Pro-forma for Submission of Concluded Research Project
(To be submitted separately for each project)

1. Project code and title:

PIB 3481: Evaluation of mulberry varieties suitable for low input soil

2. Names of the Project Investigators (including coordinator in case of collaborative projects)

Investigator	Name	Designation	Time Spent (%)
Executive Authority	Dr. Nirmal Kumar Dr. Kanika Trivedy	Director	10%
Principal Investigator(s)	M. K. Ghosh (up to 31.03.2016)	Scientist-D	20%
	D. Chakravarty (from 14-07-2016)	Scientist-D	20%
Co-Investigator(s)	P. K. Ghosh(up to June, 17)	Scientist-D	5%
	Suresh, K.(*w.e.f.,* July 2017)	Scientist-B	5%
	S. K. Dutta(up to April, 17)	Scientist-D	5%
	S.Chanda(w.e.f., July 2017)	Scientist-D	5%
	A.K.Verma(w.e.f., July 2017)	Scientist-D	5%
	S.N. Gogoi (RSRS-Jorhat)	Scientist-D	10%
	S.K. Misro (RSRS-Koraput)	Scientist-C	10%
	G. S. Singh (REC, Bhandra)	Scientist-D	10%

3. Duration (Date of Start) - (Scheduled Date of Completion):

5 years [January, 2013 to December, 2017]

4. Name(s) of the Institute(s) and Address:

Central Sericultural Research and Training Institute, Central Silk Board,
Berhampore – 742101, Murshidabad, West Bengal

5. A list of Objectives / Goals (clearly indicating how far they have been achieved; indicating the difficulties / reasons in case of achievement gap):

Objective(s): To evaluate newly evolved promising mulberry varieties suitable for low input soil.

6. Introduction:

Mulberry foliage is the only food for the silkworm (*Bombyx mori*) and is grown under varied climatic conditions ranging from temperate to tropics. Mulberry leaf is a major economic component in sericulture since the quality and quantity of leaf produced per unit area has a direct bearing on cocoon harvest. In India, most states have taken up sericulture as an important agro-industry with excellent output of silk production. Mulberry thrives well under various climatic conditions ranging from temperate to tropic located north of equator between 28° N to 55°N latitude. The ideal range of temperature is from 24-28°C and annual rainfall from 600 mm to 2500 mm. The atmospheric humidity of 65-80% and sunshine of 9.0

to 13.00 hours a day is ideally suited for mulberry growth. Mulberry flourishes well in flat, deep, fertile, well drained, and loamy to clayey, porous soils with good moisture holding capacity having soil pH of 6.2 to 6.8. In area with low rainfall, the growth is limited due to moisture stress and low fertilizer input, resulting in low yields.

Over the last 50 years there has been remarkable growth in Mulberry production in Eastern and North-Eastern India. This has improved leaf productivity from 10-12 t $ha^{-1}y^{-1}$ to 54-55 t $ha^{-1}y^{-1}$ and 8-10 to 14-16 $tha^{-1}y^{-1}$ under irrigated and rainfed condition, respectively. There was a 5-fold increase in the productivity of irrigated mulberry and 2-fold increase in the productivity of rainfed mulberry. The increase in total leaf production has arisen mainly as a result of increases in yield per unit area rather than from increases in the cultivated area. Over the same period the total cultivated area of mulberry increased by only 50-60%.

Mulberry leaf productivity for sericulture wholly depends upon the adoption of recommended cultural practices and fertilizer applications. Agricultural inputs must be reduced, especially Nitrogen (N) and phosphorus (P) fertilizer, overuse of which have led to environmental problems such as increased greenhouse gas emissions and severe water pollution. To enhance mulberry production with efficient resource utilization, improvement in soil quality is critical. Further, the expansion of sericulture to non-traditional areas among the resource poor farmers with limited land holdings necessitated the development of varieties suitable to resource constraint or low input conditions. Improving the recycling of organic manures and green manure can be an important step towards saving natural resources and, simultaneously, stabilizing and optimizing soil quality in crop production systems. Addition of biochar to soils represents a means of carbon sequestration and Zero-till or reduced till practices with largely have positive effects on ecosystem services.

Available evidence suggests that the leaf yield gap between average farm yields and the regional variety test experiments for mulberry varieties are due to the limited access to new sericulture technologies and poor soil and crop management by farmers. CSR&TIs under Central silk board has devoted great effort to developing easy-application and low-cost technology in sericulture, and has recently made remarkable progress. Breeding nutrient-efficient cultivars which give better yield under low fertilizer input can provide greater scope for reduction of input cost and horizontal expansion of sericulture. Improving the different compounds of fertilizer-use efficiency, like maintenance of photosynthesis under nutrient stress, nutrient-uptake capacity, nutrient-utilization capacity and translocation efficiency, will

contribute to higher yield and quality under low-input conditions. In addition, genotypes have different nutrient requirements and growth capacities.

In general, sericulture is confined to the poorer sections of the farming community in India. It is evident that in West Bengal and its neighboring states, most of the sericultural farmers come under the marginal category with an around less than half an acre of mulberry garden. The marginal farmers are more dependent on sericulture and application of chemical fertilizers was found to be the major constraint due to the higher cost. Moreover, high yielding mulberry varieties do not perform well under low chemical input, results in poor yield and quality.

Development of suitable nutrient efficient mulberry genotypes have been thought of for the benefit of the sericulture farmers and attempts was made to identify suitable mulberry variety for the low input condition. Seven promising efficient genotypes identified from the project PIB 3340, were assessed for their suitability to low fertilizer input condition. The evolved promising seven test genotypes *viz.*, C-1, C-2, C-3, C-4, C-5, C-6 and C-9 along with the check S-1635 (Table-1), were evaluated for leaf yield and yield contributing parameters, adaptability and suitability for silkworm through bioassay study.

