to different agro climatic conditions.

Materials and Methods
In the present study, five months old saplings of Vishwa mulberry variety were procured from KSSR&DI, Thalaghattapura, Bangalore. Field experiment was conducted at Bethamangala village of Bangarpet taluk, Kolar district, Karnataka. Randomised block design (RBD) was followed for field experiment. There were four treatments of spacing viz., 2'x1', 2'x2', 3'x3' and 4'x4' with three replications/ treatment. Standard package of practices were followed for the establishment of mulberry garden (Krishnaswami et al., 1971; Jolly and Dandin, 1986). Leaf yield contributing characters were assessed and recorded from time to time following the methods suggested by Dandin and Jolly, (1986); Das et al., (1987); Dandin and Kumar, (1989); Bhat and Shilaja Hittalamani, (1992). For phytochemical analysis total proteins were estimated according to Lowry et al., (1951) method. Total sugars were estimated by following Plummer (1971) method. Total chlorophyll, chlorophyll-a and chlorophyll-b contents from fresh mulberry leaves without maceration were estimated using Dimethyl sulphoxide (DMSO) as per the methods suggested by Arnon (1949) and Hiscox and Israelstam (1979). Leaf moisture content and moisture retention capacity were determined on fresh weight basis as per the methods suggested by Vijayan et al., (1997). Data collected on various parameters were tabulated and subjected to critical statistical analysis by adopting 'Method of Analysis of Variance' appropriate to the design of the experiment (Sundarraj et al., 1972; Singh and Choudhary, 1979).

Results and Discussion
Results revealed significant difference in average number of shoots/plant depending upon spacing. Highest numbers of shoots/plant were recorded in 4'x4' spacing (12.79) followed by 3'x3' (10.88) and 2'x2' spacing (7.92) and lowest shoots/plant noticed in 2'x1' (6.54) spacing. It is largely due to lack of space and nutrition for the plant to grow vigorously (Table 1). Therefore, competition exists for raw materials such as aeration, light intensity, soil moisture, nutrients etc., leading to poor yield. Bongale et al., (1991) observed that, mulberry plants raised under wider spacing exhibit better crop canopy resulting in leaf quality improvement. Initially average shoot length/plant found highest in 4'x4' (136.54cm) spacing followed by 3'x3' (127.69cm) and 2'x2' (120.77cm) lowest shoot length/plant in 2'x1' (108.24cm) spacing. Shorter internodal distance was observed in 4'x4' spacing (5.97cm) followed by 3'x3' spacing (6.30cm) and 2'x1' spacing (6.48cm) and longer internodal distance recorded in 2'x2' spacing (6.32cm) (Table 1). It has been observed that internodal distance varied in plants grown under different spacing and it is an important genotypic character determines total foliage produced by a plant (Fotadar et al., 1989). Significant difference in 100 fresh

