International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No.04, March 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

Mulberry breeding strategies for North and North West India

Aftab A. Shabnam, S.S. Chauhan, Gulab Khan,

Pawan Shukla, Pawan Saini and M.K. Ghosh

Central Sericultural Research and Training Institute, Pampore - 192 121, J&K, India

ABSTRACT

Mulberry (Morus sps.) is the soul food plant for silkworm (Bombyx mori L.). Bulk of the silk goods produced in the world is from mulberry silk. Thus for boosting sericultural economy, one of the major long standing approaches is both the qualitative and quantitative genetic improvement of mulberry for leaf yield, which determines the healthy and economical cocoon production. Central Sericulture Research and Training Institute, Pampore (Kashmir) is a major research Institute under Central Silk Board catering to the needs of the sericulture farmers in North and North Western India which include states such as Jammu and Kashmir, Uttarakhand, Uttar Pradesh, Himachal Pradesh, Punjab and Haryana. These states fall in the high altitude range of 1000 feet to 28250 feet above the sea level, with the climate varying from tropical to semi-arctic cold in Ladakh and could be delimited into four distinct agro-climatic zones such as cold arid zone, temperate zone, intermediate zone and sub-tropical zone. Due to these prevailing different agro-climatic conditions, the mulberry varieties and cultivation practice developed elsewhere cannot be adopted as it is into the region. Thus, it is highly essential to develop mulberry varieties suitable to this region to meet emerging challenges and to contribute substantially to the targeted bivoltine raw silk production of 20,000 MT in India by 2030 and also contribute in increasing the mulberry area to 3.86 lakh hectares from the existing 2.3 lakh hectares in India. Therefore, vigorous work in the frontier areas of Mulberry Breeding and Genetics such as molecular biology and biotechnology clubbed with traditional breeding approaches are required to create significant number of new mulberry varieties suitable to local agro-climatic conditions. Prospects and strategies for achieving this goal are discussed.

Keywords: Bivoltine, Breeding Objectives, Genetic Improvement, Mulberry, Silkworm.

I INTRODUCTION

North West Indian sericulture is broadly identified into temperate and sub-tropical sericultural zones. Temperate area is bestowed with salubrious climate, ideally suited for bivoltine sericulture. Land availability, climate and socio-economic conditions of the region favour bivoltine sericulture development in whole of North West India. The existing mulberry trees, scattered all over the region, are the only source of bivoltine silkworm rearing in the region. The silk production in this region contributes about 5 to 6% to the bivoltine raw silk production of the country. Sericulture in North and North-West plays a unique role in the socio-economic development of the people of these states. Sericulture is presently practiced by half a lakh farmers in North Western states of the

country using nearly 18000 ha of mulberry plantation. The State of Jammu and Kashmir contributes to about 70% of the total raw silk production of the North West India. Silkworm rearers in North West India are scattered, in different pockets, all over the states. Average silkworm seed intake capacity is 27 g (100 dfls) per farmer, with an average cocoon productivity of 39 kg per 100 dfls.

Central Sericulture Research and Training Institute, Pampore (Kashmir) is a major research Institute under Central Silk Board catering to the needs of the sericulture farmers in North and North Western India which include states such as Jammu and Kashmir, Uttarakhand, Uttar Pradesh, Himachal Pradesh, Punjab and Haryana. These states fall in the high altitude range of 1000 feet to 28250 feet above the sea level, with the climate varying from tropical to semi-arctic cold in Ladakh and could be delimited into following four distinct agro-climatic zones:

(1) Cold Arid Zone represents Ladakh in J&K state and parts of Lahaul Spiti and Kinnaur in Himachal Pradesh. Scope of sericulture activities in this zone was explored by CSR&TI, Pampore. A training programme on "Intensive bivoltine silkworm rearing" was conducted in Kargil area of this zone during 2016 and 2017 by utilizing the existing mulberry wealth of approximately 6000 mulberry trees growing in the area.

