Development of superior mulberry (*Morus* spp.) genotypes through Polyclonal Seed Orchard

SUBMITTED TO

CENTRAL SILK BOARD
MINISTRY OF TEXTILES (GOVERNMENT OF INDIA)
BTM LAYOUT, MADIVALA
BANGALORE – 560 068

June 2018 – May 2021
(3Years)

Submitted by:

Debashish Chakravarty
Scientist-D

MULBERRY BREEDING & GENETICS SECTION
CENTRAL SERICULTURAL RESEARCH & TRAINING INSTITUTE,
CENTRAL SILK BOARD,
MINISTRY OF TEXTILES: GOVT. OF INDIA,
BERHAMPORE - 742 101, WEST BENGAL

PROFORMA FOR COLLECTION OF DATA OF RESEARCH PROJECTS IN SERICULTURE

PART I: GENERAL INFORMATION

1.	Name of the Institute / University / Organization submitting the Project Proposal	:	**Central Sericultural Research & Training Institute,** Central Silk Board, Ministry of Textiles: Govt. of India, Berhampore - 742 101, West Bengal, India
2.	Status of the Institute(s)	:	NA
3.	Name(s) and designation of the Executive Authority of the Institute / University forwarding the application	:	Dr. Kanika Trivedy DIRECTOR
4.	Project Title	:	Development of superior mulberry (*Morus* spp.) genotypes through Polyclonal Seed Orchard.
5.	Category of the Project	:	Applied
6.	Specific Area	:	P – **P**lant I – **I**mprovement B - **B**reeding
7.	Duration	:	June 2018 to May 2021(3 years)
8.	Total cost:	:	**Rs. 3.20 Lakhs**
9.	Is the Project is single institutional or multi-institutional	:	Single institutional
10.	If the Project is multi-institutional, please furnish the following: Name, Designation and Address of the Project Co-ordinator	:	NA

11a. PROJECT SUMMARY:

Mulberry (*Morus* spp.), the food plant of silkworm *(Bombyx mori* L.), is a cross pollinated highly heterozygous perennial plant/tree. It is widely accepted that genetic variation is of fundamental importance for species' conservation [Banerjee R. *et al* (2007); Gilpin ME *et al* (1986); Barrett SCH *et al* (1991); Ellstrsnd NC *et al* (1993); Hamrick JI *et al* (1996); Karron JD (1997); Lande R (1999)]. The plant breeder is interested to know the genetic divergence among the varieties or strains available because crossing involving distantly related parents provide a broad spectrum of variability to ensure the efficiency of selection toward better types. The use of diverse germplasm as a significant factor contributing to high yield has been stressed by many workers using crops like rice, wheat, maize and pepper [Monaghan JM *et al* (2001); Patil DV *et al* (2003); Medici LO *et al* (2005); Gileta LF *et al* (2004)].

In mulberry, generally controlled crossing is being in practice to create genetic variability in the population. In control hybridization, limited genetic variability is created and provides less scope for selection of superior hybrids/seedlings. The process is labour and time consuming too. Alternately, pollen source of open pollinated seeds collected from desired female plants is unknown and several OPH varieties thus developed may have some undesired traits. In contrary, the present study of the proposed Polyclonal seed orchards consisting selected parents, upon random mating, will create desired genetic variability in the segregating population with least manpower requirement, offering greater scope for accumulation of plus genes followed by identification of superior genotypes. Though, simultaneously, the existing conventional controlled breeding programme may also be continued as per the availability of resources.

11b. AIMS AND OBJECTIVES:

1. To establish Polyclonal seed orchard for creating enormous genetic variability.
2. To identify promising mulberry seedlings for further utilization.

PART II: PARTICULARS OF INVESTIGATORS

12. NAME, DESIGNATION AND ADDRESS OF THE PROJECT CO-ORDINATOR: NA.

12 a) INVESTIGATORS

Name : D.Chakravarty, Scientist-D
Date of birth : 02.12.1962
Sex : Male
Address : CSRTI, Berhampore, West Bengal

Name : Suresh K., Scientist-B
Date of birth : 13.07.1988
Sex : Male
Address : CSRTI, Berhampore, West Bengal

13. NO OF PROJECTS BEING HANDLED BY EACH INVESTIGATOR AT PRESENT

1. D.Chakravarty : 02
2. Suresh K., : 05

14. PROPOSED RESEARCH FELLOWS: NA

PART III: TECHNICAL DETAILS OF PROJECT

15. INTRODUCTION:

Mulberry (*Morus* spp.), the food plant of the silkworm (*Bombyx mori* L.) believed to have originated in the lower slopes of the Himalayas, is the native of China and India. Even today, there exist some thousand years old, very big mulberry trees in the nature, which were discovered by the Chinese scientists in Xizang (Tibet) province of China. It grows well in many parts of the world as a fast growing deciduous tree. At present, mulberry trees are widely spread in Asia, Europe, Latin America and Africa and cultivated more than 30 countries. The distribution of mulberry trees in different regions reflects particularly their adaptability to wide range of environmental conditions. The systematic position of mulberry in the plant kingdom is Phylum: Seprmatophyta Sub-Phylum: Angiospermae Class: Dicotyledonae Sub-Class: Archichlamydeae Order: Urticales Family Moraceae Genus: *Morus* Species: *alba, indica & others.* Indian sub-continent is an important center of origin of diversity of nearly 160 domesticated plant species of economic importance. Mulberry (Morus sp) is one of them and is cultivated not only for sericulture but also for fruits, fodder, timber, fire wood etc. Mulberry (*Morus* spp.), generally a diploid (2n =2x=28), has 24 species and one sub species and distributed in wide area of tropical, sub-tropical, temperate and sub-artic zones (Koldzumi G.,1917).There are 4 species of mulberry viz., *Morus indica, M. alba*, *M. laevigata* and *M. serrata* occurring in India and are found throughout the Himalayas from Kashmir in West to Assam in East. Because of its adaptability to cross pollination with no inter-specific reproductive barriers, a vast range of diversity in the genetic stocks has crept in thereby rendering it highly heterozygous plant species, as a result every plant being different from other in natural population which signifies the wide range of diverseness in the mulberry genetic stocks. The conservation strategy unlike other field crops is yet to be refined for mulberry.

The ultimate goal towards mulberry improvement is to breed or develop high productive genotypes with quality leaves in a shortest possible time at a reasonable cost. This can be stated as to breed for economic characters while at the same time to maintain or broaden the genetic base for adaptability and resistance to biotic & abiotic stress factors. Viewing the limited success in developing new mulberry varieties, it is apparent that there are some inherent problems which hinder the development process. As mulberry is tree in nature, the generation time is quite long and such long generation time

does not permit to use different breeding processes that are generally followed for annual cross pollinated crops. Poor relationship of the important characters in juvenile stage with that of the yield in adult stage makes the prediction difficult at the young age. Non-availability of inbred lines in mulberry limits our knowledge with respect to the inheritance pattern of important economic traits. Tissue culture technique also failed to provide sufficient useful information in mulberry. However, there are some advantages also exists with this plant. There is easy fixation of heterosis – It is easily propagated through stem cuttings. Once a superior genotype is identified, at any stage of developmental process it can be preserved or fixed through cuttings or grafting. Due to the cross pollination and heterozygous nature of the parents, the progeny immediately exhibits variation on crossing. Such variation promises the success of conventional breeding. To improve mulberry foliage productivity, identification of suitable genes related to agronomiclly important traits in the available mulberry germplasm is essential (Banerjee,R. *et al.,* 2011).

Exploitation of heterosis is considered as an outstanding success of Mulberry breeding. The magnitude of heterosis gained by the hybrids largely depends on the genetic divergence between the parents. This information facilitates the breeders in selection of parents for crossing and development of hybrids. However, the genetic diversity of the parents is not always related with the geographical diversity (Garg D.K.*et al* 1988.). The importance of plant genetic diversity (PGD) is now being recognized as a specific area since exploding population with urbanization and decreasing cultivable lands. Scientists realized that PGD can be captured and stored in the form of plant genetic resources (PGR) such as gene bank, DNA library, and so forth, in the biorepository which preserve genetic material for long period. However, conserved PGR must be utilized for crop improvement in order to meet future global challenges. Biodiversity covers variety of flora and fauna, their ecological roles and the genetic variability they contain. Diversity characterizes most of the life forms. To bring greater diversity into the breeding pool, it requires introduction of exotic and wild materials. The breeders find it difficult to use unadapted materials from wild source. The intermediate materials produced after incorporating the new genes is treated as genetically enhanced materials, which may be useful to develop desired lines in mulberry (Tikader A., *et al.* 2008).

