PIB - 3610

PRELIMINARY EVALUATION OF NEWLY EVOLVED MULBERRY GENOTYPES FOR MULBERRY IMPROVEMENT

TIME PERIOD

JUNE, 2017 TO MAY, 2020

Mr. SURESH, K.,
SCIENTIST-B

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

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	:	Preliminary evaluation of newly evolved mulberry genotypes for mulberry improvement.
5.	Category of the Project	:	Applied
6.	Specific Area	:	P – **P**lant I – **I**mprovement B - **B**reeding
7.	Duration	:	03 Years (from June, 2017 to May, 2020)
8.	Total cost:	:	**Rs. 2.30 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

11. PROJECT SUMMARY:

According to the yield equation, productivity of crop canopies is analyzed in terms of total incident radiation solar radiation (Q), the proportion of the incident solar radiation that is intercepted by the crop canopy (IA'), the efficiency of conversion of intercepted radiation into plant dry matter (i.e., Є), and the partitioning of dry matter among various plant/crop components (i.e., ρ).

Historically, the methodologies used in the study of the productivity of crop canopies have been dependent on available technology. Crop canopies were analyzed in terms of weight, weight distribution, and leaf area. This is called growth analysis. Recently, infrared gas analyzer (IRGA), Chlorophyll-fluorescence technology and whole-canopy photosynthesis technology enables very quick and easy measurements of photosynthetic parameters of leaves. However, using two or more of the methods described above in combination may represent the canopy as a whole and account the spatial variability (e.g., plant-to-plant variability).The difficulty to measure plant productivity accurately and precisely is probably

the greatest challenge in any effort to improve the efficiency of production in Moriculture, irrespective whether it involves traditional plant breeding, biotechnology and cropping systems research.

In growth analysis, two basic measurements are made; dry weight and leaf area, and a large number of parameters are derived from these measurements. Total crop dry matter is the spatial and temporal integration of all plant processes and, therefore, crop dry matter is the most relevant parameter in the study of crop canopies. Rate of dry matter accumulation varies across the life cycle of a crop and dry matter and leaf area are sampled at intervals ranging from days to weeks to analyze genotypic differences between crop cultivars.

The pattern of rate of dry matter accumulation of a crop canopy is typically characterized by a sigmoid curve, with more or less three distinct distinct phases

1. a period of exponential growth during early development,
2. a period of more or less constant rate dry matter accumulation,
3. a period of declining crop growth rates during the final phase of development when green leaf area declines due to leaf senescence and leaf photosynthesis declines due to leaf aging.

Machii (1988) reported the existence of differences in crop growth rate (CGR) and leaf area index (LAI) between mulberry varieties and improved strains maintaining larger LAI. Varanagabhushana (1990) concluded that leaf area per plant, leaf dry matter per plant, number of leaves per plant, number of primary and secondary shoots per plant showed strong positive genotypic and phenotypic correlation with leaf yield. Kumar et al., (2010) studied the Physiological growth parameters of eight mulberry genotypes at periodical harvests and reported the usefulness of Leaf Area Index (LAI) & Biomass Duration (BMD) at any stage of growth and LAI &Crop Growth Rate (CGR) at later stages of growth for predicting the leaf yield while selection of mulberry genotypes.

In our previous initiative, we identified six female and eleven male parents from germplasm bank of CSR&TI Berhampore and hybridized to produce 57 cross combinations. In subsequent occasion ~ 1024 seedlings were transplanted in Progeny Row Trial plot with 60 × 60 cm spacing along with check variety, S-1635. Evaluation of the progeny for growth, leaf yield, physiological growth parameters and propagation study indicated that, twenty four genotypes recorded high mean values for physiological traits and leaf yield. In this project we have a plan to build upon these leads into its logical end by:

1. Thorough evaluation of foliage biomass production potential and associated agronomic traits of identified promising lines through progeny row trials
2. Assessment of selected lines further through physiological traits, biochemical parameters and silkworm moulting test for further evaluation of short listed genotypes

12. Brief Description of the Previous Project

Six female and eleven male parents selected from germplasm bank at CSR&TI Berhampore were hybridized to produce 57 cross combinations. Seeds collected from crossed plants are sowed in nursery. After visual screening in the nursery, a total of 1024 seedlings were transplanted in Progeny Row Trial plot with 60 × 60 cm spacing along with check variety, S-1635. Growth, leaf yield, physiological growth parameters and propagation data recorded for 2015-16 was analyzed and presented below.

Table 1: Frequency distribution of leaf yield of hybrid seedling based on pooled data of 5 crops.

Range of leaf yield (kg/plant/y)				Frequency	% age
>(x+3s)	> 2.341			13	1.32
(x+2s) to (x+3s)	1.844	to	2.341	30	3.05
(x+1s) to (x+2s)	1.346	to	1.844	93	9.47
(x) to (x+1s)	0.849	to	1.346	282	28.72
<x		<	0.849	564	57.43
			Total	982	100.00

Frequency analysis of pooled data during 2015-16 revealed that 43 genotypes provided mean leaf yield higher than mean + 2SD representing 4.37 % of the total population. However, out of 1024 genotypes, 140 genotypes recorded significantly higher yield over the ruling check S-1635 representing 13.70% of population. Finally 24 genotypes were shortlisted based on propagation, physiological parameters and significantly higher leaf yield over check (Table).

Table 2: Pedigree of newly evolved promising genotypes selected at PRT trial.