(2) Temperate Zone is mostly represented by Kashmir valley of J&K state and higher reaches of Jammu province; Shimla, Kulu, Lahaul Spiti and Kinnaur in Himachal Pradesh and higher reaches of Uttarakhand. In this zone snowfall is experienced during winter months. Sericulture in this zone is mostly practised in J&K state.

(3) Intermediate Zone represents the Shivalik Zone. This zone falls between temperate and sub-tropical area. This is the most potential area for bivoltine silk production in North West India.

(4) Sub-Tropical Zone represents the area with extreme range in temperature, varying from about 2^{O}C during winter and as high as 47^{O}C during summer. There is no snowfall in winter

Due to the above prevailing different agro-climatic conditions, the mulberry varieties and cultivation practice developed elsewhere cannot be adopted as it is into the region. Thus, it is highly essential to develop mulberry varieties suitable to this region to meet emerging challenges and to contribute substantially to the targeted bivoltine raw silk production of 20,000 MT in India by 2030 and also contribute in increasing the mulberry area to 3.86 lakh hectares from the existing 2.3 lakh hectares in India. Therefore, vigorous work in the frontier areas of Mulberry Breeding and Genetics such as molecular biology and biotechnology clubbed with traditional breeding approaches are required to create significant number of new mulberry varieties suitable to local agro-climatic conditions.

II MULBERRY IMPROVEMENT IN NORTH INDIA

Mulberry in North and North West India is mostly grown in the extensive mode of plantation as tall (tree) type. Hence, most of the mulberry wealth is available on the marginal lands, road sides, river bunds and on the boundaries of the agricultural fields, which forms the major source of foliage for silkworm rearing [1], [2], [3], [4], [5], [6], [7], [8]. The growth and development of silkworm larvae and the economic characters of cocoon

are known to be influenced by the nutritional content of mulberry leaves [9], [10], [11]. The nutritional quality of the mulberry leaves in the present cultivation system is poor due to lack of technological package for scattered mode of plantation.

High yielding mulberry varieties with desired characters have a significant role to play for the vertical growth of the sericulture and to make sericulture occupation more remunerative and lucrative. Several improved mulberry varieties have been evolved elsewhere but limited work in this direction has been taken up in North India. The existing improved genotypes in field yield poor quality of leaf and moreover, their spread in field has been slow and has its own limitation. Presently, there is no identified genotype which has the specific characters based on the varied climatic regions and soil status. Therefore, while evolving a mulberry variety for North Indian conditions, the following few characteristics are essentially to be taken into consideration:

i. The available mulberry genotypes particularly under tree cultivation, yield limited quantity of leaf which is one of the main constrains of sericulture industry under North Indian conditions. The maximum leaf yield in tree mode of plantation for improved varieties is 16-17 MT/year/ha under temperate conditions and 14-19 MT/year/ha under sub-tropical conditions [12]. Efforts have to be made to achieve the leaf yield thrush hold level and it is envisaged that the occupation can be remunerative.

ii. The extent of damage due to frost/snow in temperate climate is up to 30% in existing varieties which reduces leaf yield in main spring season [13]. Moreover, the damage caused due to frost to the saplings increases the gestation period from nursery to transplantation by about one year. Therefore, mulberry variety resistant to frost damage is a pre-requisite to save time at sapling stage and to increase the availability of mulberry foliage during the main rearing season under temperate climatic conditions.

iii. Sericulture has a huge potential under subtropical conditions of North India. However, the availability of leaf is a constraint particularly under water stress conditions. Therefore, evolution of mulberry genotypes showing tolerance to drought conditions is of prime importance.

iv. Early sprouting behaviour of mulberry is a positive attribute in silkworm rearing since mulberry cultivars which sprout early, can make the leaf available early and help in advancing the rearing at commercial level thereby helping in utilizing the congenial atmosphere for an additional crop under temperate conditions. Similarly, the early sprouting and late leaf fall varieties under subtropical conditions shall be helpful in adjusting additional crops.