For developing a mulberry variety and to make best use of available gene pool, evaluation is the important step where the parameters like growth, yield, quality and cultivation requirements are taken into account, duly compared with the existing the best one. Since, mulberry can be vegetatively propagated, therefore, once a superior mulberry

genotype, in terms of leaf productivity & quality or for any specific objective, is identified, its character can be perpetuated through vegetative propagation. Thus created genetic variability provides a heterozygous heterogeneous population, which offers the scope to the breeders to select the superior mulberry genotype than the existing one through several evaluation trials viz., Progeny Row Trial, Primary Yield Trial, Final Yield Trial & All India Experiment on Mulberry (AICEM). Improvement in the production of silk depends upon the quality leaf yielding ability of mulberry. Allard (1960) rightly opined that the contribution to human welfare made by superior varieties is the most satisfying of all the methods of increasing production. Introduction of Bivoltine as well as Multi x Bi hybrids of silkworm in the Eastern part of India, with limitation of cultivated land, has increased the demand of superior (than the existing best one) mulberry varieties. Moreover, early senescence particularly during favourable silkworm crop seasons, susceptibility to biotic & abiotic stress condition etc., are the other challenges yet to meet. Thus, continuous effort from breeders end is required to be made to develop improved mulberry varieties which stand significantly superior to the existing ruling ones.

Development of superior genotypes involves systematic evaluation for various desirable parameters of the selected genotypes. Therefore, for developing a variety and to make best use of available gene pool creating the genetic variability in the population followed by evaluation is the important step where the parameters of growth, yield, quality and cultivation requirements are compared with the existing high yielding one.

15.1: DEFINITION OF THE PROBLEM

The traditional breeding methodologies mostly rely on the production of F_1 hybrids/population for isolation of superior hybrid, where few parents with desired traits are considered and limited control hybridization is carried out to produce hybrid population. The process is time consuming and requires more mandays. However, many varieties authorized for cultivation in different agro- climatic regions of India lacks one or other important traits such as susceptibility to Pest and Diseases, early senescence, poor yield during winter months which is favourable season for silkworm rearing (November to February). To overcome shortcomings of released varieties and further to improve productivity and quality of leaf to suit the improved crossbred and bivoltine silkworm breeds is need of the hour. Polyclonal seed orchard consists of different genotypes that complement each other traits and produce variability in desired direction helps breed to impart selection effectively.

15 a. ORIGIN OF THE TECHNOLOGY

In control hybridization, limited genetic variability is created and provides comparatively less scope for selection of superior hybrids/seedlings. The process is labour and time consuming too. Alternately, pollen source of open pollinated seeds collected from desired female plants is unknown and several OPH varieties thus developed may have some undesired traits. In contrary, the present study of the proposed Polyclonal Seed Orchards (PSO) consisting selected parents, upon random mating, will provide enormous genetic variability in the segregating population with least manpower requirement, offering greater scope for accumulation of plus genes followed by identification of superior genotypes. Though, simultaneously, the existing breeding programme may also be continued as per the availability of resources.

Mulberry leaves with superior quality and higher yield are the essential requirement for quality cocoon production. Although a large number of mulberry varieties are available in the field, high yielding varieties for commercial utilization are very limited. At the same time, introduction of new silkworm hybrids, more number of silkworm crops in a year, limitation of cultivated land, demand for production of high quality silk etc., has further intensified the demand of superior mulberry varieties. Considering these factors, the present project is, therefore, proposed as an architect of the genetic variability accumulated with plus genes in mulberry population for its exploitation with minimum manpower requirement. This will act as resource material for further evaluation in the direction of developing a superior variety than the existing one in terms of leaf quality and productivity.

15 b. EXPECTED OUTCOME

1. The Polyclonal Seed Orchard (PSO) will be established for creating enormous genetic variability.
2. Promising mulberry genotypes with desired traits will be identified for their future utilization.

15.2: ORIGIN OF THE PROPOSAL/ RATIONALE OF THE STUDY

Raw silk production to a greater extent depends on higher yields and quality mulberry leaves. Researches on mulberry conducted at this Institute have been able to develop a series of high yielding varieties suitable for different agro climate zones of Eastern India in general and West Bengal in particular.

In eastern India, the local mulberry variety "Kajli" was cultivated till 1960 with a very poor leaf yield of around 8-10 t / hectare / year depending on the availability of irrigation/good rain. Then in the year 1960 one more local variety "Bombai local" started ruling with leaf yield potentiality of about 14-15 t / hectare / year. The first mulberry developed by this Institute was S-1. The seeds were collected from an unknown female mulberry plant at Mandalaya in Burma, introduced in India and finally recognized as S-1 or Mandalaya with leaf yield potentiality of 16-18 t per hectare per year under rain fed condition and 28-29 t per hectare per year under irrigated condition. It was the first mulberry variety developed by this institute with entire (unlobed) leaf. The leaf yield gain was 192% over "Kajli" and 92% over "Bombai local". Then in the year 1995 next high yielding variety S-1635 was evolved with leaf yield potentiality of 44-45 t per hectare per year. The open pollinated seeds were collected from the mother plant CSRS-1 and finally it was proved that it was a natural triploid with fast growth rate, large leaf size and superior in leaf quality. In the 1st AICEM it performed best and in the 2nd AICEM it was ranked as National variety and considered as National Check (NC). By cultivating S-1635 the rearing capacity per crop has been increased from 400-450 dfls with S-1 to 700-750 dfls with S-1635 in one hectare plantation. At present one more mulberry variety C-2038 just completed AICEM Phase III trial with leaf yield potentiality 54-56 t/ha/year.

Wind-pollinated families have often been used for progeny testing due to relatively low expense and profuse availability of seed (EI-Kassaby *et al*. 1987a; Sorensen and White 1988; Askew, G.R *et al* (1994). Breeders rely on genetic variation between parents to create unique gene combinations necessary for new superior cultivars (George Van Esbroek, *et al* 1998). The economic product of mulberry and tea is same i.e., leaf. Both are heterozygous plant. In Tea, the selected parental lines are grown in isolation to produce hybrid seeds by natural transfer of pollens. The F_1 stocks produced highly heterogenous population. The less vigorous progenies are rejected, while more favourable F_1 stocks are evaluated further for yield and quality attributes (Banerjee,B. (1993). The extreme variations in the tea population, created by both natural and man-made causes, provided an excellent opportunity to select the outstanding bushes from the field and to propagate them vegetativly (Bezbaruah, H.P., 1975). The orchards (Baries) established with selected plants of Tea, the collected seeds were tested and found real improvement (Rep. Tocklai Exp. Sta. 1959). However, the traditional breeding methodologies in mulberry mostly rely on the production of F_1 hybrids/population for isolation of superior hybrid where few parents with desired traits are considered and

limited control hybridization is carried out to produce hybrid population. Thus limited genetic variability is created and provides less scope for selection of superior hybrids/seedlings. The process is labour and time consuming too. Very often difficulties are encountered by breeders in pollination between the desired varieties (Das,B.C.,1968). Alternately, pollen source of open pollinated seeds collected from desired female plants is unknown and several OPH varieties thus developed may have some undesired traits. In contrary, the present study of the proposed Polyclonal seed orchards consisting selected parents, upon random mating, will provide enormous genetic variability in the transgressive seggregants with least manpower requirement, offering greater scope for accumulation of plus genes followed by identification of superior genotypes. Though, simultaneously, the existing breeding programme may also be continued as per the availability of resources.

15.3: RELEVANCE TO THE CURRENT ISSUES AND EXPECTED OUTCOME

Now a day, horizontal increase of the mulberry cultivation is becoming a plateau and its expansion depends on the vertical improvement in terms of productivity of mulberry leaf which in turn will generate more income per unit area. Breeding mulberry has been found to be one of the effective techniques to boost up the leaf productivity. Mulberry, being the only food plant available for the silkworm, *Bombyx mori* L., occupies a significant position in sericulture and the leaf production cost alone covers more than 60% of the total cost of cocoon production (Das & Krishnaswami 1965; Anonymous 1997). To increase the productivity it is imperative to develop high yielding mulberry variety with broad adaptability so that it can be utilized in the majority of the sericulture zones. Through gradual process of developing high yielding mulberry varieties this institute reached at the level of 52-54 t/ha/year from 8 t/ha/year to increase the brushing capacity of the stakeholders and it will be finally reflected in the cocoon production at the National level.