Volume : 3 | Issue : 8 | Aug 2013 | ISSN - 2249-555X

leaf weight was observed in plants grown in different spacing. Highest fresh leaf weight was noticed in 4'x4' spacing (648.05g) followed by 3'x3' (581.03g), 2'x2' (454.56g) and 2'x1' spacings (523.45g). (Table 1). This may be due to low to medium input conditions under close planting system compared to wider spacing (Bongale et al., 1991). Plants grown under 4'x4' spacing recorded highest leaf yield/plant (1.52kg) followed by 3'x3' (1.21kg) and 2'x2' spacing (0.63kg), in case of 2'x1' spacing, yield was too low (0.42kg). Average leaf yield/plant in 4'x4' spacing was high as yield contributing characters like number of shoots and shoot length/plant were more with decreased internodal distance (Table 1). Average weight of 100 leaves was high in plants raised under 4'x4' spacing and is suitable for high leaf yield. Similar recommendations were made by Sutani et al., (1989) and reported that, spacing of 1mx1m for mulberry growth in Islamabad and Fonseca et al., (1987) reported spacing of 1.5mx1m in Brazil for good mulberry growth. Phytochemical constituents revealed slight variation in soluble proteins (3.60%, 3.51%, 3.78%, 4.62%), total sugars (1.52%, 1.31%, 1.21%, 2.30%), chlorophyll-a (1.38, 1.51, 1.29, 2.42 mg/g.f.wt) and total chlorophyll content (2.52, 2.86, 2.61, 3.74 mg/g.f.wt) in plants raised under 2'x1', 2'x2', 3'x3', 4'x4' spacings respectively. However, there is a considerable difference in chlorophyll-b (1.12, 1.38, 1.32, 1.26 mg/g.f.wt) content in plants under different spacings (Table 3). Moisture content is high in plants grown under 4'x4' (66.18%) and minimum in 2'x1' spacing (60.29%). Moisture retention capacity is also high in 4'x4' spacing (60.58%) after six hours of harvest compared to plants raised under 3'x3', 2'x2' and 2'x1' spacing (59.58%, 58.76%, 58.46%, 57.85% respectively). This may be due to leaves grown under 4'x4' spacing are broad, thick and succulent.