S.N.	G.No.	Parentage	S.N.	G.No.	Parentage
1	350	Chinese F_1 10 x Bishnupur-10	13	400	Chinese F_1 10 x English Black
2	359	Chinese F_1 10 x Bishnupur-10	14	936	*M.multicaulis* x Almora local
3	319	China White x Charitul	15	52	*M.indica* HP x Almora Local
4	490	MS-30 x C-776	16	616	MS-30 x Bishnupur-10
5	986	Kajli OPH x Bishnupur-10	17	313	China White x Charitul
6	642	*M.multicaulis* x MS-7	18	836	*M.multicaulis* xC-776
7	362	Chinese F_1 10 x Berhampore-B	19	413	Chinese F_1 10 x English Black
8	245	China White x English Black	20	1016	Kajli OPH x Almora local
9	838	*M.multicaulis* xC-776	21	1019	Kajli OPH x Almora local
10	343	Chinese F_1 10 x Bishnupur-10	22	790	*M.multicaulis* xAc.No.1190
11	570	MS-30 x English Black	23	716	*M.multicaulis* x Charitul
12	768	*M.multicaulis* x English Black	24	721	*M.multicaulis* xBishnupur-10

Table 3: Pooled mean values of Physiological, survival and yield traits of promising genotypes

SN	Genotype No.	Chlorophyll content (µg cm^{-2})	Specific leaf area (cm^2g^{-1})	Total leaf area (m^2)	Leaf area ratio (m^2g^{-1})	Leaf area index	Absolute growth rate (g day^{-1})	Survivability (%)	Total shoot length (cm)	Leaf yield (kg/plant/y)
1	350	14.10	223.55	472.27	21.43	13.12	33.91	79.80	1348	2.561
2	359	12.54	237.55	470.16	25.65	13.06	28.20	68.29	1410	2.559
3	319	16.93	254.75	474.68	22.53	13.19	32.42	64.42	1435	2.546
4	490	13.61	215.03	369.86	18.16	10.27	31.33	62.40	1845	2.538
5	986	11.49	272.28	419.53	23.58	11.65	27.37	79.60	1534	2.526
6	642	15.91	260.55	381.18	22.60	10.59	25.94	73.60	1322	2.518
7	362	17.76	228.10	314.48	21.40	8.74	22.60	81.20	1366	2.512
8	245	16.42	246.68	352.97	22.66	9.80	23.97	71.62	1566	2.504
9	838	30.43	185.30	211.71	14.45	5.88	22.53	66.70	1108	2.499

10	343	15.50	243.30	306.14	21.78	8.50	21.62	82.40	1176	2.425
11	570	17.34	270.74	306.42	19.76	8.51	23.85	74.24	1561	2.409
12	768	12.06	323.00	304.55	19.45	8.46	24.08	76.40	1425	2.389
13	400	17.34	270.00	400.68	23.76	11.13	25.95	72.10	1760	2.367
14	936	11.78	274.91	277.15	19.00	7.70	22.44	75.80	1386	2.325
15	52	17.24	226.52	202.05	17.12	5.61	18.15	79.60	957	2.318
16	616	16.93	200.23	227.13	14.75	6.31	23.70	58.40	1415	2.316
17	313	18.92	248.98	297.43	21.60	8.26	21.19	76.40	1107	2.315
18	836	16.52	372.13	388.73	27.56	10.80	21.70	78.64	1175	2.306
19	413	15.91	205.05	269.85	22.22	7.50	18.68	79.98	960	2.256
20	1016	11.11	279.14	349.28	26.46	9.70	20.31	78.20	1145	2.256
21	1019	13.22	233.35	278.42	19.09	7.73	22.44	52.60	1234	2.179
22	790	14.40	242.93	191.02	12.95	5.31	22.70	72.60	1345	2.171
23	716	23.75	217.93	205.57	14.09	5.71	22.45	69.40	1466	2.115
24	721	21.8	228.9	243.9	21.1	6.8	21.80	58.60	779	2.104
Check- S1635		17.1	254.4	203.4	14.86	4.92	18.24	76.80	1018	1.620
Min.		4.58	142.4	75.0	8.4	2.1	10.5	52.60	63.00	0.071
Max.		32.07	409.3	474.7	37.6	13.2	33.9	82.40	1845	2.561
Avg.		13.60	254.8	226.9	21.1	6.3	16.8	72.21	675	194.6
CD@ 5%		2.1	20.1	51.0	3.3	5.3	6.9	17.53	52	0.065

11b. AIMS AND OBJECTIVES:

Development of improved mulberry with better foliage yield potential than ruling cultivar(s) is the need for quality cocoon production in sericulture. Therefore, obtained leads of our previous study will be searched further for the identification of suitable mulberry line(s) with higher foliage yield and better silkworm rearing efficiency for direct commercial exploitation.

PART II: PARTICULARS OF INVESTIGATORS

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

Dr. KANIKA TRIVEDY, Director, CSRTI, Berhampore
Coordinator and Executive authority

12 a) INVESTIGATORS

Name : **PI**: **Mr. SURESH, K**., Scientist -B
Date of birth : 13.07.1988
Sex : Male
Address **: Central Sericultural Research & Training Institute,**
Central Silk Board, Ministry of Textiles: Govt. of India,
Berhampore - 742 101, West Bengal, India

Name : **CI: Dr. Rita Banerjee, Scientist** -D
Date of birth : 05.04.1961
Sex : Female
Address : CSR & TI, Berhampore, West Bengal

Name	: **CI: Mr. ANIL PAPPACHAN**, Scientist-B
Date of birth	: 02.01.1989
Sex	: Male
Address	: CSRTI, Berhampore, West Bengal

Name	: **CI: Mr. Debojit Das**, Scientist –D
Date of birth	: 20.09.1963
Sex	: Male
Address	: CSRTI, Berhampore, West Bengal

13. NUMBER OF PROJECTS BEING HANDLED BY EACH INVESTIGATOR AT PRESENT (As a PI and Co-PI)

1. Mr. Suresh, K., : 04 projects
2. Dr. Rita Banerjee : 06 Projects
3. Mr. Anil Pappachan : 04 Project
4. Mr.Debhojith Das : 03 Project