The expected outcome of this study will be identification of superior mulberry genotypes to provide resources to set up further evaluation trials to develop a superior mulberry variety than the existing one in terms of leaf quality and productivity.

The successful completion of the project is expected to come out with the continuous flow of the resource material in the direction of development of the suitable high yielding mulberry genotypes.

15.4 OBJECTIVES

1. To establish Polyclonal seed orchard for creating enormous genetic variability.
2. To identify promising mulberry seedlings for further utilization.

16. REVIEW OF STATUS OF RESEARCH AND DEVELOPMENT OF THE SUBJECT.

16.1 INTERNATIONAL STATUS

Mulberry is a unique plant which shows high plasticity with differential response under different conditions. Such response provides protection in different environments (Gray and Gray, 1987). Machii *et al.* (1997) suggested a model guideline for characterization and evaluation of mulberry genetic resources. Under the model proposed by them, the essential and optimal characters were broadly classified into these categories namely.

1. Primary characters which include the morphological parameters characterizing stem, leaf, petiole, flowers and seeds.
2. Secondary characters include sprouting, rooting and tolerance to biotic and abiotic stresses.
3. Tertiary characters include mostly the quantitative characters such as shoot weight, leaf weight and nutritional status, specially the nitrogen content of mulberry leaf.

An intensive review of mulberry evaluation in the temperate countries like China, Russia and Japan revealed that a number of mulberry varieties were developed by the breeders for temperate conditions which have potentiality to sprout and grow well immediately after cold spell. In Russia two mulberry varieties, Zimestojkij (Filippovich and Strasonova, 1965) and Ukranin-1 (Pryluckyj, 1969) were developed which are tolerant to cold and sustain growth during cooler months. Variation of nutritional superiority in mulberry varieties differs the rearing performance of silkworm (Sarkar and Fujita, 1993a). In separate studies conducted by Katagiri and Machii (1988), Machii and Katagiri (1991) it was observed that the nutritional superiority for silkworm rearing varies with the different varieties of mulberry.

16.2 NATIONAL STATUS

The prime objective of mulberry breeding is to develop high productive genotypes with quality leaves in a shortest possible time at a reasonable cost. The mulberry breeders at different Research Institutes have developed and released many varieties like Kanva-2, S-36, S-34, V-1 (for irrigated), S-13, S-34, MR-2, DD (for rainfed), Goshoerami, China White (for temperate) and Chack Majra (for Sub-Temperate Hills). Though these varieties have high yield potentiality to produce 30-70 ton leaf/ hectare/year in their respective areas of release but in the field trial under irrigated condition of West Bengal they do not yield more than S-1635, the ruling existing mulberry variety.

According to Sarkar (2000), apart from the conventional breeding technique used for development of high yielding mulberry, polyploidy breeding and mutation breeding were also attempted earlier in India, China and Japan and in the erstwhile U.S.S.R. In mulberry variety selection, total shoot length, total weight of all branches and weight of 100 leaves are considered as the important parameters which have direct effects on leaf yield. The mulberry breeds at different research institutes have developed and released many varieties (Table -2), such as K-2, S-36, S54, V-1 (for irrigated), S13 (for Rainfed areas) and Chakmajra, China white (for temperate hills). Some of the mulberry varieties released by the other Institutes in India are mentioned below:

Variety	**Region and cultivation condition**	**Leaf yield (t/ha/year)**	**Breeding methods applied**
CSR&TI, Mysore			
Kanva-2	South India , Irrigated	30-35	Selection from natural variability
S-36	South India , Irrigated	40-45	EMS treatment of Berhampore local
S-54	South India , Irrigated	45-48	EMS treatment of Berhampore local
V-1	South India , Irrigated	55-60	Crossing
S-13	South India , Rain fed	12-15	Selection from poly cross progeny
S-34	South India , Rain fed	12-15	Selection from poly cross progeny
MR-2	South India , Rain fed	35	Selection from OPH
CSR&TI, Pampore			
Goshoerami	Temparate	15-20	Introduction from Japan
Chak Majra	Sub-Temparate	25-30	Selection from Natural variability
China white	Temparate	15-20	Clonal selection
KSRDI, Thalagattapura, Karnataka			
DD	South India,Rain fed	40	Clonal selection
Vishala	South India,Rain fed	45	Clonal selection

At this Institute:

The study on genetic diversity in 85 accessions of mulberry germplasm revealed that there is significant difference among the accessions irrespective of their country of origin. Using Tocher"s procedure, the accessions were grouped into 6 clusters. The high values of D^2 among 85 accessions in some of the clusters indicate maximum genetic divergence among them (Roy Chowdhury, S., *et al.*, 2005). The study on the morphological traits viz., sex, plant nature, leaf type, leaf lobation, leaf shape, leaf colour, leaf texture, leaf area etc. of all the 85 germplasm accessions of CSR&TI, Berhampore have been reported by Ghosh, P.L., *et al* during 2005-06 (Concluded report of the Project PIE-3197 of CSR&TI, Berhampore entitled "Mulberry Germplasm Evaluation in relation to quality, quantity and stress resistance"). *Per se* Performance of various genotypes for yield and yield related traits of 29 mulberry genotypes maintained under germplasm bank of CSR&TI, Berhampore were studied and also grouped under three different clusters (Ghosh, M.K., *et al,* 2009).

The genetic divergence of twenty five mulberry genotypes maintained under germplasm bank of CSR&TI, Berhampore were studied for fourteen morphometric traits. It was observed that there was wide variation for all the traits and suggested that direct selection of lamina length, fresh leaf weight, leaf area and single leaf weight will be rewarding for mulberry leaf yield improvement. (Rita Banerjee, *et al.*, 2007). In a trial, CT-44 & CT-11, a promising line developed performing well under different seasons, particularly during winter months (Doss *et al* 2012). Ghosh *et al* (2007) reported that mulberry can be grown successfully both under temperate/rainfed conditions. Seven species of mulberry namely *Morus indica* (x, hp and black) , *M.rubra*, *M. alba, M.rotundiloba, M. cathyana, M.australis* and *M.multicaulis* maintained in the germplasm bank of CSR&TI, Berhampore (W.B.) were studied for flowering and reproductive behaviours specially receptivity of stigma during regular flowering season January to April. Days taken on flowering were 2.5 – 6 days and 2.6-5.7 days in exotic and indigenous, respectively. Receptivity period of stigma revealed that pollination index (PI) was significantly higher between 10^{th} and 14^{th} day of emergenceof catkins from the scale leaves. (Roy Chowdhuri, S., *et al*, 2009). It is also reported that dehiscence of anther is found highest during 10.00-11.30 AM and 3.00-4.00 PM in the day time, while the event occur throughout the day and is restricted to 1-4 days (indigenous 1-3; exotic 2-4 days) for a single catkin (Roy Chowdhuri., S. *et al* (2003).

The time of flower initiation and the duration of floral maturation of 162 mulberry accessions maintained at CSR&TI, Berhampore were recorded and it was observed that flower initiation in tropical exotic genotypes started in the 2nd week of February and continued till the 1st week of April whereas in indigenous tropical genotypes it started in the 2nd week of February and continued till the 1st week of April. In case of temperate genotypes, flowering was extended till the 2nd week of April (Doss S.G. *et al*, 2001). Tikader, A. (1999) reported the importance of number of shoots, total shoot length, leaf area and moisture percent as selection criteria for improvement of leaf yield in mulberry. Vijayan, K., 1997 reported that moisture content and moisture retention capacity in mulberry are under the influence of both genetic and environmental factors. An extensive study on mulberry sex expression was conducted in 162 germplasm accessions comprised of 90 exotic and 72 indigenous accessions and different floral characters along with pollen grain viability and seed setting % were recorded to group the mulberry accessions for further utilization in commercial breeding (Tikader *et al*, 1999).