Most of the mulberry species in tropical conditions display tremendous rooting ability because mulberry propagation was carried out through cuttings (Doss, 2000). Survival rate is considered as one of the important criteria as mulberry varieties are propagated through vegetative means (Tikader and Kamble, 2009). Yokoyama (1963) reported that, mulberry leaf yield depends on the number and length of shoots, internodal distance and leaf weight/plant. Present findings are in conformity with his observations. In profusely branching varieties, yield is high even with less number of plants/unit areas. A decline in yield with a decline in plant population density was noticed in the present study. Many workers reported that, mulberry leaf yield largely depend on various leaf yield contributing characters, genotype and agronomic practices followed (Kasivishwanathan and Iyengar, 1970; Rangaswami et al., 1976; Shastry et al., 1980; Jolly and Dandin, 1986; Bari et al., 1989; Bindroo et al., 1990; Dandin et al., 1993). Madhava Rao et al., (1996) conducted an experiment under different spacing system planted with K_2 mulberry variety. Results revealed that, between two treatments, significantly higher leaf yield (35,945kg/ha/year) was recorded in closer spacing (60cmx60cm) against 30,8711kg/ha/year in wider spacing (90cmx90cm). Sarkar et al., (1996) studied five different spacings viz., Indo-Japanese system (90+180) x60cm), Indo-Brazil system (90+90+90+270)x60cm), Japanese system (180cmx60cm) along with Indian (90cmx90cm and 60cmx60cm) spacing with three different fertilizer doses namely N:P:K@ 300:120:120, 350:140:140 and 400:160:160 kg/ha/year by using S_{36} mulberry variety. Results of two years pooled data indicated that, Indo-Japanese system of plantation produced 60.9metric tone/ha/year of leaf significantly out yielding (54.9 metric tone/ha/year) under N:P:K @ 300:140:140kg/ha/year. Meera Bai (1997) conducted an experiment with mulberry variety $Kanva_2$ under three spacing systems (60cmx60cm, 75cmx75cm and 90cmx90cm). Results revealed that, among three spacing systems, 60cmx60cm spacing significantly increased leaf yield, leaf area index, leaf dry matter, total dry matter and growth rate compare to other spacing methods and economic analysis revealed that closer spacing 60cmx60cm is profitable for mulberry. Rubia et al., (1996) studied three varieties of mulberry like Calabreza, Fernão Dias and Lopes Lins under three spacings 1.5mx1.0m, 1.5mx1.5m and 1.5mx2.0m for leaf production. Results proved best production of leaves obtained with mulberry variety Calabreza in 1.5mx1.0m spacing. Choudhury et al., (1991) reported maximum mulberry leaf yield/ha were obtained at a 60cmx60cm spacing and sharp decline in leaf yield with increase in spacing. Tikader et al., (1993) observed mulberry leaf yield was higher in 60cmx30cm spacing compared to 60cmx60cm spacing for all the varieties examined. Madhavarao and Mishra (1997) conducted an experiment with $Kanva_2$ mulberry variety grown under 60cmx60cm and 90cmx90cm spacing systems and reported that, two years pooled data revealed a significant reduction in leaf yield in 90cmx90cm spacing compared to 60cmx60cm spacing. Between the crops, significantly higher leaf yield (35.7metric tone/ha/year) recorded in 60cmx60cm spacing against 30.1metric tone/ha/year in 90cmx90cm spacing. Mallikarjunappa et al., (1998) evaluated S_{41} and M_5 mulberry genotypes for leaf yield and leaf moisture content under different plant spacings methods and reported that, leaf yield and leaf moisture content differed significantly with respect to genotypes and spacings methods. S_{41} genotype revealed higher leaf yield (35,837kg/ha) and leaf moisture (75.83%) compared to M_5 genotype (31,238kg/ha, 75.35%) in both 60cmx30cm and 60cmx60cm spacing. Patak and Iyer, (1988) observed that, mulberry variety S_{1708} showed maximum leaf moisture content grown under 60cmx60cm spacing among all other varieties examined. Tikku, (1998), Doss et al., (2000) were reported that, mulberry variety S_{1708} under 60cmx60cm plant spacing showed maximum leaf sugar and leaf moisture contents among all the varieties studied. Rahman et al., (1999) observed the performance of S_{1635} mulberry variety under different planting systems for leaf yield and chemoassay parameters and reported that, leaf yield was 25,411 kg/ha/year in 60cmx60cm whereas in the closer spacing it was 23,553 kg/ha/year. Longest shoot length, total shoot length, internodal distance and leaf fall percentage showed significant variation among the spacings. There is not much variation in leaf moisture content in plants cultivated under different spacings. Sugar and protein contents in leaf were also higher in plants cultivated in 60cmx60cm spacing. Bongale et al., (2000) conducted an experiment with mulberry cultivars M_5, S_{36} and Vishwa grown in two plant spacings (60cmx60cm & 90cmx90cm) under irrigated condition and reported that, leaf moisture and leaf yield were significantly high in Vishwa (75.11% & 52757kg leaf/ha/year) followed by S_{36} (74.71% & 53248 kg leaf/ha/year) and M_5 (73.3% & 44690 kg leaf/ha/year). Santosha Gowda V. Patil (2002) evaluated mulberry genotypes S_{1635} and M_5 under plant spacing 60cmx60cm and pit system under irrigated conditions. Results showed that, genotype S_{1635} recorded higher total shoot length, stem weight/plant, number of branches/plant, number of nodes/meter, fresh leaf weight and leaf yield/plant compared to M_5 genotype. Leaf moisture content and moisture retention capacity were more in S_{1635} leaves than M_5 leaves and S_{1635} genotype was found superior in nutritive quality parameters compared to M_5 genotype. Mohamed Tom Ahamed Eltayb et al., (2013) revealed that, spacing and mulberry species have significant effect on growth parameters. High leaves number was obtained from the species Morus alba, followed by Morus mallotfolia and M. acidosa. Also M. alba and M. mesozygia recorded more leaves weight and high yield than other species. This study showed spacing 1.00mx1.00m and 1.50mx1.00m gave higher yield/unit area than other spacing treatments. Present study showed significant variations in all growth parameters. Results are in conformity with the results of Honda T. (1970) who stated a significant variation on survival and growth of mulberry. Moisture retention capacity plays an important role because leaves with high moisture remain fresh and acceptable to silkworms for longer time (Kasivishwanathan, et al., 1973; Yokayama, 1975). Further, stomatal size and frequency play a major role in moisture retention in mulberry leaves (Susheelamma and Jolly, 1986).