14. PROPOSED RESEARCH FELLOWS: NIL

PART III: TECHNICAL DETAILS OF PROJECT

15. INTRODUCTION:

Mulberry (*Morus* spp.) the unique food source of domesticated silkworm (*Bombyx mori* L.), is a perennial plant propagated exclusively through stem cuttings (clones) and thus the acquired true-to-type plant population. The vegetative reproduction leads to the perpetuation of the characters with great precision. Therefore, once a promising hybrid is identified, its characters can be perpetuated through cuttings. In preliminary selection, seedlings raised in the nursery beds are selected through visual observation and further evaluated through Progeny Row Trail (PRT). The selected genotypes of PRT are then evaluated through Initial evaluation experiment or Primary Yield Trial (PYT) in small areas and then under Final Yield Trial (FYT) in larger areas. In these steps, selection is made on the basis of the parameters like, Morpho-anatomical, biochemical parameters, palatability to the silkworms and response to diseases and pests along with yield and yield attributing characters to confirm superiority of the genotypes.

Development of high yielding mulberry varieties through various breeding methods is a continuous process and is mainly based on indirect selection for yield and growth characters. Recent studies confirm the expectation that genotypes differ extensively in the physiological process determining yield. Identification of these physiological components of yield and introgression of those possessing the physiological complementation & balance are required for high yield, thereby leading to more rapid and predictable yield improvement. Hence, parents selected based on the complementary physiological traits were hybridized to produce physiologically superior high yielding progenies. The identified superior hybrid seedlings in PRT trial need to be evaluated under Primary Yield trial/Initial clonal evaluation trial for productivity and quality for further exploitation.

15.1: ORIGIN OF THE PROPOSAL

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 for different regions, however, high yielding varieties suitable for new silkworm races and different regions for commercial exploitation are very limited. At the same time, introduction of new silkworm hybrids, more number of silkworm cocoon 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 to evaluate the newly developed mulberry genotypes for productivity and quality through Primary Yield Trial (PYT).

15.2: RATIONALE OF THE STUDY

The development of the improved mulberry varieties has been accomplished mainly on the basis of indirect selection for yield based on morphological characters. Considerable improvement in a crop variety indicates mostly the genetic improvement which may be considered as a permanent one. However, yield as a selection trait provides only an empirical evaluation without giving information on the metabolic process that underline the productivity. Hence, selection based on morphological traits alone may not be able to bring about commendable genetic improvement.

In the long run, the most effective approach would seem to be to identify physiological components causing varietal differences in economic yield and require understanding of genetic control thereby leading to more rapid and predictable yield improvement (Wallace *et al.*, 1972). Genetic behavior and dry matter accumulation studies have long been in vogue to assess the physiological basis of yield in crop plants (Evans, 1975). Certain breeding programmes have also utilized the growth analysis procedures in evolving improved crop cultivars. Growth determinants such as Crop growth rate (CGR), Relative growth rate (RGR), Net assimilation rate (NAR), Leaf area duration (LAD), Biomass duration (BMD and Leaf area index (LAI) have been analyzed in various crop plants and marked variability was observed. Growth analysis also plays an important role in comparison of genotypes of a species as a part of breeding programme (Wilson and Cooper, 1969; Tollenaar,1991).Through this approach, it is certain that some physiological traits with direct effects on yield have been concurrently improved with yield.

The continuing pressure to produce higher yielding cultivars has simulated interest in physiological factors contributing to final yield and in possibilities for using such factors for selection (Buttery and Buzzell, 1972). Identification of these physiological components of yield and their genetic controls should make it possible to plan crosses to maximize segregation of genotypes possessing the physiological complementation and balance required for high yield, thereby leading to more rapid and predictable yield improvement. Many approaches have been used in the development of high yielding cultivars. Such approaches range from selection for yield to selection of physiological traits associated with high yield. The present study is aimed at evaluate identified physiologically superior high yielding genotypes for leaf productivity and quality.

Therefore, it is imperative to develop new mulberry varieties which have the genetic potential to yield reasonably well in different regions and suitable for silkworm. *The initial phase of study to fulfill this aim has been completed and the primary yield evaluation*

is proposed in the present project which will result in the identification of a mulberry variety for cultivation.

15.3: RELEVANCE TO THE CURRENT ISSUES AND EXPECTED OUTCOME

The study is very much relevant to the prevailing sericulture conditions as the main objective of mulberry breeding is to developing high yielding varieties suitable for new silkworm races and adaptable to different regions. Considering the above facts an attempt will be made to **evaluate ~24 promising newly evolved physiologically superior mulberry genotypes which were identified in the Progeny Row Trial having** leaf yield ranged from 2.104 to 2.561 kg per plant over the ruling variety S-1635(1.621 kg).

The expected outcome of the project will be **identification of 7-8 promising physiologically superior mulberry genotypes capable of providing stable nutritious and higher leaf yield**, which may be further evaluated in larger areas *ie.*, FYT/AICEM for commercial exploitation in different regions of the country. Identification of mulberry variety with high yield and quality will result in its commercial exploitation by sericulturists of the country.

15.4 OBJECTIVE(s)

1. Evaluation of improved lines for foliage biomass and associated agronomic traits under PYT
2. Qualitative assessment of superior lines through Biochemical, propagation and Silkworm moulting test for prospective commercial utilization.

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

16.1 INTERNATIONAL STATUS

Wallace *et al.*, (1972) examined aspects of genetic variation related to growth analysis, harvest index, light interception and utilization, net CO_2 exchange, translocation and portioning and stressed the importance of identifying physiological components which affect economic yield and select for these in breeding programmes.