Table 1: Pedigree of the test genotypes along with check variety S-1635

Sl. No.	Genotype Name	Pedigree
1.	C-1	Berhampore A × V-1
2.	C-2	Assambola × V-1
3.	C-3	KPG 2 × Thailand Unlobed
4.	C-4	*Morus indica* (HP) × V-1
5.	C-5	Nagaland Local × V-1
6.	C-6	Sujanpur 5 × Almora Local
7.	C-9	Berhampore A × Shrim 2
8.	S -1635	OPH from CSRS-1

7. Methodology Adopted:

The experiment was laid out in Randomized block design with three replications under two set of conditions i.e., full and half the recommended dose of NPK fertilizer (336:180:112 Kg NPK/ha/y and 168:90:56 Kg NPK/ha/y respectively) at CSR&TI, Berhampore. The test genotypes were also evaluated simultaneously at three other test centres viz., RSRS-Jorhat (high rainfall humid climate), RSRS-Koraput (low rainfall dry climate) and REC (SU) - Bhandra (drought prone areas of Jharkhand), to assess the performance and adaptability under rainfed condition (applying the recommended fertilizer

dose i.e., 150:50:50 Kg of NPK/ha/y). The climatic parameters at the test centres and agronomic practices are depicted in Table 2 & Table 3 respectively.

Table 2: Climatic parameters at test centers under study

Parameter	Test centre			
	Berhampore (BPC)	Koraput (KPT)	Jorhat (JRT)	Bhandra (BND)
Available Nitrogen (kg ha^{-1})	218	164	221	168
Available Phosphorus (kg ha^{-1})	33	19	18	16
Available Potash (kg ha^{-1})	362	276	162	238
pH	6.90	5.05	5.57	5.53
Soil type	Gangetic alluvial	Red laterite	Alluvial sandy loam	Laterite
Annual rainfall (mm)	1288	1228	1748	1319
Rainy day(No)	98	90	148	87

Table 3: Agronomic practices followed at the test centers under study

Test center	**State**	**Test condition**	N:P:K dose (Kg/ha/y)	**Spacing** (cm)	**Transplantation**
CSR&TI, Berhampore	West Bengal	Irrigated	Full & half dose NPK 1.FD 336 : 180 : 112 2.HD 168 : 90 : 56	60 × 60	September, 2013
RSRS Koraput	Odisha	Rainfed	Full dose of NPK 150 : 50 : 50	90 × 90	March,2013
RSRS Jorhat	Assam	Rainfed	Full dose of NPK 150 : 50 : 50	90 × 90	September,2013
REC, Bhandra	Jharkhand	Rainfed	Full dose of NPK 150 : 50 : 50	90 × 90	September,2013

NPK- Nitrogen, Phosphorus & Potash FD-Full dose, HD-Half dose

8: Observations / Results duly indicating the output in terms of adding to knowledge; know-how / new packages/ practices / processes /products / innovations developed and their utility and advantages; etc.,

8.1 Evaluation of test genotypes under full and 50% RDF in irrigated condition.

The leaf yield and yield contributing parameters of test genotypes were recorded for three years covering fifteen crops for irrigated and nine crops at rainfed test centres. The results of analysis of variance show that all the traits studied for mulberry genotypes were significant under effect of two levels of NPK fertilizer (Table 4 &5). The interaction of genotype and season/year for traits showed highly significant differences.

Interactions of site by genotype as well as genotype by N application were also significant with regard to most of the parameters. The variation due to years was maximum for leaf yield under half dose, while in full dose variation due to seasons was highest. The parameters differed significantly among sites, genotypes and N applications with a few exceptions.

Table 4: Pooled ANOVA for growth parameters under full RDF at CSR&TI, Berhampore centre

Source of variation	DF	LYP	DHS	PH	NPS	TSL	ID	LS	LM	LM 6hrs (%)
Replication	2	1.32	21.33	58.04	5.48	8144.09	0.97	13.05	1.20	7.69
Year(Y)	2	125.86**	9.09**	2304.37**	30.60**	82194.55**	3.07**	4716.81**	68.09**	12.11**
Season(S)	4	270.67**	69.80**	2328.13**	24.54**	642333.86**	1.70**	501.84**	431.05**	294.16**
Genotype(G)	7	69.82**	9.24**	4606.73**	59.29**	379726.07**	3.75**	132.83**	42.27**	97.41**
Y x S	8	129.41**	6.08**	2047.71**	51.07**	235769.32**	1.00**	269.91**	126.47**	71.15**
Y x G	14	11.49**	1.27	639.46**	8.69**	71598.19**	0.09	13.13**	5.67**	6.43**
S x G	28	2.24**	0.63	109.43**	1.08*	15336.75**	0.02	3.25	1.60**	1.54**
Y x S x G	54	2.92**	0.48	143.97**	1.22**	11488.03**	0.03	2.95	1.25**	1.45**
Error	370	0.48	0.77	32.75	0.69	2718.54	0.09	3.58	0.70	0.66

Table 5: Pooled ANOVA for growth parameters under half RDF at CSR&TI, Berhampore centre

Source of variation	DF	LYP	DHS	PH	NPS	TSL	ID	LS	LM	LM 6hrs (%)
Replication	2	0.39	6.14	71.51	2.06	4513.32	0.50	10.74	0.47	0.96
Year(Y)	2	447.65**	15.88**	752.73**	26.21**	487684.15**	0.87**	2680.53**	48.38**	66.43**
Season(S)	4	117.89**	126.55**	2554.32**	14.23**	489585.16**	0.08**	271.94**	409.68**	356.87**
Genotype(G)	7	36.96**	9.77**	3884.99**	27.58**	261149.26**	1.87**	106.70**	76.38**	74.89**
Y x S	8	54.52**	8.10**	5296.37**	17.36**	692661.95**	0.22**	173.37**	146.80**	106.58**
G x Y	14	10.70**	1.43**	362.34**	3.48**	20689.90**	0.14**	5.08**	2.22*	3.18**
G x S	28	1.11**	1.01**	234.45**	1.31**	18765.09**	0.10**	4.94**	2.03*	3.03**
Y x S x G	54	1.47**	0.62	135.70**	1.24**	8703.55**	0.09**	3.67**	1.99*	2.48**
Error	370	0.20	0.51	35.24	0.60	2535.62	0.03	1.67	1.28	1.34

Note: LYP-Leaf yield per plot (kg), DHS -Days to100% sprouting, PH -Plant height(cm), NPS- No of primary shoots per plant, TSL-total shoot length(cm), ID - inter nodal length(cm), LS- leaf senescence(%), MC-moisture content(%) and MC 6hrs-moisture content after six hours(%)