Conclusion

Ultimate goal of any plant breeder is to evolve high yield-

Volume : 3 | Issue : 8 | Aug 2013 | ISSN - 2249-555X

ing suitable varieties which can suit all seasons and regions. Superiority of the race can be ascertained by detailed evaluation of varied physic-chemical parameters coupled with bioassay. Vishwa which is gaining popularity in recent years and tested under different spacing systems and it was observed that wider spacing (4'x4') is found to be more beneficial compared to other modes of spacing adopted in mulberry plantation. Due to copious absorbance of sunlight, supply of nutrients, water and sumptuous aeration in wider spacing play a pivotal role in availing the beneficial morpho-biochemical traits. It is further required to subject the variety for bioassay tests to confirm the hegemony of the race over a period of time.

Table 1: Effect of different spacing on growth and yield parameters of Mulberry variety Vishwa.

Spacing Treatments	No. of shoots/ plant	Shoot length/ plant (cm)	Internodal distance (cm)	100 fresh leaf weight (gm)	Leaf yield/ plant(kg)
2'x1'	6.54	108.24	6.32	523.45	0.42
2'x2'	7.92	120.77	6.48	454.56	0.63
3'x3'	10.88	127.69	6.30	581.03	1.21
4'x4'	12.79	136.54	5.97	648.05	1.52
CD @ 5%	1.08	19.62	0.59	68.12	0.18

Table 1: Effect of different spacing on phytochemical constituents of Mulberry variety Vishwa.

Spacing Treatments	Soluble Proteins (%)	Total Sugars (%)	Chlorophyll-a (mg/ g.f.wt)	Chlorophyll-b (mg/ g.f.wt)	Total Chlorophyll (mg/ g.f.wt)	Moisture content (%)	Moisture retention capacity (%)
2'x1'	3.60	1.52	1.38	1.12	2.52	60.29	57.85
2'x2'	3.51	1.31	1.51	1.38	2.86	61.28	58.46
3'x3'	3.78	1.21	1.29	1.32	2.61	61.66	58.76
4'x4'	4.62	2.30	2.42	1.26	3.74	66.18	60.58
CD @ 5%	0.29	0.31	0.24	0.19	0.32	1.82	2.71