Delanney and Dobrens (1974) found SLW in different alfa alfa genotypes was related directly to the thickness of leaf and of palisade tissue and inversely to leaf area. However, Barnes *et al*., (1969) concluded that SLW and leaf area were under separate genetic control, with all possible combination being encountered. Yoshida (1972) and Evans (1975) while reviewing the factors influencing the crop productivity, stressed the importance of source size in productivity. They observed that increased Crop Growth Rate (CGR) and productivity in many recently developed crop varieties are essentially due to increased leaf area.

Khokhal et al., (1999) evaluated growth analysis of different cultivars of garden pea (*Pisum sativum*) and noticed continuous increase of dry matter linearly with LAI and CGR. High yielding cultivars recorded more LAI, DMA and CGR. Xu *et al*., (1997) recorded higher dry matter production for a newly bred high yielding rice cultivar, Takanari. Takanari exhibited higher NAR owing to better light intercepting characters and the CO2 exchange rate.

16.2 NATIONAL STATUS

Sarkar *et al*. (1992) and Rahman *et al*. (1994) reported that in mulberry variety selection, total shoot length, total weight of all branches and weight of 100 leaves may be considered as the important parameters which have direct effects on leaf yield. Over the years, attempts were made at different institutes and a number of high yielding mulberry varieties

have been developed for different regions to meet these demands (Benchamin and Anantharaman, 1990; Sathyanarayana *et. al.,* 1990; Chaluvachari and Bongale, 1996). Susheelamma *et al*. (1988) observed that genotypes associated with larger leaf size and higher leaf weight yielded better leaf yield than those having higher number of primary shoots, more number of leaves per meter of shoot length and higher plant height.

Machii (1984) reported that RGR increased with the growth of plants in mulberry. The growth pattern of *M. acidiosa* has been discussed in relation to RGR, NAR and LAR during different seasons. Machii (1988) reported the existence of differences in crop growth rate (CGR) and leaf area index (LAI) between mulberry varieties and improved strains maintaining larger LAI.

Varanagabhushana (1990) concluded that leaf area per plant, leaf dry matter per plant, number of leaves per plant, number of primary and secondary shoots per plant showed strong positive genotypic and phenotypic correlation with leaf yield.

Shailaja and Varanagabhushana (1992) have reported that the best single character index was the leaf area followed by number of secondary and primary shoots while studying the selection indices for leaf yield in mulberry. Sarkar *et al.,* (1992) while studying the harvesting index in mulberry, reported that increase in biomass is more important the harvest index as he found poor correlation between harvest index and leaf yield.

Kumar et al., (2010) studied the Physiological growth parameters of eight mulberry genotypes at periodical harvests and reported the usefulness of Leaf Area Index (LAI) & Biomass Duration (BMD) at any stage of growth and LAI &Crop Growth Rate (CGR) at later stages of growth for predicting the leaf yield while selection of mulberry genotypes.

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

Improvement in mulberry productivity and quality lead to increase in the profitability of marginal and small farmers' which is essential for sustainable growth of silk industry. Hence, identification of mulberry variety with high yield and quality for the eastern regions will result in its commercial exploitation by sericulturists of this region. It is expected that mulberry variety with high yield and quality will be very useful for improving the economic conditions of the farmers by increasing the DFLs brushing capacity of farmers.

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

The expected outcome of the project will be identification of 7-8 high yielding qualitatively superior mulberry varieties/genotypes that are suitable for silkworm rearing and produce stable leaf yield across crop schedules for final yield trial.

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 with all the investigators having sufficient experience in mulberry breeding.

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

Sl. No	Name	Designation	Address
1	Dr. D.L. Savithramma	Professor	University of Agricultural Sciences, Bengaluru
2	Dr. P.D.Ghosh	Professor	Kalyani University
3	Dr. Chikkalingaiah	Professor	Department of Sericulture, UAS, Bengaluru
4	Dr. P.K.Das	Professor	BCKV, Mohanpur
5	Dr. S. Roy	Professor	Calcutta University

17. WORK PLAN

17.1 Methodology: The Project is having 3 (three) experiments
Planting material: 24 test genotypes; 3 check
Saplings of the selected mulberry genotypes shall be planted as per the details given below

Experimental layout:

Design – RBD with 3 replications with 12 saplings of each genotype per replication with common border.
Spacing – 60 x 60 cm.
No. of leaf harvests – 5 crops
Manure – 20 MT/ha/year

Fertilizer – N: P: K:: 336:180:112 kg/ha/yr.
No. of selected varieties – 24 + 3(check variety S-1635, C-2038 and HY-5)
Crop Protection measure – as per recommendation evolved by this Institute

Leaf harvest and Pruning:

Package of practices recommended for mulberry cultivation under irrigated condition will be followed.

E01: Studies on physiological, growth and yield in different mulberry genotypes through Primary Yield trial

Leaf yield and yield attributes of the genotypes shall be recorded for two years after completion of one year of establishment from the date of planting. Data will be recorded on the following parameters:

Physiological, Growth and yield attributing characters:

- Days to sprout after pruning (days)
- Number of shoots per plant
- Total shoot length (cm)
- Length of the longest shoot (cm)
- Internodal distance (cm)
- Leaf shoot ratio
- Total leaf yield (g/plant)
- Specific leaf are(cm^2g^{-1})
- Moisture content (%)
- Leaf Area Index (LAI)
- Biomass Duration (BMD)

E02: Studies on disease and pest incidence in different mulberry varieties under PYT experiment

Disease and Pest incidence recording (PDI)

Percentage of infestation (PI) and percent of disease/pest Index of the major foliar diseases and pest will be studied in each and every crop season.

E03: Biochemical, propagation and Moulting test of superior genotypes.

Superior genotypes identified will be subjected to

Biochemical Studies: Fifth leaf from the top was collected for estimation of total chlorophyll by using Chlorophyll meter index (SPAD) Samsone *et al.* (2007), total soluble protein and sugar by the method of Lowry *et al.* (*1951)* and Morris *et al.* (1948) respectively.