The mean leaf yield and yield contributing parameters of the test genotypes along with check variety (S-1635) in full dose and 50% dose of NPK under irrigated condition is depicted in Table 6. All the parameters recorded were higher mean values in full dose of NPK fertilizers over the 50% dose except for inter-nodal distance. The coefficients of variation for plant height, number of primary branches and total shoot length were significantly higher under half dose than for full dose of recommended fertrilizer, suggesting larger variation for these traits among genotypes may be due the responses to rate of NPK application. It was found that the recorded mean values were higher for genotypes that received full dose of recommended fertilization in comparison with the genotypes that received half dose of only mineral fertilizer (NPK) in all studied variables except for inter-nodal distance. The genotype C-9 recorded highest mean values for total shoot length (1137 cm), primary branches (11), high leaf moisture content (79-80%) and low inter-nodal distance (3.9 – 4.1 cm).

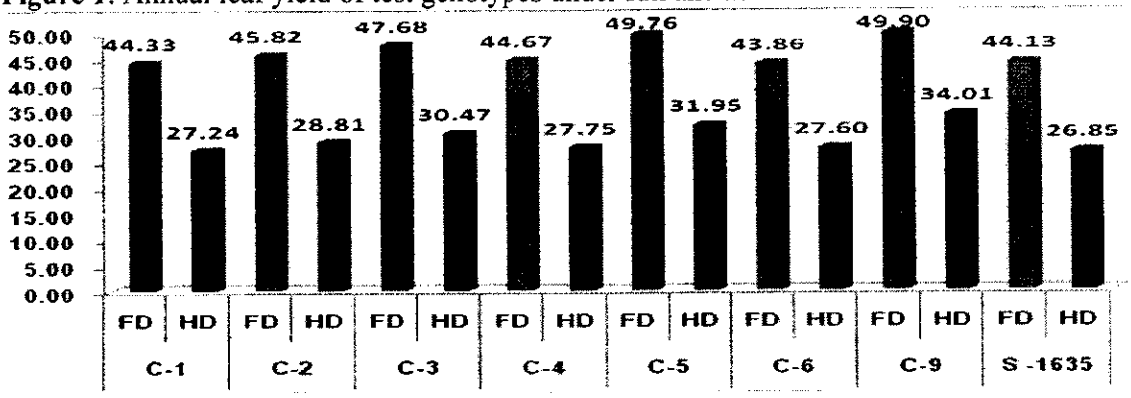
Table 6: Mean values of leaf yield and yield contributing traits under irrigated condition at CSRTI, Berhampore.

Geno type	Condition	Leaf yield (kg/ha)	DHS (%)	PH (cm)	NPB (Nos)	TSL (cm)	ID (cm)	LS (%)	MC (%)	MC 6hrs (%)
C-1	FD	44326	9.38	135	7.51	907	4.06	10.01	79.27	73.29
	HD	27235*	9.13	121	6.03	752	4.19	7.33	77.55	72.97
C-2	FD	45822*	9.40	136	8.02	918	3.84	9.51	78.63	72.16
	HD	28809*	9.62	125	6.26	799	4.06	7.71	77.43	72.58
C-3	FD	47675*	8.76	146	9.08	1007	4.16	8.51	79.92	74.48
	HD	30470*	8.96	133	7.08	842	4.42	6.03	78.41	73.79
C-4	FD	44666*	9.38	133	7.47	872	4.47	9.61	77.38	71.17
	HD	27753*	9.16	126	6.00	718	4.62	8.49	77.33	72.31
C-5	FD	49764*	8.67	152	9.67	1066	4.35	6.69	80.01	74.49
	HD	31948*	8.49	138	7.25	864	4.52	6.44	78.85	73.68
C-6	FD	43862	9.71	139	8.00	904	4.53	9.13	78.03	73.09
	HD	27604*	9.38	117	6.76	772	4.48	7.85	75.79	71.03
C-9	FD	49899*	8.62	159	10.77	1137	3.98	8.04	79.93	75.26
	HD	34007*	8.44	143	8.35	929	4.18	6.55	80.18	75.44
S -1635	FD	44131	9.71	131	8.57	971	4.65	12.62	79.34	74.42
	HD	26846	9.69	119	7.15	708	4.53	10.89	78.65	73.59
CD@ 5%	FD	151	0.36	2.37	0.35	21	0.12	0.79	0.35	0.84
	HD	106	0.30	2.46	0.32	21	0.08	0.54	0.47	0.48
CV	FD	4.38	9.43	4.14	9.95	5.33	6.81	33.70	1.06	1.10
	HD	4.96	7.71	4.74	11.73	6.65	4.10	29.19	1.46	1.59

DHS (Days to100% sprouting), PH (Plant height), NPS (No of primary shoots per plant), TSL (total shoot length), ID (inter nodal length.), LS(leaf senescence, MC (moisture content) and MC 6hrs(moisture content after six hours, FD(full dose)and HD(half dose)

Out of seven genotypes tested, 5 genotypes exhibited significant superiority for annual leaf yield over the check S-1635 under both the fertilizer input (fig.1). Under full dose of NPK, genotype C-9 recorded significantly high mean values for annual leaf yield 49899 kg/ha followed by C-5(49764 kg/ha), C-3(47675 kg/ha), C-2(45822 kg/ha) and C-4(44666 kg/ha. However, under 50% reduced NPK fertilizer application, all test genotypes recorded significantly higher values than check S-1635, which ranged from 27235 to 34007 kg/ha/y (table 7).