v. Popular mulberry genotypes in the field in temperate region show poor response to rooting and more often conventional root grafting method takes 3-4 years from nursery to transplanting site which is uneconomic and time consuming. Hence evolving mulberry genotypes with the desired rooting ability can be meaningful. CSR&TI, Pampore has evolved a mulberry variety PPR-1, which shows good rooting ability through stem cuttings. However, the same needs to be propagated on large scale in the field to reduce the cost on cultivation of mulberry.

vi. Mulberry is mostly available as tree type of plantation in North India and evolving mulberry suited in tree mode of cultivation is essential. Therefore the evolved genotype should have erect branching to train as tree.

vii. Qualitative genetic improvement of mulberry leaf is essential for boosting sericultural economy. Therefore, palatability of the leaf for silkworm rearing is an essential component in the evolved varieties.

III GENERAL OBJECTIVES OF MULBERRY BREEDING IN NORTH INDIA:

3.1 Temperate Conditions

The general objective in mulberry breeding under temperate conditions is to evolve a cultivar which has the following characteristics:

i. Higher leaf yield per unit area.
ii. Resistance to extreme cold climate (frost).
iii. Early sprouting behaviour.
iv. Easy to root when propagated through stem cuttings.
v. Height and branching habit.
vi. Palatable leaf for silkworm rearing.

3.1.1 Sub-Tropical Conditions

The general objective in mulberry breeding under sub-tropical conditions is to evolve a cultivar which has the following characteristics:

i. Higher leaf yield per unit area.
ii. Drought tolerance.
iii. Early sprouting behaviour.
iv. Late leaf fall.
v. Height and branching habit.
vi. Palatable leaf for silkworm rearing.

3.2 IMPORTANT CONTRIBUTIONS MADE SO FAR BY CSR&TI, PAMPORE:

The Institute has identified and developed a number of mulberry varieties along with associated technologies for this region through various All India Coordinated Experimental Trials for Mulberry (AICEM), multilocational trails of exotic genotypes and breeding programmes. A few important among them are detailed below:

Mulberry Varieties developed/recommended:

Mulberry Variety	**Leaf Yield**
Tr-10, S146, S1635 and Vishala	14 to 19 MT/ ha/yr leaf yield (Under rainfed conditions) Recommended for Subtropical region [12]
Goshoerami, Ichinose, KNG and Tr-10	16 to 17 MT/ ha/yr leaf yield (Under rainfed conditions). Recommended for

Mulberry Variety	Leaf Yield
	temperate region [12]
PPR-1	15 to 18 MT/ ha/yr leaf yield (Under rainfed conditions) with 80-90% rooting ability and more than 90% survival, early sprouting after winter dormancy and high nutritive value (Table 1). Recommended for temperate region and hilly areas of Uttarakhand [14]

Introduction of improved mulberry varieties recommended by CSR&TI, Pampore has increased the quality leaf production to an extent of 50% as against local genotypes. The production of quality leaf as well as quality cocoon production due to intervention of various improved Mulberry varieties, Silkworm hybrids coupled with user friendly technologies has led to the substantial increase in the productivity and in turn enhancement in the average income of the farmers.

Further, the Institute is maintaining temperate mulberry germplam of 82 mulberry accessions (36 exotic and 46 indigenous) represented by 10 countries at CSR&TI, Pampore. Similarly, 82 mulberry accessions are maintained at Sahaspur and 18 accessions at RSRS, Jammu as sub-tropical mulberry germplasm. Over the years, these accessions were evaluated for 65 morpho-metric, biochemical and reproductive traits, which has lead to identification of promising mulberry varieties for utilization in the breeding programmes. Major achievements/findings are as under:

- Collections made from Ladakh region in Jammu and Kashmir have shown 100% frost tolerance. Therefore, these collections are presently utilized in the ongoing research programme on identification of cold tolerant genes for evolving a cold resistant mulberry variety.
- Large variability with regard to evaluatory traits (3.97 to 52.0%) exists in the mulberry germplasm bank (Table 2 & 3).
- Punjab local was found earliest sprouting genotype (Sprouts 20-25 days earlier than Goshoerami). The variety will be utilized in future breeding programmes to evolve an early sprouting mulberry variety.
- Divergence in characters among the mulberry varieties of temperate and tropical origin. Tropical genotypes complete flowering earlier than temperate genotypes by a period of one month.
- *M. multicaulis* has been found superior in most of the characters except rooting ability. Therefore, can be used as a parent in different crop improvement studies.
- Studies have thrown light on the utility of *M. bombycis* in crop improvement programmes under temperate conditions since it shows greater cold hardiness and resistance to die-back disease which is of prime importance.