Propagation studies: Cuttings of test genotypes will be planted in the black polythene bags containing well dried pulverized garden soil, sand and well-decomposed farmyard manure in the proportion 2:1:1 and maintained with consistent care (Jolly and Dandin, 1986). The experiment was carried out in RCBD method with 2 replications / genotype. Ninety days old saplings were used to score the various propagation parameters viz., sprouting percentage, survivability, shoot length, fresh shoot weight, dry shoot weight, number of roots/sapling, root length, fresh root weight, root volume were recorded by following the standard descriptor (Bhat and Shilaja Hittalamani, 1992). The data collected on various parameters subjected to statistical analysis by adopting "Method of Analysis of Variance" appropriate to the design of the experiment (Sundarraj et al., 1972).

Moulting test: It will be carried out up to 2nd moult following standard rearing methods with three replications/variety and 1 DFL/replication. Tender leaves (1st-4th order) on healthy shoots were harvested and fed to young age silkworm larvae up to second moult. Silkworm rearing will be conducted under standard conditions. Daily three feedings were given at 8am, 12 pm and 5 pm from brushing to end of II moult with tender, succulent and nutritious leaves. First appearance of one larva out of moult was considered as commencement of moulting. Comparative moulting ratio with respect of all superior test genotypes under evaluation was fixed depending on time duration which recorded more than 50% of the larvae under moult. Larval weight was also recorded (Benchamin and Anantharaman, 1990)

Statistical Analysis – Pooled data of 10 crops for 2 years were statistically analyzed by the method followed by Panse and Sukhatme (1967).

17.2 : ORGANISATION OF WORK ELEMENTS

Sl. No.	Name of the scientist	Designation	Time	Organisation of work elements
1.	Mr. Suresh, K.	Scientist – B	50%	Multiplication, establishment, recording growth, physiological and propagation and yield data, data analysis (80%) and report writing.
2.	Dr. Rita Banerjee	Scientist – D	15%	Moulting test, Biochemical estimation (30%) and data analysis (20%).
3.	Mr. Anil Pappachan	Scientist – B	15%	Recording of disease incidence and Biochemical analysis (70%) of selected genotypes.
4	Mr. Debojith Das	Scientist – D	10%	Recording of Pest incidence for 10 crops under PYT.

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 identified superior mulberry genotypes suitable for silkworm will be further evaluated under (Final Yield Trial) FYT cum Multi-Location trial (MLT) for commercial exploitation.

TIME SCHEDULE OF ACTIVITIES GIVING MILESTONES

Sl. No.	Milestone / Activity	Expected Date of		Expected Outcome / visible/ measurable indicator
		Starting	Completion	
1	Multiplication, plantation and establishment of test genotypes.	June, 2017	May, 2018	Transplantation and establishment of the test genotypes.
2	**E01**: Studies on physiological, growth and yield in different test genotypes through Primary Yield trial.	June, 2018	May, 2020	Data recording on physiological, growth, and yield parameters
3	**E02**: Studies on disease and pest incidence in different mulberry genotypes under PYT experiment.	June, 2018	May, 2020	Recording data on disease and pest infestation
4	**E03**: Biochemical, propagation and Moulting test of superior genotypes.	February, 2020	April, 2020	Testing of leaf quality through silkworm molt out percentage & Biochemical parameters and suitability for multiplication by propagation studies.
5	Data compilation, Data analysis and final report preparation.	April, 2020	May , 2020	Final Report preparation

17.5. 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 (in Rupees):** Rs.2.30 lakh

[In case of multi-institutional projects, the budget details should be provided separately for each of the institute]

A. Non-Recurring (e.g. equipments, accessories, etc.) [Rupees in Lakh]:

Sl.No.	Item	1st Yr	2nd Yr	3rd Yr	Total
	-	-	-	-	-

B. Recurring:

B1. Manpower: NIL

B2. Consumables: [Rupees in Lakh]:

Sl. No.	Item	1st Yr	2nd Yr	3rd Yr	Total
1.	Stationeries/ Office Contingencies.	0.10	0.20	0.20	0.50
2.	Research Operations (FYM, Fertilizers,chemicals etc.)	0.20	0.30	0.50	1.50
3.	Wages for Labourers	0.10	0.20	0.20	0.50
	Sub-total B2:	0.40	0.70	0.90	2.00

Sl.No.	Item	1st Yr	2nd Yr	3rd Yr	Total
B3	Travel	0.10	0.10	0.10	0.30
B4	Contingency	-	-	-	-
B5	Overhead charges	-	-	-	-
	Grand-total (B1+B2+B3+B4+B5):	**0.50**	**0.80**	**1.00**	**2.30**

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	✓				
16	SPECTROPHOTOMETER	✓				
	HOT AIR OVEN	✓				
16.	ANY OTHER					

PART VI: REFERENCE

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Evans, G.C.(1975) The physiological basis of crop yield. *In L.T. Evans, Crop physiology : Some case histories Cambridge University Press, Cambridge,* 327-355.

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Samsone,I., Andersone,U., Vikmane, M., Ieviņa,B., Pakarna, G. Ievinsh,G. 2007. Nondestructive methods in plant biology: an accurate measurement of chlorophyll content by a chlorophyll meter. *Acta Universitatis Latviensis,* 723:145–154.

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Sundararaj, G. L., Nagaraju, M. N. and Venkataramuand Jaganath. 1972. Design and Analysis of field experiments. U.A.S., Misc., Series No. 22, Bangalore, India. pp. 424-440.

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Yoshida, T. 1972. Physiological aspects of grain yield. *Ann. Rev. Plant Physiol.* 23 : 437-64.

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

PRINCIPAL INVESTIGATOR

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 Plant Biotechnology	First class with Distinction
University of Agricultural Sciences Bangalore	Ph.D. (Agri.)	2017 expected	Plant Breeding, Physiology, Marker assisted selection	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, : 12
Research Abstracts : 07
General articles : 00
Pamphlet : 02 (In 2 languages)

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

Sl.No	Title of the Project	Funding Agency	Duration		Total approved 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.