Figure 1: Annual leaf yield of test genotypes under full and half RDF



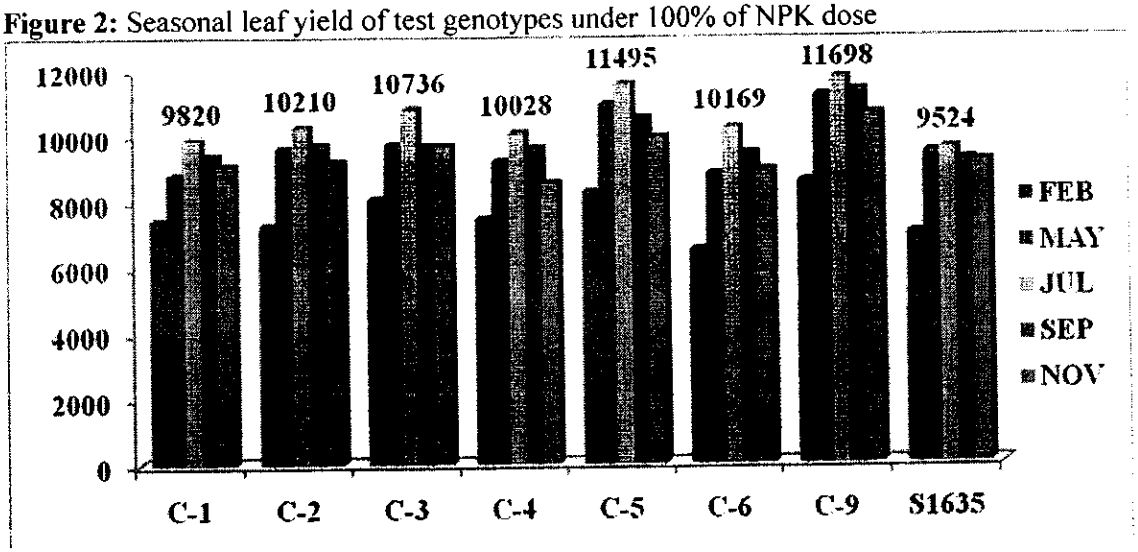
The leaf yield improvement in C-9 was to a tune of 27% and 13% over the check S-1635 under 50% and 100% NPK fertilizer application, respectively. Moreover, the percentage leaf yield reduction was lowest in C-9 (by 31.8%) as compared to check S-1635(by 39.2%) with 50% reduction of fertilizer dose, indicating its fertilizer use efficiency. The results of the present study suggested that, in Eastern and North-Eastern India, mulberry leaf productivity can be achieved to an extent of 34-35 t/ha/y (26%–27% over S-1635) with 50% reduced NPK fertilizer input under irrigated condition, if C-9 cultivar is used.

Table 7: The year wise annual leaf yield of test genotypes at Berhampore under irrigated condition across three years spanning over five seasons per year

Genotype	Annual leaf yield (kg ha^{-1} y^{-1})							
	Year-1		Year-2		Year -3		Pooled	
	FD	HD	FD	HD	FD	HD	FD	HD
C-1	42323	19645	45217	28452	45437	33609	44326	27235*
C-2	42768	22784	45871	29210	48827	34433	45822*	28809*
C-3	45721	25794	47560	30270	49742	35346	47675*	30470*
C-4	42257	21504	44673	27460	47068	34295	44666*	27753*
C-5	47703	29473	48144	29233	53446	37138	49764*	31948*
C-6	35905	18621	47585	30442	48095	33748	43862	27604*
C-9	47986	33000	49378	32256	52333	36765	49899*	34007*
S -1635	39305	20503	44892	26347	48195	33688	44131	26846
CD@ 5%							151	106

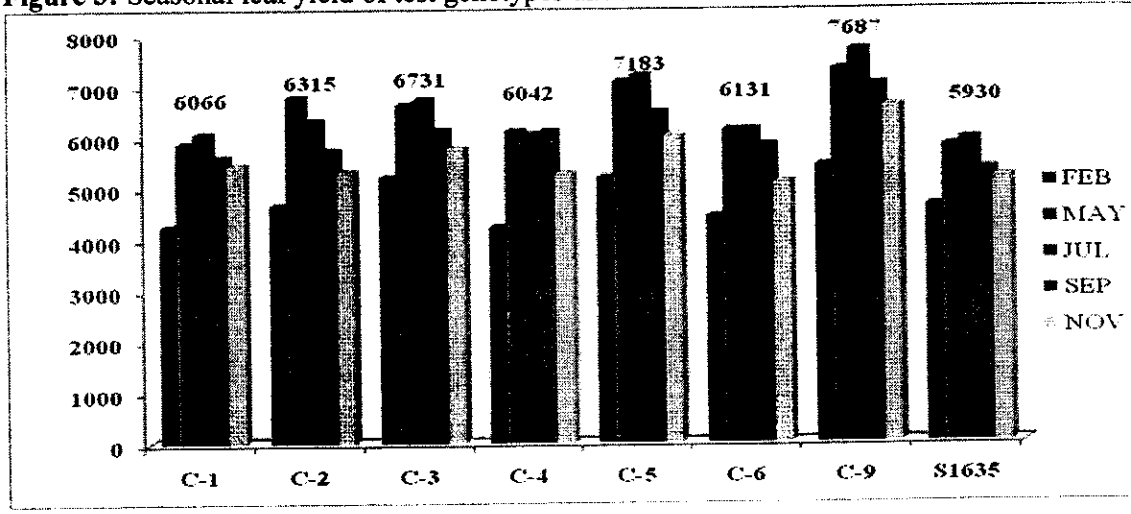
The leaf yield of test genotypes ranged from 6477 – 8550 kg/ha and 9820 -11698 kg/ha during February and July crop, respectively. All the genotypes had maximum seasonal leaf yield during July crop. The genotype C-9 recorded highest leaf yield per crop which is significantly higher than Check S-1635 under full dose of fertilizer (Fig 2.).

Figure 2: Seasonal leaf yield of test genotypes under 100% of NPK dose



The leaf yield of the test genotypes ranged from 4252 – 5424 kg/ha and 5930-7687 kg/ha during February and July mulberry crop, respectively. The genotype C-9 recorded highest leaf yield per crop which is significantly higher than Check S-1635 under half dose of fertilizer (Fig 3.)

Figure 3: Seasonal leaf yield of test genotypes under 50% of NPK dose



8.2. Evaluation of test genotpes under rainfed condition.

Mean annual leaf yield of seven test genotypes ranged from 10.79 to 14.02 t ha^{-1} y^{-1} which is significantly higher than S-1635. Among the test genotypes evaluated under rainfed test centers, C-9 showed significantly highest leaf yield (14026 kg/ha/y) followed by C-3 (13441 kg), C-5 (13277 kg), C-4 (11659 kg) and C-6 (11401 kg). The leaf yield of C-9 was around 14 t ha^{-1} y^{-1} which stands significantly higher than the check S-1635(~11 t ha^{-1} y^{-1}) to the tune of 28%. The leaf and growth parameters recorded showed wide variation among the test genotypes.