Furthermore, the Institute is presently working on following 04 mulberry breeding projects to evolve mulberry varieties for both Temperate and Sub-tropical climatic conditions. Advanced as well as traditional techniques are applied in collaboration with University of Kashmir, SBRL, Kodathi and CGRC, Hosur for logical conclusion of these projects:

i. Evolution of superior mulberry varieties suitable for temperate region through somatic hybridization. (In collaboration with University of Kashmir, J&K)
ii. Identification of cold tolerant genes for improvement of mulberry genotypes. (In collaboration with Seri Biotech Research Laboratory, Kodathi, Bangalore)
iii. Development of superior mulberry varieties through controlled hybridization for North-West Indian states. (In collaboration With Central Sericultural Germplasm Resource Centre (CSGRC), Hosur, Tamil Nadu)
iv. Development of mulberry genotypes suitable for rainfed hill farming in North West India. (In collaboration With CSGRC, Hosur, Tamil Nadu)

Based on the breeding objectives and contributions made so far, the short term and long term priority areas for mulberry improvement in North and North West India are as under:

IV PRIORITY AREAS FOR MULBERRY IMPROVEMENT:

4.1 Short Term:

- Evaluation of evolved F_1s/other mulberry genotypes with high rooting ability, early sprouting, quality yield and resistance to frost (temperate conditions) and drought resistance (sub-tropical conditions).
- Enrichment of mulberry gene pool by additions of exotic mulberry accessions from CSGRC, Hosur in phased manner under safety backup programme. Screening of gene pool for desirable characters for subsequent utilization in conventional breeding.
- Survey of North West Himalayan region for collection and conservation of wild mulberry genetic resources and utilization of these mulberry accessions in pre-breeding programme to transfer genes of choice into popular genotypes.
- Development of efficient and effective *in vitro* and *in vivo* protocols for raising the mulberry saplings and to utilize unproductive winter months in Kashmir for sapling raising under laboratory conditions.
- Screening of mulberry genotypes for their suitability under extreme soil conditions.
- Development of eco-friendly INM package for quality leaf production suitable for varied soil and environmental conditions of North India.
- To exploit full genetic potential of the genotypes, the yield gaps from lab to field need to be reduced. Presently, mulberry genotypes yield 14-19 MT/ha/yr under tree type of plantation and same can be increased substantially, if all the requirements of the mulberry are met.

4.2 Long Term

- Development of mulberry genotypes, which show resistance to diseases and pests through conventional/bio-technological approach.
- Evolution of triploids, which can show high resistance to diseases and pests and cold climate in addition to higher quality yield.

- Use of bio-technological and molecular biology techniques as a tool for crop improvement in collaboration with other Institutes.
- Evolution of mulberry genotypes, which are region and season specific along with improvement in quality leaf production.
- Evolution of mulberry genotypes, which suit tree type mulberry cultivation.