Attempt has been made to estimate the magnitude of genotypic and phenotypic variation present in the mulberry germplasm of CSR&TI, Berhampore for effective utilization in mulberry breeding programme. Vijayan K *et al* (1997) reported that China white (female) and MS-1 (male) were the best general combiners among the 8 parents tested. The leaf yield, a complex trait, in mulberry is attributed by several quantitative traits (Vijayan K, 1996). Tikader, *et al* (1995) reported the sex expression in 301 genotypes includes, the germplasm collection, polyploids & evolved new genotypes of CSR&TI, Berhampore. Tikader, *et al* (1999) reported that the exotic and indigenous accessions maintained at CSR&TI, Berhampore provide ample scope for crop improvement. The prime objective of mulberry breeding is to develop high productive genotypes with quality leaves in a shortest possible time at reasonable cost. Breeders put its constant efforts in improving the mulberry yield coupled with quality particularly for the eastern & north eastern agro-climatic zones of the country. Since 1960, the Institute has developed a number of high yielding varieties namely S-1, S-1635, C-763, C-776, $BC_2$59, Tr-10 and C-1730 and recommended for different regions (Das, *et al.,* 1970; Das and Prasad, 1974; Das, 1983; Sarkar, 2000). These genotypes are superior in quality with an average leaf yield ranging between 30 and 40 t/ha/year compared to 12-13 t/ha/year of local cultivars (Das and Krishnaswamy, 1969; Annual Report, CSR&TI, Berhampore, 1997-98). The yield potential of the varieties developed by this Institute along with the specific regions is presented in Table -1.

Table -1. Mulberry varieties developed by CSR&TI, Berhampore

Variety	Region and cultivation condition	Leaf yield (t/ha/yr)	Breeding methods applied
S-1	Eastern & NE India, Irrigated	27-29	Selection from an exotic variety- Mandalaya(Burma)
S-799	Eastern & NE India, Irrigated	30-35	Selection from open pollinated hybrid
S-1635	Eastern & NE India, Irrigated & Rain fed	40-44 14-16	Open pollinated hybrid from CSRS-1
C-2038	Irrigated & Rain fed condition	52-54 16-19	CF_1 10 x C763
Tr-10	Hills of Eastern India	6-8	Crossing
$BC_2$59	Eastern & NE India irrigated	8-10	Back crossing(*Morus indica* x Kosen)
S-146	Hills of Uttarakhand and J&K	10-11	Selection from open pollinated hybrid
Tr-23	Hills of Eastern India	10-12	Crossing
C-1730	Low rainfall drought prone areas of Eastern India	13-14	Crossing
C-2028	Tolerant to water logging condition	32-34	Crossing

16.3 IMPORTANCE OF THE PROPOSED PROJECT IN THE CONTEXT OF CURRENT STATUS

To compete the global market, it is necessary to improve the quality and quantity of silk output per unit area by developing improved strains of mulberry and silkworm. To increase the brushing capacity of the farmers and in turn the cocoon production per unit area, it is imperative to develop high yielding mulberry variety with broad adaptability so that it can be utilized in the majority of the sericulture zones. With gradual process of developing high yielding mulberry varieties through conventional breeding, this Institute reached at the level of 52-54 t/ha/year leaf productivity from 8 t/ha/year.

The proposed project is the first step in the direction of development of mulberry variety significantly superior to the existing ruling one in terms of leaf quality and productivity. Moreover, the defects of the existing varieties in terms of early leaf senescence particularly during winter and susceptibility to pest and diseases will also be addressed during the selection process. However, once the Polyclonal Seed Orchard is established, it will consume least manpower to produce enormous genetic variability year after year and will provide lot of opportunity to the mulberry breeders for selecting the desired types.

16.4 ANTICIPATED PRODUCTS, PROCESSES/TECHNOLOGY, PACKAGES/INFORMATION OR OTHER OUTCOME FROM THE PROJECT AND THEIR EXPECTED UTILITY:

I). TECHNOLOGY TO BE EVOLVED: Nil.

II). PRODUCTS TO BE DEVELOPED: A resource bank in terms of Polyclonal seed orchard (PSO) will be established to create desired genotypic variability through open pollination/random mating, which provides the breeders a great opportunity for selecting the superior transgressive segregants with least manpower requirement. After preliminary screening, the selected progenies/seedlings will be subjected to further evaluation trial in the direction of developing a superior mulberry variety for its commercial exploitation.

III).EQUIPMENT FABRICATION/DESIGN TO BE EVOLVED: Not Applicable.

1V).OTHERS: Not Applicable.

16.5 EXPERTISE AVAILABLE WITH PROPOSED INVESTIGATION GROUP / INSTITUTION ON THE SUBJECT OF THE PROJECT:

Expertise on all the parameters envisaged to be studied is available within the investigating group as all the investigators having Genetics & Plant breeding back ground.

16.6. LIST OF FIVE EXPERTS IN INDIA IN THE PROPOSED SUBJECT AREA

Sl. No.	Name	Designation	Address
1.	Prof. S. N. Sinha	Professor	Professor & Head, Deptt. of Botany, University of Kalyani, Nadia, W.B.
2.	Prof. K.K.Mukherjee	Professor	Bose Institute, kolkata
3.	Prof. C. Sengupta	Professor	Microbiology & Virology, University of Kalyani, Nadia, W.B.
4.	Prof. G.J.Sharma	Professor	Manipur University
5.	Dr. P.K.Bhattacharyya	Associate Professor	Genetics & Plant Breeding, BCKV, Mohanpur, Nadia

MATERIALS AND METHODS

Genetic resources are the backbone of plant improvement. The literature and documents of the mulberry germplasm acts as source of information to set-up any

breeding experiments. Since, not much study on inheritance pattern in mulberry could be carried out due to its quite long generation time, non-availability of inbred lines and failure in tissue culture techniques, in the present study, the selection of parental lines stands most challenging and crucial. Therefore, the parents has been selected based on **available pedigree record of mulberry genotypes, flower synchronization, sex, ploidy level, *per se* performance on leaf quality & productivity parameters, genetic diversity studies, combining ability studies etc i.e.,** more emphasis has been given on the available records / references. The dioecious female genotypes are considered as mother parent to avoid inbreeding. As seeds of the designated male parent will not be considered, it may be monoecious or may have bisexual flowers too.

Parental lines under consideration**
Sujanpur-5, MS-1, S1, Berhampore-A, Moulai, MS-7, MS-5, *M. multicaulis*, C-2038, C-776, China white, C-2016, T-13, M.alba, Kosen, Phillipines, CSRS-1, S-30, Bogura-4, Jodhpur, Kajli OP, White badan, Almora local, CT – 44, CCB-5, CT-11, Mandalaya, Bush Malda A, Monlai, RG-76 and C-01. ** May be slightly modified as per the cutting availability

17. WORK PLAN

17.1 Methodology

1. Establishment of Polyclonal Seed Orchard (PSO):

A) **Nursery Preparation:** Cuttings of selected parents will be planted in nursery bed. Saplings will be raised & maintained in nursery bed with standard method. Due care will be taken against disease incidence & pest attack also. The saplings will get ready for uprooting & transplantation within 6 months.

B) **Establishment of New Plantation:** The site will be selected in the extreme north of the Institute premises, which is surrounded by mostly S1635, a sterile variety, to avoid contamination with the undesired pollen. After bringing the soil of the main field to fine tilth, pits (1cubic ft.) will be prepared (with FYM) in a particular design (enclosed in Annex. I) at a spacing of 5'x5'and the saplings will be transplanted in such a way so that each male parent is surrounded by different female parents.

2. Maintenance of mulberry plantation & allowing open pollination/random mating: The plants will be maintained as per the recommended package of practices under irrigated condition (The maintenance part of PSO will be a continuous process year after

year). The parental lines will be allowed for random mating among themselves during the flowering season followed by fruit setting.

3. Harvesting of fruits from the mother plant, collection & preservation of seeds: The matured fruits will be harvested and seeds will be extracted out. After thorough washing, cleaning, drying & tagging, it will be preserved in the desiccators.

4. Preparation of seed bed, sowing seeds and maintenance: Seed bed, having irrigation facility, will be prepared as per standard size and seeds will be sown during pre-monsoon period. The seedlings will be maintained as per the recommended practice.

5. Observation & selection of superior seedlings: Though each seedling is obtained from known female parent but it differs genetically with each other even if it belongs to the same mother. The heterozygosity of the different parents, which too allowed for random mating, will invite lot of genetic variability due to segregation & recombination. Thus created genetic variability will give rise to ample scope of selection of desired type. Here on the basis of morphological characters viz., **leaf greenness, leaf smoothness, leaf thickness, leaf entireness (lobation), leaf erectness, better plant health/height, plant erectness etc.**, desired seedlings will be selected for future utilization.