CO-INVESTIGATOR -I

Name	**Rita Banerjee** Scientist -D Mulberry Breeding & Genetics Section Central Sericultural Research & Training Institute Berhampore 742 101 E-mail: rita_csb@rediffmail.com
Date of Birth	5th April, 1961
Nationality	Indian
Sex	Female
SC / ST	No

Educational (Post graduation onwards and professional career):

Sl. No	Institution Place	Degree Awarded	Year	Award / prize / Certificate
1	Calcutta University West Bengal, India	M. Sc. (Genetics& Plant Breeding)	1985	**First Class** **Specialization**: Genetics& Plant Breeding **Dissertation topic:** Genetic parameters and path-coefficient analysis in Rosselle (*Hibiscus sabdariffa* L.)
2.	Bidhan Chandra Krishi Viswavidyalaya, West Bengal,India	Ph. D (Genetics& Plant Breeding)	1991	**Thesis topic:** Assessment of mutagenic effects of mytomycin and streptomycin on tossa jute (*Corchorus olitorius* L) **Supervisor:** Prof. S.C.Rakshit, Dept. of Genetics & Plant Breeding, Bidhan Chandra Krishi Viswavidyalaya, West Bengal

Position and Honors

Post Doctoral Fellow / SRF / JRF Dept. of Genetics & Plant Breeding, Bidhan Chandra Krishi Viswavidyalaya, West Bengal 1985 – 1988 JRF 1988 - 1990 SRF ***Enjoyed following research fellowships:*** • Hindusthan Lever Ad-hoc SRF in the project entitled "Evaluation of male sterile lines in jute by genetic manipulations", BCKV, West, Bengal • Hindusthan Lever Ad hoc JRF	**Major exposure during research fellowships:** **a)** Induction of male sterility in jute by chemical mutagens. **b)** Detection and isolation of photoperiodic insensitive lines. **c)** Evaluation and characterization of mutagen treated population for important yield traits

Professional Training undergone:

Topic of professional training	Organized by and venue	Period
Intensive Bivoltine Training	CSR&TI, Central Silk Board Berhampore,	45days
Intensive Bivoltine Training	CSR&TI, Central Silk Board Mysore,	45 days
Summer School Training	SSTL, Central Silk Board, Kodathi, Bangalore	10 days
Computer application	Murshidabad Institute of Technology, Berhamore, Murshidabad	06 days
Basic techniques and application procedures of DNA markers	Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal	20 days
Basic training programme	SBRL, Central Silk Board, Kodathi, Bangalore	10 days

/exposure to molecular biology techniques		
Exposure training on molecular biology at lab	SBRL, Central Silk Board, Kodathi, Bangalore	03 days
Training workshop on "Winning Research Proposals"	NAARM, Hyderabad	23 day

Membership of Professional Societies:

a) Life Member National Academy of Sericulture Sciences
b) Member Indian Society of Genetics & Plant Breeding, New Delhi
c) Publications (Numbers only): Research Papers, Reports : 40
d) General articles : 06
e) Book chapter : 01;
f) Brochures:01

Research Support: Ongoing/Completed Research Projects: ***last 10 years***

#	Title of Project	Funding Agency	Amount (Rs. in lakh)	Date of sanction and Duration
1.	Development of DNA marker based genetic linkage map of mulberry and QTL analysis for agronomically important *planta* traits-PI	DBT [Collaboration with CCMB, Hyderabad	22.07*	2011-2014
2	Development, validation and utilization of SCAR markers for powdery mildew (Phyllactinia corylea) resistance in mulberry-PI	DBT [Collaboration with CCMB, Hyderabad]	15.54*	2009-2014
3	Identification of DNA markers associated with bacterial leaf spot resistance in mulberry-PI	CSB	5.55	2013-2015
4	Screening of germplasm and raising of progeny towards development of disease resistant mulberry against bacterial leaf spot-PI	CSB	10.67	2005-2010
5	Development of weather based forewarning system of mulberry diseases-CI	CSB	39.51	2005-2008
6	Development, characterization and validation of expressed sequence tag derived microsatellite markers for mulberry (*Morus* spp.)-CI	CSB	2.95	2014-2017
7	Assessment of promising powdery mildew resistant mulberry lines for prospective commercial use-CI	CSB	3.32	2015-2018

****CSR&TI, Berhampore component.***

Selected peer-reviewed publications (In chronological order):

1. **Banerjee R**, S Chattopadhyay, A K Saha and S. Nirmal Kumar(2014) *Archives Of Phytopathology And Plant Protection*(Taylor & Francis), DOI: 10.1080/03235408.2013.868693

2. **Banerjee R**, S Chattopadhyay,N K Das, S G Doss, A K Saha and S. Nirmal Kumar(2014) *Journal of Crop Improvement*(Taylor & Francis), 28:305–323

3. **Banerjee, R**., Chattopadhyay, S., Sarkar**,** S., L.alitha, L.,Saha A.K. and Bindroo, B.B (2013) Proceedings of International Seminar on Bioresources and Human Sustenance, pp.153-159. Cotton College, Guwahati, Assam.