Table 8: annual leaf yield of test genotypes under three rainfed test centers

Genotypes	REC-BND	RSRS-JHT	RSRS-KPT	Pooled mean
C-1	11427	9693	11270	10797*
C-2	11134	9495	12641	11090*
C-3	12632	11845	15845	13441*
C-4	11271	10247	13459	11659*
C-5	12696	12575	14561	13277*
C-6	12171	9329	12703	11401*
C-9	12810	13254	16014	14026*
S1635	10990	10347	11518	10952
CD@ 5%	86	83	119	96

REC-research Extension centre, RSRS-Regional sericultural research Station, BND-Bhandra, JHT-Jorhat, KPT-Koraput

The leaf yield per crop of the test genotypes ranged from 3966 – 4670 kg/ha during August crop at REC, Bhandra. The genotype C-9 recorded highest leaf yield per crop which is significantly higher than Check S-1635 (Fig 4).

Fig. 4: Seasonal leaf yield of test genotypes at REC, Bhandra

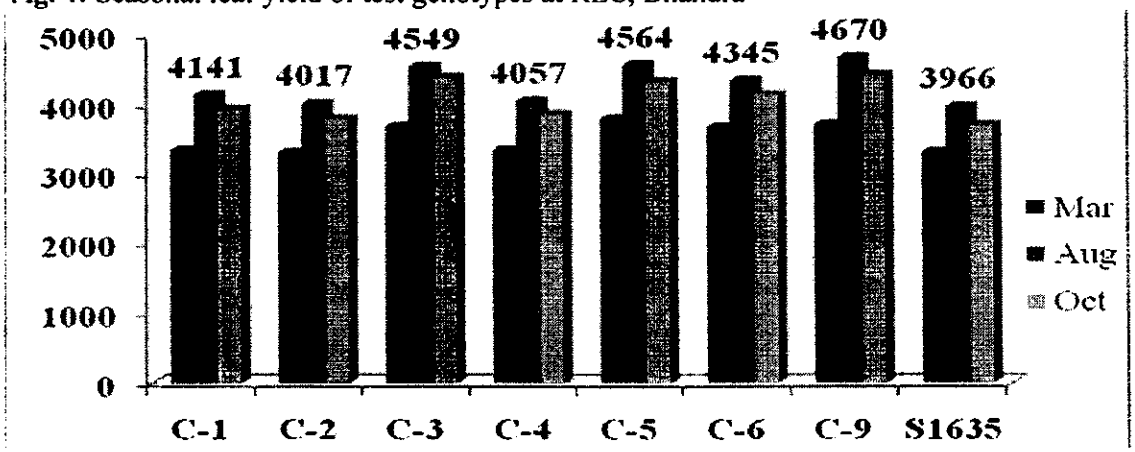
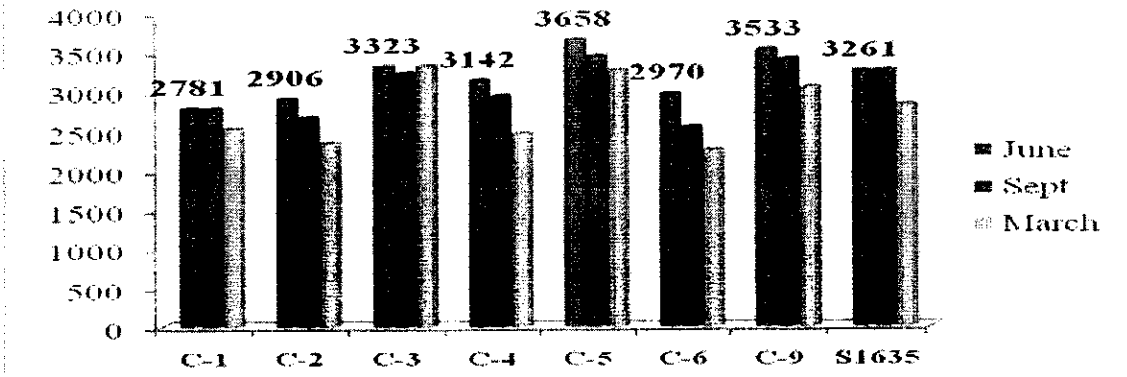
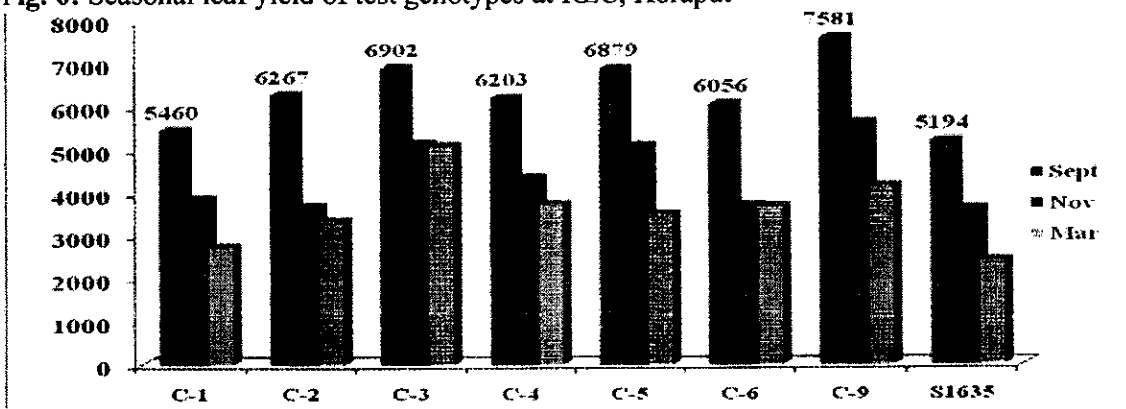


Fig. 5: Seasonal leaf yield of test genotypes at RSRS, Jorhat



At RSRS, Jorhat test center, average seasonal leaf yield of the test genotypes ranged from 2906 – 3658 kg/ha during September crop. The genotype C-9 and C-5 recorded highest leaf yield per crop which is significantly higher than Check S-1635 (Fig 5).