REFERENCE

Annual Report. (2012). Department of Sericulture, Government of Karnataka. | Arnon, D. I. (1949). Estimation of chlorophyll (DMSO). Plant Physiology, 24, 1-15. | Babu, K. R., Ramakrishna, S., Reddy, Y. H. K., Lakshmi, G., Naidu, N. V., Basha, S. S. & Bhaskar, M. (2009). Metabolic alterations and molecular mechanism in silkworm larvae during viral infection: A review. Afr. J. Biotechnol., 8, 899-907. | Bari, M. A., Qaiyyum, M. A. & Ahmed, S. U. (1989). Correlation studies in mulberry (Morus alba L.). Indian J. Seric., 28(1), 11-16. | Bhat, G. G. & Hittalamani, S. (1992). Clonal differences in mulberry (Morus spp.) for root growth parameters, Indian J. Seric., 31(1), 5-8. | Bindroo, B. B., Tiku, A. K. & Pandit, R. K. (1990). Variation of some metrical traits in mulberry varieties. Indian J. Forester, 116, 320-324. | Bongale, U. D., Narayana Gowda, S. N. & Veeresh, M. (2000) Effect of different plant densities and nitrogen levels on Vishwa (DD), S36 and M5 mulberry (Morus indica L.) varieties under irrigated condition. Indian J. Seric., 39(2), 103-107. | Bongale, U. D., Chaluvachari & Narahari Rao, B. V. (1991). Mulberry leaf quality evaluation and its importance. Indian Silk, 51-53. | Choudhury, P. C., Shukla, P., Ghosh, A., Mallikarjuna, B. & Sengupta, K. (1991). Effect of spacing, crown height and method of pruning on mulberry leaf yield, quality and cocoon yield. Indian J. Seric., 30, 46-53. | Dandin, S. B. & Jolly, M. S. (1986). Mulberry descriptor. Sericologia, 26(4), 465-475. | Dandin, S. B. & Kumar, R. (1989). Evaluation of mulberry genotypes for different growth and yield parameters. In: Genetic resources of mulberry and utilisation. Ed.by Sengupta, K., Dandin, S. B. C.S.R. & T.I, Mysore, India. 143-151. | Dandin, S. B., Rajanna, L., Mala V. Rajan & Saratchandra, B. (1993). Preliminary studies on the yield potential of new mulberry strains. Sericologia, 33(3), 571-574. | Das, B. C., Bindroo, B. B., Tiku, A. K. & Pandit, R. K. (1987). Propagation of mulberry through cuttings. Indian Silk, 26(1), 12-13. | Doss, S. G., Vijayan, K., Rahman, M. S., Das, K. K., Chakraborti, S. P. & Roy, B. N. (2000). Effect of plant density on growth, yield and leaf quality in triploid mulberry. Sericologia, 40(1), 175-180. | Fonseca, A. S., Fonseca, T. C. & Posto. (1987). Study in Sao Paulo (1981-1987) rearing of mulberry plants using spacing of 1.5mx1m for pruning for silkworm. Revista de Agricultura, 62(2), 137-147. | 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. | Hiscox, J. D., Israelstam, G. F. (1979). A method for the extraction of chlorophyll from leaf tissue without maceration. Canadian J. Bot., 57, 1332-1334. | Honda, T. (1970). Study on the propagation of mulberry trees by cutting. Bult. Seri. Expt. Sta., Tokyo, Japan. 24(1), 133-145. | Horie, Y. (1995). Recent advances of nutritional physiology and artificial diet of the silkworm in Japan. Korean J Seric Sci., 37, 235-243. | Jolly, M. S. & Dandin, S. B. (1986). Collection, Conservation and Evaluation of Mulberry (Morus spp.) Germplasm. C.S.R. & T.I, Mysore, INDIA. pp. 43. | Kasivishwanathan, K. & Iyengar, M. N. S. (1970). Effect of plant densities, method of leaf harvest and nitrogen fertilisation on the leaf yield of irrigated mulberry in Mysore. Indian J. Seric., 9(1), 43-48. | Kasiviswanathan, K., Krishanswami, S. & Venkatramu, C. V. (1973). Effect of storage on the moisture content of mulberry leaves. Indian J. Seric., 12(1), 13-21. | 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 | Lowry, O. H., Rosebrough, N. J., Farr, A. L. & Randall, R. J. (1951). Protein measurement with the folin phenol reagent. J. Biol. Chem., 193, 265-275. | Madhava Rao, Y. R., Mishra, R. K. & Choudhury, P. C. (1996). Development of intercropping system for mulberry-mulberry as an intercrop. Annual Report, C.S.R. & T.I, Mysore, INDIA. 27-28. | Madhava Rao, Y. R. & Mishra, R. K. (1997). Development of intercropping system for mulberry-mulberry as an intercrop. Annual Report, C.S.R. & T.I, Mysore, INDIA. 