6. Simultaneous, pruning of PSO after fruit harvest & random mating among the parents during flowering season is repeated for next cycle which will continue year after year till the genetic variability existing under PSO are fully exploited.

17.2: ORGANISATION OF WORK ELEMENTS

Sl. No.	Name of the scientist	Designation	Time	Organisation of work elements
1.	D. Chakravarty	Scientist - D	60%	• Selection of parental materials • Allowing random mating among the parents (for first cycle), harvesting of fruits, extracting seeds, washing, drying & preservation of seeds • Maintenance of Polyclonal Seed Orchard (PSO)

				• Maintenance and selection of superior genotypes (seedlings) based on morphological traits • Maintenance of PSO & allowing random mating among the parents (for next cycle). • Concluding report preparation & submission
2.	Suresh K.	Scientist - B	40%	• Raising saplings of selected parental materials. • Transplantation of saplings to the main field. • Sowing of seeds of collected from PSO in nursery bed.

17.3 PROPRIETARY / PATENTED ITEMS, IF ANY, EXPECTED TO BE USED FOR THIS PROJECT:

Not applicable

17.4 SUGGESTED PLAN OF ACTION FOR UTILIZATION OF THE EXPECTED OUTCOME FROM THE PROJECT

The short listed genotypes will be further evaluated through Progeny Row Trial for further short-listing.

17.5. TIME SCHEDULE OF ACTIVITIES GIVING MILESTONES

Sl. No.	Milestone / Activity	Expected Date of		Expected Outcome / visible/ measurable indicator
		Starting	Completion	
1	• Selection of planting materials & sapling raising. • Simultaneously preparation of main field.	June , 2018	Sept., 2018	Promising seedlings will be short listed based on morphological traits for further evaluation trial
2	• Transplantation of saplings to the main field & establishment of Polyclonal Seed Orchard (PSO) • Maintenance of (PSO) with once post-monsoon pruning.	October 2018	December 2019	

3	• Allowing random mating among the parents (for first cycle), harvesting of fruits, extracting seeds, washing, drying & preservation of seeds • Maintenance of PSO) (Continuous process)	January, 2020	April, 2020	
4	• Seedling raising, thinning & maintenance • Selection of superior genotypes based on morphological observation • Maintenance of PSO & allowing random mating among the parents (for next cycle).	May, 2020	April, 2021	
5	Preparation of final report	May, 2021	May, 2021	

17.6 PROJECT IMPLEMENTING AGENCY/ AGENCIES:

Name of the Agency	Address of the Agency	Proposed Research Aspects	Proposed Amount	Cost Sharing %
CSB	CSB, Bangalore			100 %

PART IV: BUDGET PARTICULARS

18. BUDGET (Rupees in lakhs):

Sl. No.	**Item**	**1st year**	**2nd year**	**3rd year**	**Total**
1.	Stationeries/Office contingencies	0.20	0.20	0.30	**0.70**
2.	Research Operations	1.00	0.50	0.50	**2.00**
3.	Travel	0.50	-	-	**0.50**
Total		**1.70**	**0.70**	**0.80**	**3.20**

A. Non-Recurring (e.g. equipments, accessories, etc.) [Rupees in Lakh]:						
Sl.No.	Item	1st Yr	2nd Yr	3rd Yr	4th Yr	Total
	-	-	-	-	-	-

B. Recurring:

B1. Manpower: -

Sl.No.	Position	Nos.	Consolidated Emoluments	1st Yr	2nd Yr	3rd Yr	4th Yr	Total
	JRF/SRF/RA	Nil	NA	-		-		-
	HRA	NA	NA	-		-		-
	CCA	NA	NA	-		-		-
	Sub-total B1:	-	-	-		-		-

B2. Consumables: [Rupees in Lakh]:

Sl.No.	Item	1st Yr	2nd Yr	3rd Yr	Total
1.	Stationeries/ Office Contingencies.	0.20	0.20	0.30	0.70
2.	Research Operations (FYM, Fertilizers, Chemicals, Glassware's)	1.00	0.50	0.50	2.00
	Sub-total B2:	**1.20**	**0.70**	**0.80**	**2.70**
B3	Travel	-	-	-	
B4	Contingency	-	-	-	-
B5	Overhead charges	0.30	0.10	0.10	0.50
	Sub-total (B1+B2+B3+B4+B5):	**1.50**	**0.80**	**0.90**	**3.20**

PART V: EXISTING FACILITIES

19. AVAILABLE EQUIPMENT AND ACCESSORIES TO BE UTILIZED FOR THE PROJECT:
[Should be provided separately for each of the Institution]

Sl.No.	Name of the Equipment / Accessory	Required or not	Make	Model	Funding Agency	Year of Procurement
1.	WORKSHOP FACILITIES	-				
2.	WATER & ELECTRICITY	✓				
3.	STAND-BY POWER SUPPLY	✓				
4.	LABORATORY SPACE & FURNITURE	✓				
5.	AIR CONDITION ROOM FOR EQUIP	-				
6.	TELECOMMUNICATION	-				
7.	TRANSPORTATION	-				
8.	ADMIN. & SECRETARIAL SUPPORT	✓				
9.	LIBRARY FACILITIES	✓				
10.	COMPUTATIONAL FACILITIES	✓				
11.	REARING / GLASS HOUSE	-				
12.	MULBERRY GARDEN	✓				
13.	REARING EQUIPMENT	-				
14.	LAND	✓				
15.	LABOUR	✓				

PART VI: REFERENCES

Allard, R.W. (1960). Principles of plant breeding. John Wiley and Sons Inc., New York

Anonymous, (1997). New illustrated sericulture reader. Central Silk Board, Bangalore, p 153.

Annual Report, (1997-1998).Central Sericultural Research and Training Institute, Berhampore,West Bengal.

Askew, G.R. *et al*. (1994). Estimation of relationship coefficients among progeny derived from wind- pollinated orchard seeds. Theor Appl Genet 88:267-274.

Askew, G.R .*et al.* (1994). Estimation of……..wind pollinated orchard seeds. Theor Appl Genet 88:267-272.

Banerjee, B. (1993).Tea: production and processing (chapter 3: Tea selection & Breeding p. 26-52)

Banerjee, R., *et al*.(2007). Genetic diversity ….mulberry genotypes. I. *J*. Genetics & Genomics,34 (8):691-697.

Banerjee, R., *et al*. (2011). Phenotypic divergence ……germplasm collections. J.Crop Improvement (Taylor &Francis), 25(5):459- 471.

Barrett, SCH., *et al* (1991). Genetic and evolutionary consequences of small population size in plants: implications for conservation. In: Falk DA, Holsinger KE, eds. Genetics and conservation of rare plants. New York: Oxford University Press, 3-30.

Banerjee, R., *et al*. (2011). Phenotypic divergence ……germplasm collections. J.Crop Improvement (Taylor &Francis), 25(5):459- 471.

Banerjee, R., *et al*. (2011). Phenotypic divergence ……germplasm collections. J.Crop Improvement (Taylor &Francis), 25(5):459- 471.

Concluded report of the Project PIE-3197 of CSR&TI, Berhampore entitled "Mulberry Germplasm Evaluation in relation to quality, quantity and stress resistance".

Das, B.C., *et al*. (1965). Some observations in interspecific hybridization in mulberry. Indian j. Seric. 4:1-8.

Das, B.C., (1968). Germination and storage of Mulberry Pollen. Sansi-Kenkyu (Acta Sericologica) No. 69, Oct., 1968.

Das, B.C. and Krishnaswamy, S. (1969).Estimation on components of variation of leaf and its related traits in mulberry.*J.Sericult. Sci. Japan.38 (3):242-248.*

Das, B.C., *et al.* (1970). Colchicine induced tetraploids in mulberry.*Caryplogia, 23:283-295.*

Das, B.C., *et al.* (1974).Evaluation of some tetraploids and triploid mulberry through biochemical analysis and feeding experiment *Ind. J. Seric.3:17-22.*

Das, B.C. (1983).Mulberry taxonomy, cytology and breeding. Lead paper presented in Seminar on Silk Research and Development. *Central silk Board, pp.1-9.*

Doss, S.G., *et al.* (2001). Studies on flowering time …..in mulberry;., Indian *J*. of Foresty, vol.24(2): 203-205.