Fig. 6: Seasonal leaf yield of test genotypes at REC, Koraput



At RSRS, Koraput, leaf yield per crop during September crop ranged from 5194 – 7581 kg/ha. The genotype C-9 recorded highest leaf yield per crop which is significantly higher than Check S-1635 (Fig 6).

Analysis of soil NPK status at plantation and after final harvesting of the experimental plot applied with reduced dose of NPK fertilizer during the project period revealed that, reduced fertilizer application had reduced availability of NPK in the soil substantially. Hence, it clearly indicates that under such a NPK stress condition, the genotype C-9 showed significant superiority over the check S-1635 in terms of leaf productivity.

Table9: Initial and final status of available soil N, P and K (kg/ha) in HD plot of CSR&TI.

Test center	Condition	N	P	K
HD plot CSR&TI, Berhampore	Initial (Simulated, before initiation of the project)	218	33	362
	Final (after completion of the project)	156	21	273

Fig.8 Plant growth at 65 day after pruning under Irrigated full dose of NPK

Fig.9 Plant growth at 65 day after pruning under Irrigated half dose of NPK

8.3 Silkworm bioassay study for assessing palatability of test genotypes

Leaf quality through rearing performance is an important parameter used for evaluation of genotypes aimed at selection of superior varieties (Bongale et al., 1997). Growth and development of silkworm *Bombyx mori* L. is known to vary depending on the quality and quantity of mulberry leaf used as food source, which in turn indicated by commercial characteristics of cocoon (Nagaraju, 2002). Leaves of superior quality enhance the chances of good cocoon crop (Ravikumar, 1988). In the present study an attempt has been made to evaluate performing eight rest genotypes including check variety through silkworm rearing. Silkworm rearing was conducted as standard rearing package of the region and cross breed M.Con.1 x B.Con.4 hybrid was fed with the leaves of test genotypes at all the four test centres.

Silkworm rearing experiment were conducted during favourable season of each centres. For each mulberry genotype, one egg laying was reared with 3 replications. After III moult, 300 larvae per replication were maintained. Appropriate cellular rearing practice was adopted and separate rearing trial was conducted for different centres (Krishnaswami et al., 1970b; Benchamin and Nagaraj, 1987; Krishnaswami, 1990). Larvae were fed three times daily (7am, 12pm, 7pm) with healthy, fresh leaves. Young age larvae were fed with tender and succulent leaves known to favour growth and development of chawki silkworms, while mature leaves were fed to late age silkworms till ripening. Cocoons were harvested on 5th day of mounting and assessed for commercial parameters *viz.,* cocoon weight, shell weight, shell percentage, ERR and leaf to cocoon ratio as per methodology adapted by Sonwalkar (1991).

Table 10: Silkworm bioassay results of M.Con.1 x B.Con.4 fed with the test genotypes & check

Genotype	Cocoon weight(g)		Shell weight(g)		Shell %		ERR No.		ERR weight(kg)		Leaf to cocoon ratio	
	FD	HD	FD	HD	FD	HD	FD	HD	FD	HD	FD	HD
C-1	1.560	1.310	0.198	0.192	15.26	14.92	8067	7367*	10.2	9.6*	21.20	24.11
C-2	1.570	1.380	0.241	0.183	15.44	15.26	7067	6033	9.6	7.9	22.00*	23.98*
C-3	1.537	1.390	0.238	0.191	15.96	15.06	8790	7912*	12.1	9.8*	21.00	22.89
C-4	1.551	1.380	0.216	0.205	16.43	16.08*	7633	7433*	10.4	9.8*	22.10*	23.09
C-5	1.501	1.420	**0.241**	**0.231**	17.84*	16.14*	8001	7400*	12.3	10.3*	20.10	20.91
C-6	1.580	**1.490**	0.241	0.209	16.38	15.86	7133	5400	9.4	8.6	20.80	20.67
C-9	1.577	1.430	0.215	0.209	15.89	15.34	8367	6567	11.9	8.5	20.20	22.02
S 1635	**1.596**	1.450	0.223	0.223	15.83	15.35	8767	6266	12.7	8.8	21.30	23.22
CD@ 5%	0.158	0.170	0.034	0.031	0.78	0.70	254	210	0.98	0.81	0.42	0.34

FD-full dose, HD-half dose, ERR-Effective rate of rearing

Silkworm rearing results were presented in table 10. Significant differences were observed in commercial cocoon characters. All the cocoon parameters recorded had significant variation among the test genotypes indicating scope for selection of better quality

genotypes with respect to silkworm palatability. Cocoon weight was highest in silkworms reared on S-1635 and C-6 leaves grown under full and half dose of fertilizer respectively (Fig.6). Single shell weight was highest in cocoons of silkworms reared on C-5 leaves grown under both the condition which is at par with the check variety (Fig.7). However, most of the genotypes were found to be at par with the check *w.r.t.* cocoon and shell weight. Shell percentage was significantly higher over check in cocoons of silkworms reared on C-5 leaves followed by C-4.

Effective rate of rearing by cocoon number and weight was maximum in C-3 & C-5 and lowest in C-2 & C-6 genotypes grown in full and half dose of fertilizer, respectively. The genotypes C-1, C-3, C-4 and C-5 were significantly higher over check for ERR by number and weight under both dose fertilizer. The genotype C-2 recorded significantly high leaf to cocoon ration under both dose of fertilizer. The results of cocoon characters from leaves of test genotypes grown under both dose (half and full dose) of NPK application, the performance of most of the genotypes was found be at par with the Check S-1635.