33-34. | Mallikarjunappa, R. S., Venkateshaiah, H. V., Rao, M. S. E., Dandin, S. B. & Bongale, U. D. (1998). Evaluation of promising germplasm genotypes of mulberry (Morus Species) for higher productivity under irrigated condition. Indian J. Agric. Sci., 68(3), 186-187. | Meera Bai, M. (1997). Production potential of mulberry under different management practices. Ph.D.Thesis. Kerala Agricultural University, Thiruvananthapuram, INDIA | Mohamed Tom Ahamed Eltayb, Essam Eldin Ibrahim Warrag & Ahamed Elhuri Ahamed. (2013). Effect of Spacing on Performance of Morus Species. J. Forest Products and Industries, 2(3), 13-23. | Pathak, J. P. N. & Iyer. (1988). Correlation between water contents of mulberry leaves, larvae and amount of urination in the spinning larvae of multivoltine race of Bombyx mori L. Indian J. Seric., 27, 122-125. | Plummer, D. T. (1971). An introduction to practical Biochemistry, Tata McGraw Hill Publishing Company Limited, Bombay and New Delhi, INDIA. | Qader, M. A. (1991).Varietal differences and correlation studies in the nutritional composition of the mulberry. Sericologia, 31, 449-453. | Rahman, M. S., Doss, S. G., Vijayan, K. & Roy, B. N. (1999). Performance of the mulberry | variety S1635 under three systems of planting in West Bengal. Indian J. Seric., 38(2), | 165-167. | Rangaswami, G., Narasimhanna, M. N., KasiVishwanathan, K., Sastry, C. R. & Jolly, M. S. (1976). Mulberry cultivation. Manual on sericulture. FAO.1, 1-150. | Rubia, Antonio Castilho, Aloisi Sobrinho, Joao & Abramides Eduardo. (1996). Effect of pruning season and spacing stated in the first crop season upon leaf production on the mulberry trees of different varieties shaped by the 'cepo' system. Part-1: Studies in the Pindorama region. Bragantia. 25(1), 233-236. | http://dx.doi.org/10.1590/S0006-87051966000100020. | Santosha Gowda V. Patil. (2002). Evaluation of promising genotype S1635 under irrigated conditions. Indian Silk, 41(2), 7-9. | Sarkar, A., Ramakant & Aqueel, S. A. (1996). Development of mulberry cultivation technology. Annual Report, C.S.R. & T.I, Mysore, INDIA. 21. | Sastry, C. R., Raju, R., Ravindran, S., Susheelamma, B. N. & Bongale, U. D. (1980). Evolution of improved varieties. Annual. Report, C.S.R. & T.I, Mysore, INDIA. 4-16. | Shamachary & Jolly, M. S. (1988). A simple device for quick determination of mulberry leaf area in the field. Indian J. Seric., 27(1), 51-54. | Singh, R. K. & Choudhury, B. D. (1979). Bio-metrical methods in quantitative genetic analysis, Kalyani Publishers, New Delhi, India. | Sundararaj, G. L., Nagaraju, M. N., Venkataramu & Jaganath. (1972). Design and Analysis of field experiments, Miscellaneous Series 22, U.A.S, INDIA. 410-440. | Susheelamma, B. N. & Jolly, M. S. (1986). Evaluation of morpho-physiological parameters associated with drought resistance in mulberry. Indian J. Seric., 25(1), 6-14. | Sutani, M., Zafarudin & Ghulam Abbar. (1989). Testing and adaptation study on the exotic mulberry varieties for foliage yield. Pakistan Journal of Forestry, 39(1), 11-14. | Tikader, A., Roychowdhuri, S., Mishra, A. K. & Das, C. (1993). Foliage yield of different varieties of mulberry (Morus species) grown at two spacings in hills of West Bengal. Indian J. Agric. Sci., 63, 36-37. | Tikader, A. & Kamble, C. K. (2009). Studies on sprouting and survival of different exotic mulberry (Morus spp.) accessions. Indian J. Forestry, 32(1), 81-84. | Tiku, A. K. (1998). Seasonal variations in carbohydrate content of leaves of field grown mulberry (Morus L.). J. Seric. Sci., 6, 16-19. | Vijayan, K., Raghunath, M. K., Das, K. K., Tikader, A., Chakraborti, S. P., Roy, B. N. & Qadri, S. M. H. (1997). Studies on leaf moisture of mulberry germplasm varieties. Indian J. Seric., 36, 155-157. | Yokoyama, T. (1963). Sericulture, Annual Review of Entomology, 8, 287-306. | Yokoyama, T. (1975). Text book of tropical sericulture, Japan overseas Co-operation volunteers, Tokyo. 444-539. | |