4. CHATTOPADHYAY, S., ALI, K.A. , DOSS, S. G., **BANERJEE, R.,** SAHA, A K., SARKAR, A. AND BINDROO, B. B. (2013) PROCEEDINGS OF INTERNATIONAL SEMINAR ON BIORESOURCES AND HUMAN SUSTENANCE pp.143-152. Cotton College, Guwahati, Assam

5. **Banerjee, R.,** Das, N.K., Doss, S.G., Saha, A.K., Bajpai, A.K and Bindroo B.B. (2012) *Eur. J Pl. Pathol*. (Springer) doi: 10.1007/s10658-011-9894-z

6. **Banerjee, R.**, Roychowdhuri, S., Sau, H., Das, B.K., Saha, A.K., Saratchandra, B. And Bajpai, A.K. (2011) *J. Crop Improvment* (Taylor & Francis) doi: 10.1080/15427528.2011.583715

7. **BANERJEE, R**., GHOSH, S., DOSS, S.G., SAHA, A.K., BAJPAI, A.K AND KHATRI, R.K. (2011) *IND.J. GENET* 71(4): 392-396.

8. **RitaBanerjee**, Manas Dev Maji,Pannalal Ghosh&Amitabh Ssarkar(2009). *Archives of Phytopathology and Plant Protection*. (Taylor & Francis) 42:291-297.
9. **BANERJEE R,** DAS NK, MAJI MD, MANDAL K, BAJPAI AK (2009). *INDIAN. J. GENET*.69:292-296.

10. **RITA BANERJEE**, SUKHEN ROYCHOWDHURI, HARADHAN SAU, BIMAL KUMAR DAS, PANNALAL GHOSH & BEERA SARATCHANDRA (2007). *JOURNAL oF GENETICS aND GENOMICS.* (Elsivier)34:691-697.

11. **R.BANERJEE**, S.ROY CHOWDHURI, H.Sau, B.K.Das, P.L.Ghosh and A.Sarkar (2007) *THE IINDIAN JOURNAL* OF AGRICULTURAL *RESEARCH*78:142-145.

12. **BANERJEE R,** CHAKROBORTY SP, DAS BK (2006). *Indian. J. Genet.*66:134-136.

13. MONDAL BK, DHARA MC, MONDAL BB, DAS SK aND **NANDY R** (1989) EFFECT OF INTERCROPPING ON THE YIELD COMPONENTS OF RICE, MUNGBEAN SOYBEAN, PEANUT AND BLACKGRAM *J. AGRONOMY*.162:34:34

14. Mondal BK., Dhara MC, Mondal BB, Das SK and **Nandy R** (1990) Rice, Mungbean Soybean, Ricebean and Blackgram when grown as sole and intercrops. *Agronomy J.* 82:1063-66.
15. **Rita Banerjee,** S Ghosh, SG Doss, AK Saha, AK. Bajpai and RK Khatri (2011) Morphological, anatomical and molecular characterization of full-sib pseudo-F_2 (F_1) progenies in mulberry with resistance to bacterial leafspot (*Xanthomonas campestris* pv. *mori*) *Indian J. Genet*., **71**: 356-362.

CO-INVESTIGATOR

1. Full Name (in Block letters): **Mr. ANIL PAPPACHAN**
2. Designation: Scientist-B
3. Department/Institute/University Address for communication: Moriculture-II, Central Sericultural Research & Training Institute, Institute, Berhampore -742 101, Dist. Murshidabad, West Bengal
4. Date of birth: 02.01.1989
5. Sex: Male
6. Education (Post Graduation onwards & Professional Career):

Name of the University	Degree Passed	Year of Passing	Subject taken with specialization	Class/ Division
ANGRAU, Hyderabad	M.Sc (Ag)	2013	Agriculture (Plant Pathology)	1st

Memberships/fellowship: -

Patents: (Not required for in-house personnel)

Publications (Number only):

Books: -Nil

Research Papers / Reports: 6 full papers, 1 abstract

General articles: Nil

No of projects being handled

As PI – 1

As CI - 3

List of important publications:

1) **Anil Pappachan**., R. Sarada Jayalakshmi Devi., S. Bommalinga., K.B. Palanna., 2015., Management of leaf late leaf spot (*Phaeoisariopsis personata*) disease in groundnut with fungicides., *Environment and Ecology*., **33** (3) : 1147-1150.
2) **Anil Pappachan.**, R. Sarada Jayalakshmi Devi and Shreeshail Sonyal., 2015., Effect of weather parameters on development and progress of late leaf spot (*Phaeoisariopsis personata*) disease in groundnut. *Journal of Pure and Applied Microbiology*., **9** (4) : 2987-2990.
3) Shreeshail Sonyal., **Anil Pappachan**., K. B. Palanna., Mahesha, H. S., Manjunath, S. Hurakadli and Madhu S. Giri., 2015., Effect of antagonists against *Ceratocystis fimbriata* ELL. and Halst. causing wilt in pomegranate., *International journal of pure and applied bioscience.*, **3** (4): 18-22.
4) Shreeshail Sonyal., **Anil Pappachan.**, K. B. Palanna., Mahesha, H. S., Manjunath, S. Hurakadli and Madhu S. Giri., 2015., Survivl ability of *Ceratocystis fimbriata* causing pomegranate wilt in different temperature and Hydrogen ion concentration (pH)., *International journal of pure and applied bioscience.,* **3** (4): 49-53.
5) Shreeshail Sonyal., V.B. Nargund., **Anil Pappachan.**, V.I. Benagi., K.B. Palanna., Madhu S. Giri., H. Shivalingappa., H.S. Mahesha., Devanshu Dev., M.E. Puneeth and Yallappa Jagarkal., 2016., Studies on interaction between *Ceratocystis fimbriata* and *Meloidogyne incognita* on pomegranate wilt complex., *Journal of Pure and Applied Microbiology.*,**10** (1): 197-201.
6) S. Bommalinga., K. B. Palanna., **Anil Pappachan**., N. S. Somaning., N. G. Ravichandra., B. Manjunatha., 2015., Effect of bio-agents on population and reproductionof root-knot nematode *Meloidogyne incognita* infecting bell pepper., *Environment and Ecology*., **33** (1B) : 453-457.