Fig. 6: Single cocoon weight (g) of test genotypes under FD and HD of fertilizer

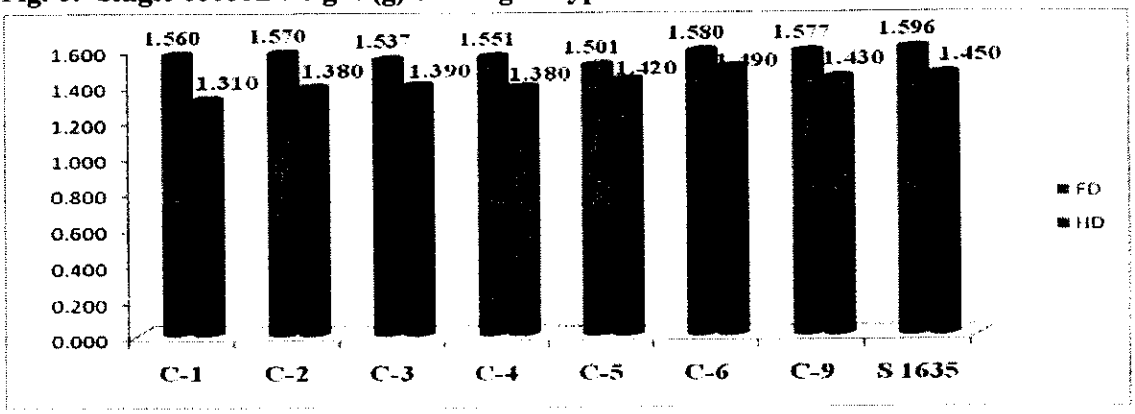
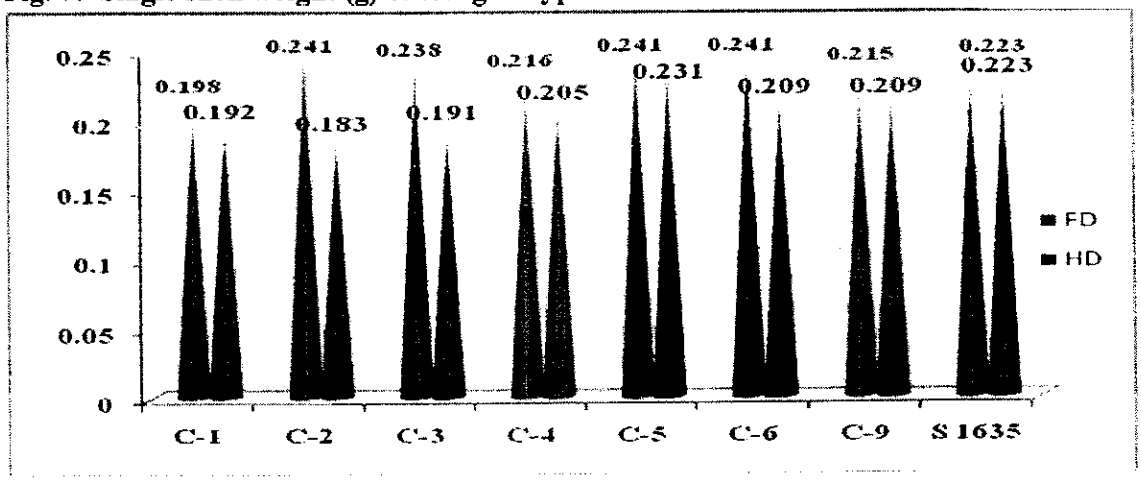


Fig. 7: Single shell weight (g) of test genotypes under FD and HD of fertilizer



Silkworm rearing results of test genotypes under rainfed condition were presented in table 11. Significant differences were observed in all the commercial cocoon characters studied except shell percentage. C-1 recorded maximum cocoon weight at two centers and C-9 at koraput. For single shell weight and shell percent the check variety S-1635 recorded maximum value at all the test centres. However, most of test genotypes had cocoon characters at par with the check variety.

Table 11: Silkworm bioassay results of M.Con.1 x B.Con.4 at rainfed test centres

Genotypes	Single cocoon wt.(g)			Single shell wt.(g)			Shell percent (%)		
	BND	JHT	KPT	BND	JHT	KPT	BND	JHT	KPT
C-1	1.650*	1.530	1.550	0.240	0.270	0.280	14.68	17.50	17.20
C-2	1.440*	1.510	1.580	0.240	0.270	0.290	16.62	18.12	18.32
C-3	1.380	1.510	1.530	0.250	0.270	0.250	18.11	17.80	17.60
C-4	1.380	1.500	1.520	0.210	0.270	0.250	15.17	17.78	17.58
C-5	1.310	1.550	1.500	0.230	0.290	0.300	17.09	18.48	18.28
C-6	1.330	1.520	1.550	0.220	0.270	0.280	17.47	17.66	17.68
C-9	1.320	1.500	1.600	0.280	0.270	0.290	16.87	18.22	18.52
S 1635	1.360	1.500	1.540	0.290	0.310	0.300	17.55	19.10	19.00
CD	0.062	0.045	0.038	0.016	0.013	0.015	1.026	NS	NS

8.4 Studies on disease and pest incidence in different test genotypes under testing

Assessment of the incidence and intensity of disease and pest is essential to avoid economic loss. Mulberry is affected by various diseases and pest during different seasons. It was therefore imperative to assess test genotypes against major insect pests and disease resistance before commercial exploitation.

Table 12: Mean PDI of foliar disease at CSR&TI, Berhampore

Genotype	Myrothecium LS (September)		Pseudocercospora LS (November)		Bacterial LS (July)		Powdery mildew (February)	
	FD	HD	FD	HD	FD	HD	FD	HD
C-1	1.44	2.89	9.93	8.88	4.17	3.38	6.61	6.01
C-2	2.66	4.15	11.36	6.53	3.43	2.85	5.86	1.27
C-3	3.99	1.67	8.39	5.85	2.54	1.96	4.27	1.37
C-4	2.10	0.78	9.55	6.38	3.76	2.51	4.41	2.00
C-5	2.46	2.28	6.76	7.10	3.91	2.32	4.35	1.59
C-6	1.38	1.73	8.53	7.49	2.93	2.55	5.05	3.11
C-9	1.84	1.41	4.49	3.52	2.37	1.01	3.46	1.08
S-1635	4.85	2.26	10.51	12.27	4.25	3.12	6.17	4.49
$LSD_{(0.05)}$	NS	NS	NS	NS	NS	NS	1.80	2.83

FD-full dose, HD-half dose, LS-Leaf spot

No significant difference was observed between the test genotypes and the check in terms of Leaf spot disease occurrence. However, in C-9 Powdery mildew occurrence was observed significantly lower than the check S-1635.