Doss, S.G., *et al.* (2012). Variability, heritability and genetic advance…..yield attributes. Agricultural Sciences, 3(2):208-213.

Doss, S.G., *et al* (2012). Development of mulberry…….tropical regions of India. Euphytica, 185(2):215-225.

EI-Kassaby, Y. A., *et al.* (1987 a). Effect of family size and number on the accuracy and precision of the estimates of genetic parameters in the IUFRO Douglas-fir provenance-progeny trial. For Ecol Management 18:35-48.

Ellstrsnd, N.C. *et al.* (1993). Population genetic consequences of small population size: implication for plant conservation . *Annu Rev Ecol Syst*, 24:217-242.

Filippovich, J.B. and Strasnova, M.I. (1965).Relationship between frost resistance of mulberry and water metabolism.*Shelk,* 2:7-8.

Garg, D.K., *et al* (1988). Evaluation of collections of wheat (*Triticum* spp.) germplasm. Genetica Agr., 42: 255-262.

George Van Esbroeck, *et al* (1998). Cotton germplasm diversity and its importance to cultivar development. The Journal of Cotton Science 2:121-129

Geleta, L.F., *et al*., (2004). Hybrid performance for yield and other characteristics in peppers (*Capsicum annum* L.).

Ghosh, M.K., *et al.* (2009). Genetic diversity….mulberry germplasm. *J*. New seeds (Taylor & Francis).10:41-50.

Gilpin, M.E., *et al.* (1986). Minimum viable population: processes of species extinction. In: Soule ME, ed. Conservation biology: the science of scarcity and diversity. Sunderland, MA: Sinauer Associates,.19-34.

Gray,E . and Gray, R.E. (1987). Leaf lobation pattern in mulberry. Castanea, 52:216-224.

Hamrick, J.I., *et al.* (1996). Conservation genetics of endemic plant species. In: Avise JI, Hamrick, J.L., eds. Conservation genetics: case histories from nature. London: Chapman and Hall, 281-304

Katagiri, K. and Machii, H. (1988). Varieties differences in value of leaves as food of silkworms. JARQ,25(3):202-208.

Karron, J.D. (1997). Genetic consequences of different patterns of distribution and abundance. In: Kunin WE, Gaston KJ, eds. The biology of rarity: causes and consequences of rare common differences, London: Chapman and Hall, 177-189.

Koldzumi, G., (1917). Taxonomic discussion on *Morus* plants. Bull. Imp. Sericulture Expt. Stat., 3: 1-62.

Lande, R. (1999). Extinction risks from anthropgenic, ecological and genetic factor. In: Landweber LF, Dobson AP, eds. Genetics and extinction of species: DNA and 5the conservation of biodiversity. NJ: Princeton University Press, 1-22.

Machii, H., and Katagiri, K. (1991). Varietal differences in nutritive value of mulberry leaves for rearing silkworms. JARQ,25(3):202-208.

Machii, H., Koyama, H., Yamauchi, H. and Katagiri, K. (1997).Manual for characterization and evaluation of mulberry genetic resources.National Institute of Sericultural and Entomological Sciences.No.22.March, Pp. 105-124.

Medici LO., *et al.* (2005). The identification of maize lines with contrasting responses to applied Nitrogen. *J Plant Nutr*., 28:903-915.

Monaghan JM *et al.* (2001). The use of grain protein deviation for identifying wheat cultivars with high grain protein concentration and yield. Euphytica, 122:309-317.

Patil DV *et al.* (2003). Combining ability for parents and yield contributing traits in two line hybrids rice (*Oryza sativa* L.). Crop Res., 25: 520-524.

Pryluckyj, O.V. (1969).Study of metabolism in mulberry varieties of different winter hardiness.Sovkivn *Mizrid Nank zbrm., 5:59-64.*

Report of Tocklai Exp. Station, 1959.

Roy Chowdhuri, S., *et al*. (2005). Genetic diversity in germplasm……root proliferation. Indian *J*.Genetics & Plant Breeding,65(4):333-334.

Roy Chowdhuri, S., *et al*. (2005). Studies on anthesis ……. in mulberry germplasm. Indian J.Genetics & Plant Breeding, 64(2):130-360131.

Roy Chowdhuri, S., *et al*. (2003). Influence of……..seed set and seedling behavior in mulberry. Tropical Science, 43(3):152-155.

Roy Chowdhuri S., *et al*.(2009). Studies on flowering & receptivity of stigma in mulberry germplasm. *J*.Crop & Weed, 5(1):58-60

Roy Chowdhuri S., *et al*. (2006). Studies on floral characters and pollen behavior…..in mulberry. Indian J.Genetics & Plant Breeding,66(2):167-168.

Sarkar, A. (2000).Improvement in mulberry status and future strategies (*Lead paper -national Conference on Strategies for Sericulture .Research and Development, Nov., 16-18.*

Sarkar, A. and Fajita, H., (1993a). Japanese system of breeding: crossing methodology. *Indian Silk, August, 5-8.*

Sorensen, F.C. *et al.* (1988). Effect of natural inbreeding on variance structure in tests of wind pollinated Douglas-fir progenies. For Sci. 34:102-118.

Tikader, A. *et al.* (1999). Growth potential in different mulberry germplasm accessions. Indian *J*. of Forestry, vol.22(4):362-365,

Tikader, A. *et al.* (1995). Studies on sexual variation in mulberry, Euphytica 84;115-120.

Tikader, A. *et al.* (2008). Mulberry wild species ……..in crop improvement-A review.
Australian *J* of crop science,2(2):64-72

Tikader, A. *et al.* (1999). Genetic variability and character association in mulberry germplasm; Indian *J*. of forestry vol. 22(1);26-29,

Tikader, A. *et al.* (1999). Sexual behaviour in mulberry germplasm, Bull. Ind. Acad. Seri. Vol.3 (2) pp 33-37.

Vijayan, K. *et al*. (1997). Studies on leaf moisture of mulberry germplasm varieties; Indian *J*. Seric., vol.36 No.2, 155-157.

Vijayan, K. *et al.* (1998). Heterosis for yield and related characters in mulberry; Indian *J*. Genet., 58(3) 369-374

Vijayan, K . *et al.* (1997). Correlation studies in mulberry (*Morus* spp.) Indian *J*. Genet., 57(4) 455-460