Abstract

1) **Anil Pappachan**, R. Sarada Jayalakshmi Devi and S. Khayum Ahammed., 2014., Effect of microclimate on development and progress of late leaf spot disease in Groundnut ., National symposium on plant health for sustainability in the field and horticultural crops., 18-20 November., pp-65.

CO-INVESTIGATOR

1	Full Name	DEBOJIT DAS
2.	Employee No.	04938
2	Designation	Scientist – D
4	Project Designation	Co- Investigator
5	Expertise Area	Extension, Pest Management
6	Institute Name City: State: Pin: Fax: Mail: Phone:	Central Sericultural Research & Training Institute Berhampore West Bengal 742 101 03482-251233 debu42_das@rediffmail.com 03482-253962,63,64 (O) 8900383228 (M)
7	Scale of Pay	Rs. 15,600 – 39,000/-. Grade Pay:- Rs.7,600/-
8	Date of birth	20.09.1963
9	Sex	Male

10. Educational Qualification :

Degree	Year	University	Country	Subject
B.Sc. (Ag)	1986	BCKV	India	Agril. Entomology
M.Sc.(Ag)	1990	BCKV	India	Agril. Entomology (Economic Entomology)

11.	Area of Specialization	Economic Entomology
12.	Thesis Title	Thesis write-up is under final scrutinization by the Guide. "Studies on root mealy bug of mulberry and its management in Darjeeling hills of West Bengal"

13. **TRAINING UNDERGONE**

Sl. No.	Course name	Duration	Address of the Institute	Remarks
1.	Bivoltine Training	02.01.93 - 30.193	CSR&TI Berhampore	Bivoltine Rearing technology.
2.	Mulberry Breeding and Genetics" (JICA)	06.06.94 – 15.07.94	CSR&TI Mysore	Training on mulberry breeding and genetics.
3.	Mulberry Breeding and Physiology	25.07.94 – 22.09.94	Sericulture Research Institute, Zhenjiang, China.	Training on Mulberry Breeding and Physiology
4.	Statistical Methods for Sericultural Research	26.09.05 – 29.09.05	CSB Central Office, Bangalore	Statistical Methods used in seri-research
5.	Pest and Disease Management (JICA)	01.12.05 – 30.12.05	CSR&TI Mysore	Methodologies for Pest and Disease Management
6.	Disciplinary proceedings Training	2010	CSR&TI, Berhampore	Administrative training

14. Experience:

Organization	Designation	Duration	Subject	Significant Achievement
P1 Farm Banguria	Senior Research Assistant	5.2.1992-10.2.1994	Mulberry cultivation and silkworm rearing	Successful crops at the P1 farm level including bivoltine rearing.

RSRS Kalimpong & RSRS Annexure	SRA / SRO	1994-2008	Mulberry crop protection and Extension	Plant protection, pest incidence, weather based forecasting and adaptive and operational research.
Central Sericultural Research & Training Institute, Berhampore, W.B.	Scientist-C	2008-till date	Extension and Field oriented problems	a) Presently implementing (2015-16) IVLP (*Seri Model Village*) involving 880 farmers in the eastern and north-eastern region of the country. b) Successful implementation of IVLP Phase III and IVLP IV (*Adarshgram*) involving 1750 farmers in the eastern and north-eastern region of the country.. c) Associated in a Transfer of Technology programme on the Popularization of Botanicals for the major mulberry pests. d) Associated in a Transfer of Technology programme on the Popularization of thiamethoxam for the effective management of whitefly. e) Organization of Awareness programme, Field days, Farmers' Field Schools, Exhibitions, Vichargoshti, Brainstorming Workshop and Resham Krishi Mela f) Imparted training on Extension Management in various structured & non-structured courses g) Attending to emerging field problems h) Crisis management at farmers' level.

15. Research Projects Pursued :

SL. No.	PROJECT / PROGRAMME WITH DURATION	IMPORTANT CONTRIBUTIONS OF THE SCIENTIST
1.	PRP 028 : Survey of pests and diseases of mulberry and silkworm and their control in North Eastern hill and Tarai region (1996-2004)	Survey of pests and diseases of mulberry and silkworm, specific identification and their control control.
2.	TEMP 004. Studies on root mealy bug *Paraputo sp.* Of mulberry *Morus sp.* (1999-2001).	Identifying the pest, complete study on the pest and its control.
3.	PIP 004. Evaluation of mulberry varieties for Eastern and N.E. regions of India (1998 - 2001)	Evaluation of 6 mulberry varieties and specifying region wise suitable variety.
4.	KPG CP8. TAVT (2001-2004)	Evaluation of technologies and identifying the technologies suited best for the hills.
5.	PPE 3261. Studies on the botanical control of root mealy bug and screening of mulberry genotypes for its resistance (2003-2006).	Extracts of Neem oil was found to be best effective against the root mealy bug, followed by Citronella oil.
6.	PPS 002. Assessment of phosphorus and potassium requirements for mulberry based on M.B. concept. (2000-2005).	Exact requirements of phosphorus and potassium could be specified based on soil test based fertilization.
7.	PRE 3345. Development of weather based forecasting models for major mulberry pests (2005-15).	Collected the data, compiled the same and sent to CSR&TI Berhampore (till 2008) towards development of weather based forecasting models.

8.	BMO(P) 003. IVLP Phase III (2010 – 2013)	1020 farmers covering the eastern and north eastern region of the country were considered under the purview of the project, whose leaf and cocoon yield were considerably increased.
9.	IVLP Phase IV (Adarshgram) (2014 – 2015)	1750 farmers covering the eastern and north eastern region of the country were considered under the purview of the project, whose leaf and cocoon yield were considerably increased.

16. Research Publications : 47

17. Training Imparted:

Extension Management & Transfer of Technology, to the trainees of various Structured (Post Graduate Diploma in Sericulture & Integrated Skills Development Scheme) and non-structured courses (Skill Updation programme, Management Development Programme and on-job training programme).