Table 13: Mean foliar pest incidence at CSR&TI, Berhampore

Genotype	White fly (No. of adult/leaf)		Thrips (No. of nymphs./leaf)		Tukra (%)		Bihar hairy cater pillar (No. of leaf infested /plant)	
	FD	HD	FD	HD	FD	HD	FD	HD
C-1	5.61	2.84	2.29	1.25	3.69	2.10	0.45	0.35
C-2	5.96	3.41	2.89	1.30	4.59	2.40	0.85	0.56
C-3	4.69	2.55	2.64	1.00	5.11	3.01	1.24	1.12
C-4	5.89	2.38	3.03	0.85	3.01	1.11	0.56	0.45
C-5	6.66	3.46	3.79	1.45	2.72	1.21	0.50	0.26
C-6	4.48	2.44	2.95	1.01	3.60	1.45	1.20	0.84
C-9	3.00	3.12	2.61	1.23	3.39	1.25	0.46	0.38
S 1635	6.16	4.50	3.91	2.01	6.87	3.56	1.85	1.45
$LSD_{(0.05)}$	1.24	1.20	0.58	0.46	1.20	0.86	0.45	0.36

FD-full dose, HD-half dose

Whitefly, thrips, mealy bug and Bihar hairy caterpillar infestation was observed in the test genotypes, which was significantly lower than the check and the values were found below ETL.

9. Discussion:

Out of seven genotypes tested for leaf yield, 5 recorded significant superiority over check S-1635 to the extent of 1.2 to 13.1% under half and 3.4 to 26.6% full dose of NPK, respectively. The genotype C-9 recorded highest annual leaf yield under irrigated condition in two levels of NPK fertilizer (49.89 & 34.01 t/ha/y under full and half NPK dose respectively). Under rainfed condition also C-9 was found to be superior with average leaf yield 14.02 t/ha/y, which is significantly 28% higher over S-1635. As far as the bioassay parameters are concerned, the study revealed that the performance of C-9 was at par with the check variety for most of the cocoon characters studied.

10. Inférence / Recommandations:

C-9: high yielding genotype for reduced fertilizer input condition for Eastern and North-Eastern India may be recommended for authorization and it can be released for commercial exploitation by the desired farmers.

11. Applications made for patenting / commercialization if any: Nil

12. References:

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

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

Krishnaswami,S. (1990). Improved method of rearing young age (chawki) silkworms. Bulletin No.2, Central Silk Board, Bangalore, India. pp.1-24.

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

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

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

Sonwalkar,T.N. (1991). Handbook of Silk Technology. Wiley Eastern Limited, New Delhi

13. Summary:

The seven test genotypes *viz.,* C-1, C-2, C-3, C-4, C-5, C-6 and C-9 along with the check S-1635 were evaluated for leaf yield and yield contributing parameters, adaptability and suitability for silkworm through bioassay study.

The genotypes were tested under two levels of fertilizer i.e., full and half the recommended dose of NPK fertilizer (336:180:112 Kg NPK/ha/y and 168:90:56 Kg NPK/ha/y respectively) at CSR&TI, Berhampore.

Test genotypes were also evaluated simultaneously at three other test centres to assess the performance and adaptability under rainfed condition

The genotype C-9 recorded highest annual leaf yield under irrigated condition in two levels of NPK fertilizer (49.89 & 34.01 t/ha/y under full and half NPK dose respectively).

In rainfed condition also C-9 was found to be superior with average leaf yield 14.02 t/ha/y, which is 28% higher over S-1635.

The bioassay study also revealed the performance of C-9 cocoon parameters was at par with the check variety

14. Budget utilized (In lakh rupees): 0.279

Sl.No.	Item	Total
1	A. Non-Recurring	-
2	B. Recurring:	-
3	B1. Manpower	-
4	B2. Consumables	-
5	Stationeries/ Contingencies.	**0.90**
6	Research Operations	**0.90**
7	B3.Travel	**2.40**
8	B4.Contingency	**0.75**
9	B5.Overhead charges	
10	**Total**	**4.95**

15. Decision / Recommendation of RAC committee

#	Decision / Recommendation	Follow-up action taken
[Shri. D. Chakravarty, Sc-D, MBG Section]	While reviewing the project, PIB 3481: "Evaluation of mulberry varieties suitable for low input soil", PI was advised to determine the status of the low input and normal input soils in different centers before completion.	The reduced dose of fertilizer was applied at Berhampore only hence the status of NPK in the reduced RDF applied plot after completion of the project has been analysed and incorporated in the concluded report

Certified that the Project work has been carried out and financial expenditure incurred for executing the Project are in accordance with the declaration / certification submitted at the time of submission of the Project Proposal and sanction obtained from time to time thereafter as per the revision made.

12. Signature of the

Principal Investigator

Shri Debashish Chakravarty
Scientist-D
Moriculture Division
9/5/18

Co-Investigator (s)

(Suresh, K) 9/5/18
Scientist-B

S.Chanda 10/5/18
S.Chanda
Scientist-D

09/05/18
A.K.Verma,
Scientist-D

S.N. Gogoi
Scientist-D
RSRS Jorhat

S.K. Misro
Scientist-C
RSRS Koraput

G. S. Singh
Scientist-D
RSRS Bhandra

13. Signature (with comments, if any) of Head of Division

Shri Debashish Chakravarty
Scientist-D
Moriculture Division
9/5/18

14. Signature (with comments, if any) of Director / Executive authority

The newly developed mulberry genotype C-9 is observed to give higher leaf yield under reduced fertilizer (NPK) input over S-1635, which may be authorized by MYAC, Bangalore for future commercial exploitation.

9/5/18

Dr. Kanika Trivedy
Director
(डॉ. कणिका त्रिवेदी)
(Dr. Kanika Trivedy)
निदेशक/Director
केन्द्रीय रेशम उत्पादन अनुसंधान एवं प्रशिक्षण संस्थान, बहरमपुर
Central Sericultural Research & Training Institute, Berhampore 742101