V ACTION PLAN FOR ACHIEVING THE OBJECTIVES

The following activities are proposed to be initiated for achieving the set objectives:

i. Thirty two putative cold tolerant gene sequences from mulberry data base have been identified in the project "Identification of cold tolerant genes for improvement of mulberry genotypes (PIB-3579)". Collections made from Ladakh are utilized under this programme. Isolation of these identified gene sequences will be carried out in collaboration with SBRL, Kodathi. Functional characterization of these isolated cold tolerant genes will be carried out for their further utilization in evolving a cold tolerant mulberry variety. The evolution of a variety with cold tolerance character will solve the problem of frost damage in mulberry and will make additional leaf to an extent of up to 30% available during main spring season. This will in turn increase the quantum of rearing and hence cocoon production during spring season.

ii. Under the project "Evolution of superior mulberry varieties suitable for temperate region through somatic hybridization (PIB-3571)" Protoplast isolation and fusion protocols have been standardized for different mulberry varieties. The standardization of procedure for regeneration of plants from the fused protoplasts is under progress. The viable tetraploids to be developed out of this project will be utilized for evolving a triploid mulberry variety. Triploid mulberry genotypes evolved from temperate mulberry varieties can show high resistance to disease and pests and cold climate under temperate conditions of Kashmir.

iii. Under earlier breeding programmes, 58 selections (F_1s) were identified out of which 11 selections were further shortlisted in the concluded project "Breeding of early sprouting and high yielding mulberry variety (ies) amenable to propagate by stem cuttings and high survival ability for rainfed conditions of Kashmir and other temperate regions of North India (PIB-3392)". All these shortlisted selections are good rooting and some of them are early sprouting as well. These selections will be tested under multilocational trials to identify a variety for varied agro-climatic conditions of North India.

iv. Accessions identified in the germplasm characterization programme will be utilized as parents in the recently initiated two breeding programmes (one each at Pampore and Jammu). It is expected to evolve promising F_1s under these projects.

v. 50 exotic accessions have been added to the temperate mulberry germplasm bank at P4 Basic Seed Farm (BSF), Manasbal, J&K under safety backup programme. These accessions will be screened for desired characters for their further utilization. North West Himalayan region will be surveyed in association with CSGRC, Hosur for collection of wild mulberry accessions growing under extreme climatic conditions for their utilization in the pre-breeding programmes.

Table 1: Growth parameters of Evolved F_1 selection "PPR-1 Vs Goshoerami"

Parameter	PPR-1	Goshoerami (Ruling variety)
Rooting ability by stem cuttings (%)	95	18.67
Leaf Yield/ Plant/year (Kg)	4.329	3.802
Stem Diameter of primary branches (cm)	1.86	1.52
No. of primary branches/plant	39.0	32.0
Length of longest branch (m)	2.6	1.9
Sprouting of winter buds by March end (%)	54.79	1.1
Leaf Moisture (%)	80.38	75.79
Leaf Moisture Retention Capacity (%)	84.68	77.58
Frost Damage (%)	7.41	15.99

Table 2: Range of diversity in various growth parameters (evaluatory) of mulberry genetic resources

S. No	Character	Min	Max	Mean ±SD	C.V
1	No. of shoots/plant	7.16	32.92	21.72 ± 7.64	43.07
2	Total shoot length (cm)	318	3376	1725.1 ± 83.35	50.74
3	Internodal distance (cm)	3.40	5.32	4.52 ± 0.43	9.79
4	100 leaf weight (kg)	0.11	0.93	0.325 ± 0.17	**52.00**
5	Leaf petiole ratio (weight)	3.02	36.27	17.14 ± 3.72	21.78
6	Leaf yield/plant/crop (kg)	0.90	4.62	2.08 ± 0.79	38.23
7	Moisture content (%)	53.00	82.22	74.75 ± 5.77	7.71
8	Moisture retention capacity (MRC) after 6 hours	74.24	92.24	85.18 ± 3.98	4.66