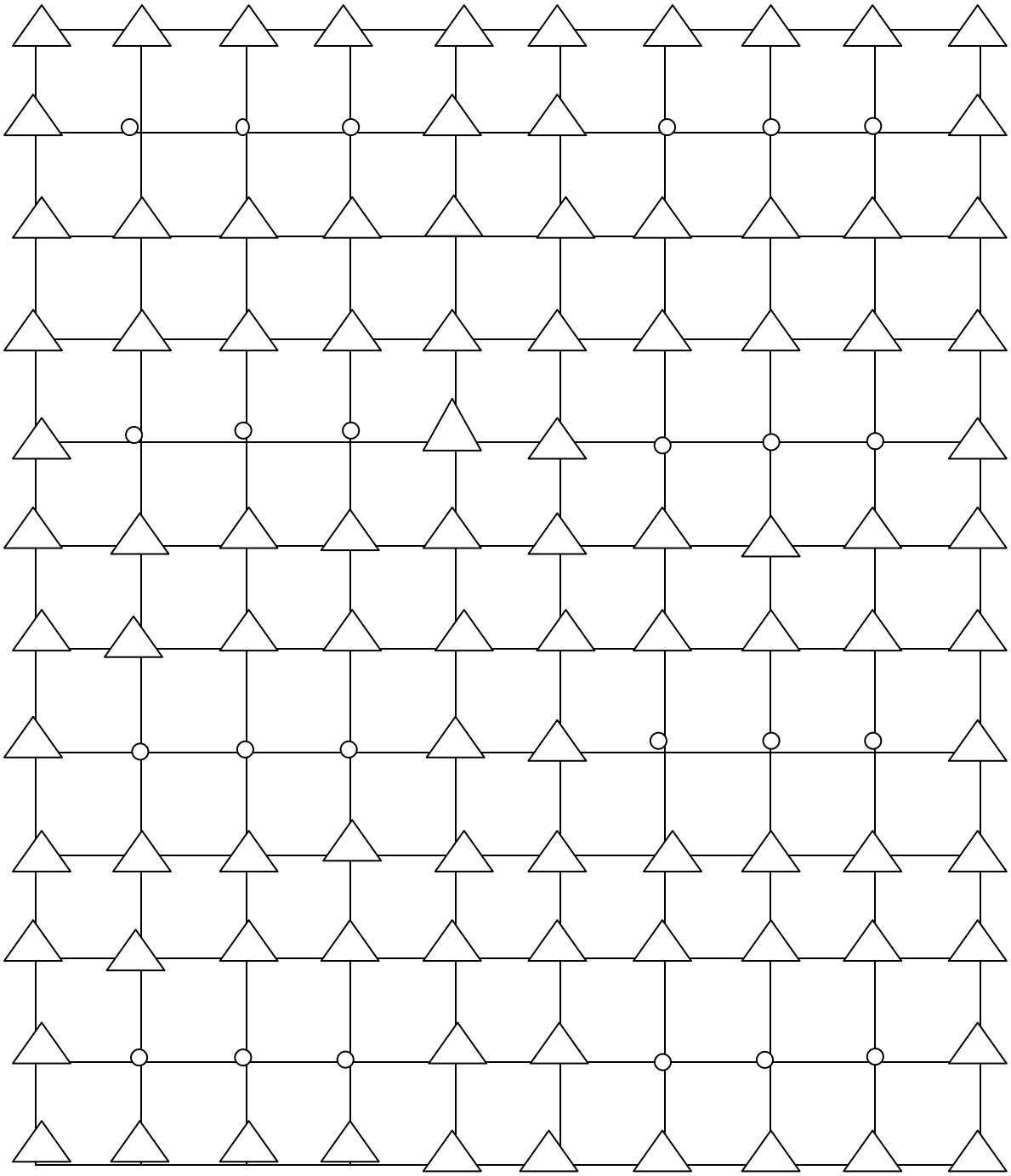
Vijayan, K. *et al.* (1997). Leaf yield component combining abilities in mulberry; Euphytica 98; 47- 52,

Annexure I

LAY-OUT PLAN FOR POLYCLONAL SEED ORCHARD (PSO)

◯ = **Male parent** △ = **Female parent**

Spacing = 5 x 5 feet



PART VII: BIODATA OF PROJECT COORDINATOR / INVESTIGATOR / CO-INVESTIGATOR (S)

PRINCIPAL INVESTIGATOR

1. Full Name (in Block letters) : **D. Chakravarty**
2. Designation : Scientist- D
3. Department/Institute/University : Mulberry Breeding and Genetics Section
4. Address for Communication : Central Sericultural Research and Training Institute, Berhampore –742 101, Murshidabad, West Bengal
5. Date of birth : 02.12.1962
6. Sex : Male
7. Education (Post Graduation onwards & Professional Career):

Name of the University	Degree Passed	Year of Passing	Subjects taken with Specialization	Class / Division
BHU (Varanasi)	M.Sc. (Ag.) (In Genetics & Plant Breeding)	1985	Genetics and Plant Breeding	**1st OGPA 3.91/4.00**
Qualified All India written exam. & received National Scholarship in Genetics & Plant Breeding from ICAR for perusing M.Sc (Ag.).				
BHU (Varanasi)	B.Sc (Ag.) elective in Genetics & Plant Breeding)	1983	Agriculture (Genetics & Plant Breeding)	**Topper (1st class 1st) OGPA 3.89/4.00**

8.Awards:
[Not required for in-house personnel]

Year	Award	Agency	Purpose	Nature

9. Positions Held / Research Experience in various institutions:
[Not required for in-house personnel]

Employer	Designation of the post held	Date of Joining	Date of leaving

10. Members / Fellowships:
[Not required for in-house personnel] –
11. Patents:
[Not required for in-house personnel] : 01 application submitted
12. Publications (Numbers only):
Full Paper : 08
Abstract : 18
Posters: 06
Popular Article : 03
Books : 03
Booklet/Pamphlet: 03
Manual: 01
Short communication : 02
Reports: 06
13. Project(s) submitted/being pursued/ carried out by Investigator:

Sl.No	Title of the Project	Funding Agency	Duration		No. of Scientists / Associates working under the project	Total approved cost of the project
			From	To		
1.	PIB 3481: Evaluation of mulberry varieties suitable for low input soil (As PI)	CSB	July' 16	Contd.	08	4.95
2.	Collection, Establishment & Evaluation of some castor (*Ricinus communis* L.) genotypes for their adaptability in Eastern Part of India. (As PI)	CSB	March, 2005	May, 2008	04	2.25
3.	PIB 3515: Evaluation of newly developed triploid mulberry varieties under irrigated condition. (As CI)	CSB	July' 16	March, 2017	06	1.75

14. Highlights of outcome / progress of the project(s) handled during the past 10 years, their outcome and utilization (in 200 words).

1. **E**valuation of mulberry varieties suitable for low input soil

Progress till date: Result revealed that three mulberry genotypes, C-3, C-5 & C-9, are performing better both under reduced dose of N,P, K application (168: 90:56) as well as under full dose (336:180:112) in compare to existing ruling variety S-1635. The project is under progress.

2. Collection, Establishment & Evaluation of some castor (*Ricinus communis* L.) genotypes for their adaptability in Eastern Part of India.

Outcome:

- ✓ Out of 84 castor genotypes evaluated and shortlisted 9 genotypes based on ranking analysis. Further these genotypes werte evaluated and significant superiority observed in RG2717, NBR-1 & RG 2824 in leaf productivity, out of which RG 2824 recorded highest gain 22.4% (21.14 t/ha/yr) over the check Agia local (17.27 t/ha/yr).
- ✓ Leaf Petiole ratio was found significantly superior in NBR-1 (2.61:1)
- ✓ Annual seed yield was recorded highest (955 kg/ha/yr) in NBR-1 when 30% leaves (7.19 t/ha/yr) were harvested.
- ✓ Bio-assay report revealed that NBR-1 & RG2824 were significantly superior in all the rearing parameters, viz., ERR%, 10 larval wt., single cocoon wt., single shell wt. and SR % indicating better leaf quality.
- ✓ All the genotypes were susceptible to the attack of Semi-looper, Jassid, Bihar hairy caterpillar, Mites & Stem Borer.
- ✓ Cumulative disease index was found lowest in Damalgiri red followed by RG2717
- ✓ Study on Physio-biochemical parameters viz., moisture %, RWC, Total chlorophyll, Total soluble sugar, total soluble sugar, total soluble protein etc. reveals that NBR-1 performing better in almost all the parameters.

Utilization: NBR-1 & RG2824 may be commercially utilized in Eri-culture, after its successful completion of All India Coordinated Trial & proper validation at progressive farmers level farmers.Damalgiri red may be utilized in future breeding programme.

1. Evaluation of newly developed triploid mulberry varieties under irrigated condition.
Outcome: Seven mulberry genotypes, C-105, C-252, C-116, C-131, C-57, C-174 & C-124 were found significantly superior to the existing ruling variety S-1635 in terms of leaf productivity.

Utilization: These short-listed genotypes will be further evaluated under FYT for identifying the top performer.