Table 3: Range of diversity in reproductive parameters of mulberry accessions

S. No	Character	Min.	Max.	Mean	Vari-ance	S.E	C.V%	Ske-wness	Kur-tosis
1	Seed set (%)	6.2	98.1	61.4	752.61	3.513	15.479	-0.416	-1.039
2	100 seed wt (g)	0.09	0.24	0.162	0.001	0.005	3.708	0.022	-0.687
3	No. of Catkins/ cluster	1	7	3.9	1.799	0.166	21.834	0.258	0.188
4	Stamen Length (mm)	2.84	4.02	3.326	0.083	0.048	8.371	0.411	-0.366
5	Anther Length (mm)	0.68	0.77	0.729	0.0005	0.004	4.883	-0.196	-0.464
6	Pollen diameter (µm)	16.89	24.67	19.53	3.087	0.293	8.591	1.411	1.750
7	Pollen Viability (%)	69.08	80.27	73.553	5.459	0.389	3.967	0.600	1.459
8	Style length (mm)	0.36	1.56	0.634	0.047	0.036	9.824	3.311	12.131
9	Stigma length (mm)	3.62	7.06	5.417	0.869	0.155	8.954	-0.018	-0.827

REFERENCES

[1] A.K. Tiku, B. B. Bindroo, and R.K. Pandit, 1989): Effect of training on the yield of mulberry. *Indian J. Seric. 28(2): 191-193.*

[2] A. Dhar, B.B. Bindroo, and R.K. Fotadar, (1996). Prune for productivity. *Indian Silk 34(9): 12-13.*

[3] A. Dhar, P.M. Tripathi, and B.B. Bindroo, (1999). Jammu Va Kashmir Mein Shahatoot Krishi. *Indian Silk. August. 99, Pp: 50-52.*

[4] A. Dhar, B.B. Bindroo, P.M. Tripathi, and M.A. Khan, (2001). Sericulture Industry - A boon for rural development. *Asian Textiles Journal, Vol. 10(12): 60-66.*

[5] A. Dhar, and B.B. Bindroo, (1997). Mulberry raising under subtropical conditions of India – An Economic Appraisal, *Sericologia, 37(1): 147-152.*

[6] P.M. Tripathi, A. Dhar, R.K.Bali, P. Ranjan and B.B. Bindroo, (1999). Jammu Kashmir Mein Resham Keet Palan Avam Gramin Vikas Mein Iska Yogdan, *Indian Silk. Sept. 1999: Pp. 47-48.*

[7] M.A. Khan, (2006). Introduction of autumn crop in North Indian states – Constraints and requirement of need based Technological support for its commercialization. Lead paper presented at workshop on stabilization of second silkworm crop in North India, 20-21 Feb. 2006.

[8] S. Koul, R.K. Fotadar, A. Dhar, and B.K. Singhal, (2007). Suitable crops for intercropping with mulberry in Jammu area. *Indian Silk 46 (7):4-6*.

[9] S. Krishnaswamy, S. Kumararaj, K. Vijayaraghavan, and K. Kasiviswanathan, (1971). Silkworm feeding trail for evaluation of the quality of mulberry leaves as influenced by variety, spacing and nitrogen fertilization. *Indian J. Seric., 9(1): 79-89*.

[10] M. Machi, and K. Katagiri, (1991). Varietal difference in nutritive value of mulberry leaves for rearing silkworms. *JARQ 25: 202-208.*

[11] B. K. Singhal, A. Dhar, P.M. Tripathi, S.M.H. Qadri, N.N. Saxena, B. B. Bindroo, and M.A. Khan, (2005). Leaf nutritional quality in different plantation types of mulberry *(Morus* sp.) in Indian subtropics. Advances in Tropical Sericulture. Proc. Nat. Conf. on Tropical Seric. for Global Competitiveness held at C.S.R.&T.I.,Mysore. Pp: 153-156.

[12] A. Dhar, R.K. Fotadar, R. Kaur, and M.A. Khan, (2007). Suitable mulberry genotypes for North India. CSR&TI, Pampore publication. Bulletin No. 11.

[13] A. A. Shabnam, R. K. Fotadar, A. Dhar and A.H. Bhat, (2012). Comparative analysis to Tropical and Temperate Genotypes and behaviour of five species of Mulberry under Temperate conditions of Kashmir. *Research Journal of Agricultural Sciences, 3(1): 089-093.*

[14] A. A. Shabnam, and S.P. Sharma, (2016). Improved mulberry variety (PPR-1) for Temperate region. CSR&TI, Pampore publication. Bulletin No. 20.