15. Selected Publication:

1. Studies on the relationship between leaf lamina yield and yield components of some high leaf yielding castor (Ricinus communis L.) food plants suitable for ericulture. **Chakravarty, D.,** Choudhuri (nee Mukhopadhyay), M. & Bajpai, A.K., *R&D Advancement in Indian Sericulture, December,2013, pp 315.*
2. Path coefficient analysis on foliage yield of some castor genotypes (Ricinus communis L.) Choudhuri (nee Mukhopadhyay), M., **Chakravarty, D.** & Bindroo, B.B. *Indian Agric.*, Vol.56, No. 1 & 2,pp. 39-41,2012
3. Genetic variability and association of yield traits in RG 2824-A promising castor (Ricinus communis L.) food plant for eri silkworm. Choudhuri (nee Mukhopadhyay), M., **Chakravarty, D.,** Das, N.K., Ghosh A. & Bajpai, A.K. *R&D Advancement in Indian Sericulture, December,2013, pp 312-314.*
4. Genotype x Environment interaction & estimation of stability for foliage yield of some castor genotypes suitable for ericulture. Choudhuri (nee Mukhopadhyay), M., **Chakravarty, D.** & Bindroo, B.B., *Indian Biologist* vol. 44 No. 1, Jan, 2012.
5. Salient features of castor genotype RG2824 suiting ericulture in West Bengal. Monica Choudhuri (nee Mukhopadhyay), **D. Chakravarty** & A.K.Bajpai J.Oilseeds Res., Vol.27 (Special issue), 2010 p-259-261.
6. Genetic analysis of important character association with leaf yield for selection of castor (*Ricinus communis* L.) accessions with higher productivity. Abs.op-012pp-170-171. **Chakravarty, D.,** Banerjee, R., Ray, B.C., Das, N.K., Ghosh, A. and Bajpai,A.K.(2009). *National Conference on Vanya Silk* , 28th-30th January,2009 Ladoigarh, Jorhat, Assam .
7. Evaluation of some new genotypes for leaf quality in mulberry (Morus L.), *National Conference on Sericulture innovations before and beyond*, 2011. Chakraborty, S.P., Sengupta, T., **Chakravarty, D.,** Doss, S.G., Ghosh, M.K., Majhi, C. and Bajpai, A.K. Abs. p. 5. MIM/P-008.
8. Evaluation of some castor genotypes to foliar diseases under Gangetic plains of W.B. Majhi, M.D., **Chakravarty, D**., Ray, B.C., Ghosh, A. and Bajpai, A.K. Abs. 5th *International conference on plant pathology in the globalized area*, Nov 10-13, 2009, New Delhi.
9. Suresh, K., M.K. Ghosh, R. Banerjee, P. K. Ghosh, **D. Chakravarty** and K. Trivedy. 2016. *Assessment of leaf yield potential of mulberry genetic resources for utilization in improvement programme*. National Conference on Mulberry Seri-biodiversity – Challenges and future perspectives for sustainable conservation and utilization held on 8.9.16 at CSGRC Hosur . pp. 6-7.
10. Suresh, K., Jalaja S. K., R. Banerjee, P. K. Ghosh, **D .Chakravarty** and K. Trivedy. 2016. *Estimation of genetic parameters of physiological and yield attributes and their association in mulberry (Morus spp.*). National Conference on Mulberry Seri-biodiversity – Challenges and future perspectives for sustainable conservation and utilization held on 8.9.16 at CSGRC Hosur. pp. 5-6.

CO-INVESTIGATOR (S)

1. Full Name (in Block letters) : **Mr. SURESH, K.**
2. Employment No. : 5815
2. Designation : Scientist- B
3. Section/Expertise area : Mulberry Breeding and Genetics
4. Address for Communication : Central Sericultural Research and Training Institute, Berhampore –742 101, Murshidabad, West Bengal
5. Date of birth : 13.07.1988
6. Sex : Male
7. Education (Post Graduation onwards & Professional Career):

Name of the University	Degree Passed	Year of Passing	Subjects taken with Specialization	Class / Division
University of Agricultural Sciences, Bangalore	M. Sc. (Agri.)	2012	Plant Breeding and Genetics	First class with Distinction
University of Agricultural Sciences Bangalore	Ph.D. (Agri.)	At the stage of thesis submission	Plant Breeding, Molecular breeding	Under thesis submission

8.TRAINING UNDERGONE:

Course name/ Subject	Address of Institute	Duration	Period		Sponsoring agency
			From	to	
Foundation training on Sericulture	CSB, Bengaluru	16 days	29.2.2016	15.3.2016	Central silk board,
Bioinformatics tools and techniques in Agriculture	ICAR-NAARM Hyderabad	10 days	1.11.2016	10.11.2016	CSR&TI, Berhampore

9. EXPERIENCE:

Organization /Institute	Designation /Capacity	Duration	Period		Subject /area	Remarks
			From	To		
CSR&TI, Berhampore	Scientist-B	1 year	15.12.15	till now	Mulberry Breeding	

10. PUBLICATIONS (Numbers only):

Research Papers, : 14
Research Abstracts : 12
General articles : 01
Pamphlets : 02

11. **PROJECT(S) COMPLETED:**

Sl.No	Title of the Project	Funding Agency	Duration		Total cost of the project(Lakhs)
			From	To	
1.	**PIB-3479:** Development of high yielding mulberry varieties using physiological growth parameters as markers for selection **[as PI]** *w.e.f.* 1.6.2016	CSB	October, 2013	September 2016	0.80

12. Highlights of outcome / progress of the project(s) handled during the past 10 years, their outcome and utilization (in 200 words).

PIE-3479: Development of high yielding mulberry varieties using physiological growth parameters as markers for selection.

Outcome: Identified/developed 24 genotypes which are physiologically superior with leaf yield ranged from 2.104 to 2.561 kg.

13. Publication (selected):

1. **Suresh, K**., Shivakumar, N., Shanthavva, G., Krishnappa, M.R. and Veeraganti, S. 2014. Correlation and path analysis of grain yield and yield attributes among rice (*Oryza sativa* L.) inbred lines. *Trends in Biosci.,* **7**(**10**):952-954.

2. Kiran, K. K., Gururajarao. M. R. and **Suresh, K.** 2013. Variability and frequency distribution studies in F2 population of two crosses of rice (*Oryza sativa* L.*)*. *Asian J. Biosci.*, **8**(2):153-159.

3. Savithramma, D.L.,Rajashekar, I., **Suresh, K.** and Mallikarjuna, K. 2013. Evaluation of mini core collection and identification of water use efficient and late leaf spot resistant genotypes of groundnut (*Arachis hypogaea* L.). National conference of plant physiology on current trends in plant biology. 2013. Page no.440-441.

4. **Suresh, K.** and Savithramma, D.L. 2015. Genetic diversity and identification of drought tolerance analysis tomato germplasm. *Mysore J. Agric. Sci.*, **49** (2): 258-262.

5. Sanjeev. B. G., **Suresh K**, Muralidhara Y. S., Krishnappa M. R.2016. Variability Studies for Fodder Yield and its Contributing Traits in Fodder Cowpea [*Vigna unguiculata* L. Walp.]. *Advances in life Sciences.* 5(1):226-229.

6. Sanjeev, B. G. Krishnappa, M. R. **Suresh, K.** Shekara, B. G. Madhusudan, N. 2016. General combining ability, specific combining ability, heterosis and their relationship in fodder cowpea [*Vigna unguiculata* L. Walp.]. *Environment and Ecology*.34(2): 477-480.

7. **K. Suresh,** S. K. Jalaja, R. Banerjee and K.Trivedy. 2017. Genetic variability, correlation and path analysis of physiologicaland yield attributes in mulberry (*Morus spp*.). *Journal of Crop and Weed*, 13(1): 28-33.

PART VIII: DECLARATION / CERTIFICATION

It is certified that

a. The research work proposed in the project does not in any way duplicate the work already done or being carried out elsewhere on the subject
b. The same project has not been submitted to any other agencies for financial support
c. The emoluments for the manpower proposed are those admissible to persons of corresponding status employed in the Institute/ University or as per the Ministry of Science & Technology guidelines (Annexure-III).
d. Necessary provision for the project will be made in the Institute in anticipation of the sanction of the scheme.
e. If the project involves the utilization of genetically engineered organism, it is agreed that we will ensure that an application will be submitted through our institutional bio-safety committee and we will declare that while conducting experiments, the bio-safety guidelines of the Department of Biotechnology would be followed *in toto*.
f. If the project involves field trials / experiments / exchange of specimens etc. we will ensure that ethical clearances would be taken from the concerned ethical committees / competent authorities and the same would be conveyed to the Department of Biotechnology before implementing the project.
g. It is agreed by us that any research outcome or intellectual property right(s) on the invention(s) arising out of the Project shall be taken in accordance with the instructions issued with the approval of the Ministry of Finance, Department of Expenditure, as contained in annexure-V.
h. We agree to accept the terms and conditions as enclosed in Annexure-IV. The same is signed and enclosed.
i. The institute agrees that the equipment, the basic facilities and such other administrative facilities as per terms and conditions of the grant will be extended to investigators through out the duration of the project.
j. The institute assumes to undertake the financial and other management responsibilities of the project.

1.	2.
Signature of Project Co-ordinator & Executive Authority of Institute with Seal Date:	Signature of Principal Investigator Date:
3.	4.
Signature of Co-Investigator Date	Signature of Co-Investigator Date: