वार्षिक प्रतिवेदन
ANNUAL REPORT
2021-22

केन्द्रीय रेशम जननद्रव्य संसाधन केन्द्र

केन्द्रीय रेशम बोर्ड, वस्त्र मंत्रालय, भारत सरकार, होसूर - 635 109

Central Sericultural Germplasm Resources Centre

Central Silk Board, Ministry of Textiles, Govt. of India, Hosur- 635 109

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प्रस्तावना

केन्द्रीय रेशम जननद्रव्य संसाधन केन्द्र, होसूर, की स्थापना 1991 में हुई थी, और केंद्र ने संग्रह, लक्षण वर्णन, मूल्यांकन, संरक्षण तथा इसके उपयोग के अधिदेशानुसार व्यवस्थित रूप से शहतूत और रेशमकीट आनुवंशिक संसाधनों के संरक्षण को संबोधित किया है। इस केंद्र को शहतूत जननद्रव्य के लिए राष्ट्रीय पादप आनुवंशिक संसाधन ब्यूरो (एनबीपीजीआर), आईसीएआर, नई दिल्ली द्वारा राष्ट्रीय सक्रिय जननद्रव्य साइट (रासजस) तथा रेशमकीट जननद्रव्य को राष्ट्रीय कृषि कीट संसाधन ब्यूरो (एनबीएआईआर), आईसीएआर, बेंगलुरु द्वारा मान्यता प्राप्त है। तदनुसार, शहतूत जननद्रव्य किस्मों/ रेशमकीट जननद्रव्य अभिगमों को विशिष्ट राष्ट्रीय अभिगम संख्याएं दी गई।

यह केंद्र 1317 शहतूत और 489 रेशमकीट आनुवंशिक संसाधनों के विशाल संग्रह का प्रबंधन तथा अधिकतम विविधता सुनिश्चित करता है और पारंपरिक तरीकों, जैव रासायनिक और आणविक मार्करों के साथ-साथ क्रायोप्रिजर्वेशन जैसी अन्य तकनीकों को नियोजित करके आनुवंशिक विविधता, आनुवंशिक अखंडता, जनसंख्या संरचना, प्रजातियों के संबंधों, विशेषता विशिष्ट होनहार अभिगमों की पहचान आदि के व्यवस्थित विश्लेषण पर जोर देता है। केरेजसंके, होसुर शहतूत और रेशमकीट जननद्रव्य संसाधन के फसल सुधार और फसल संरक्षण में सहायता करने हेतु शहतूत आनुवंशिक संसाधनों की साइटोलॉजिकल स्थिति, डुप्लिकेट की पहचान हेतु शहतूत आनुवंशिक संसाधनों के आणविक लक्षण वर्णन एवं उनके प्रभावी उपयोग, जैविक और अजैविक तनाव के लिए रेशमकीट जननद्रव्य संसाधनों की पहचान पर केंद्रित, रेशमकीट में आणविक लक्षण वर्णन और आनुवंशिक विविधता का आकलन आदि पर इन-हाउस और सहयोगी नेटवर्किंग अनुसंधान परियोजनाएं शुरू कर रहा है।

मैं इस अवसर पर सदस्य-सचिव, केंद्रीय रेशम बोर्ड और केंद्र की अनुसंधान सलाहकार समिति के साथ-साथ अन्य संस्थानों/संगठनों को अनिवार्य गतिविधियों के सफल निष्पादन में उनके समर्थन और प्रोत्साहन हेतु अपनी हार्दिक कृतज्ञता व्यक्त करना चाहता हूँ। मैं केंद्र के वैज्ञानिकों और कर्मचारियों को उनके बहुमूल्य योगदान और संघ-भावना के लिए ऋणी हूँ जो केंद्र की महत्वपूर्ण उपलब्धियों के लिए प्रेरक शक्ति रही है। यह वार्षिक रिपोर्ट वर्ष 2021-22 के दौरान केंद्र की महत्वपूर्ण उपलब्धियों को दर्शाती है। वार्षिक रिपोर्ट में सुधार के लिए किसी भी सुझाव का स्वागत है।

बी.टी. श्रीनिवास

[डॉ. बी टी श्रीनिवासा]
निदेशक

PREFACE

Central Sericultural Germplasm Resources Centre, Hosur was established in 1991, and the centre has systematically and strategically addressed conservation of mulberry and silkworm genetic resources against its mandate of collection, characterization, evaluation, conservation and utilization. The centre is recognized by the National Bureau of Plant Genetic Resources (NBPGR), ICAR, New Delhi as a National Active Germplasm Site (NAGS) for mulberry germplasm and by National Bureau of Agricultural Insect Resources (NBAIR), ICAR, Bengaluru for silkworm germplasm. Accordingly, the mulberry germplasm varieties/ silkworm germplasm accessions are assigned unique National Accession numbers.

The centre manages the vast collection of 1317 mulberry and 489 silkworm genetic resources ensuring maximum diversity and laying emphasis on systematic analysis of genetic diversity, genetic integrity, population structure, species relationships, identification of trait specific promising accessions etc. by employing conventional methods, biochemical and molecular markers as well as other techniques like cryopreservation. CSGRC Hosur is taking up in-house and collaborative networking research projects that focusses on cytological status of mulberry genetic resources, molecular characterization of mulberry genetic resources for the identification of duplicates and their effective utilization, identification of silkworm germplasm resources for biotic and abiotic stress, molecular characterization and assessment of genetic diversity in silkworm etc. to aid crop improvement and crop protection of both mulberry and silkworm germplasm resources.

I wish to take this opportunity to extend my deepest gratitude to the Member-Secretary, Central Silk Board, and the Research Advisory Committee of the Centre as well as other institutes/organizations for their support and encouragement in the successful execution of mandated activities. I am indebted to the scientists and staff of the centre for their valuable contributions and team spirit that has been the driving force for the significant achievements of the centre. This annual report depicts the significant achievements of the centre during the year 2021-22. Any suggestions for improvement of the annual report are welcome.

[**Dr. B T. SREENIVASA**]
DIRECTOR

CONTENTS

1. अनुसंधान की रूपरेखा

वर्ष 2021-22 के दौरान, केरेजसंके, होसुर ने केंद्र में उपलब्ध विशाल मात्रा में सेरी-आनुवंशिक संसाधनों के व्यवस्थित प्रबंधन की दिशा में अपनी वैज्ञानिक खोज जारी रखी और इसके रोग मुक्त संरक्षण और उपयोग को सुनिश्चित किया। केंद्र ने 489 रेशमकीट जर्मप्लाज्म स्टॉक का संरक्षण और इनब्रीडिंग डिप्रेशन के लिए उनका मूल्यांकन किया। 1317 शहतूत आनुवंशिक संसाधनों का संरक्षण किया गया। रिपोर्टाधीन अवधि के दौरान शहतूत और रेशमकीट प्रभाग की उपलब्धियों का सार निम्नानुसार है:

शहतूत विभाग:

- परियोजना **पीआईई-06001 एसआई**: संग्रह, लक्षण वर्णन, मूल्यांकन, संरक्षण और शहतूत आनुवंशिक संसाधनों की आपूर्ति के तहत, विभिन्न लक्षणों के लिए शीर्ष प्रदर्शन करने वाले शहतूत के परिग्रहणों की पहचान की गई, एमई-0285, एमई-0119, एमई-280, एमई-281 एवं एमई -282। वृद्धि एवं उपज मापदंडों के लिएME-0135, ME-0267, ME-0285ने 9 लक्षणों और ME-0284 और ME-0268 7 से अधिक बहु वांछित लक्षणों के लिए बेहतर प्रदर्शन किया जिनका संभावित अभिभावक के रूप में संकरण कार्यक्रमों में उपयोग किया जा सकता है।

- परियोजना **पीआईजी-06004एसआई**: शहतूत आनुवंशिक संसाधनों की कोशिकीय स्थिति के अध्ययन के तहत, शूट टिप्स का उपयोग करके मेटाफ़ेज़ तैयारी के लिए अब तक अध्ययन किए गए 136 परिग्रहणों में से 127 परिग्रहण द्विगुणित, 4 त्रिगुणित, 3 चतुर्गुणित, 1 षट्गुणित और 1 डेकासोप्लाएड (2n = 22x = 308) पाए गए। अध्ययन किए गए परिग्रहणों की अंतर-विशिष्ट विविधता ने *मोरस इंडिका* से संबंधित 79%, *एम. मैक्रोरा* से 14%, और जीनस *मोरस* की अन्य प्रजातियों से 17% के थे।

- परियोजना "**पीआईजी-06005एसआई**: डुप्लिकेट की पहचान और उनके प्रभावी उपयोग हेतु शहतूत आनुवंशिक संसाधनों का आणविक लक्षण वर्णन" के तहत, 41 एसएसआर प्राइमरों का उपयोग करके 42 संदिग्ध डुप्लिकेट के लिए पीसीआर किया गया ।परिग्रहणों के बीच कोई बहुरूपता नहीं देखी गईजो रूपात्मक वर्णनकर्ताओं के आधार पर पहचाने गए डुप्लिकेट के साथ पुष्टि करता है।

- सहयोगी अनुसंधान परियोजनाओं, डीबीटी-सीएसबी नेटवर्क परियोजना और फल मूल्यांकन आदि के लिए विभिन्न सीएसबी संस्थानों / विश्वविद्यालयों / संगठनों के 8 मांगकर्ताओं को कटिंग / ग्राफ्टेड पौधे के रूप में 28 विदेशी और 82 स्वदेशी सहित कुल 110 शहतूत परिग्रहण की आपूर्ति की गई।

रेशमकीट विभाग:

- परियोजना **एआईई: 06002 एमआई**: चयनित हॉट स्पॉट में अजैविक तनाव के प्रति सहयताके लिए द्विप्रज रेशमकीट आनुवंशिक संसाधनों का मूल्यांकन के तहत, ग्रीष्म और पतझड़ के मौसम के लिए विभिन्न परीक्षण केंद्रों पर दस द्वप्रज परिग्रहणों का मूल्यांकन किया गया। परिग्रहण BBI-0338 एवं BBI-0301 CSR&TI, बरहामपुर में, BBI-0336 एवं BBI-0339 क्षे.रे.अ.के.,जम्मू में, और BBI-0334 एवं BBE-0184 अ.वि.के.,चित्रदुर्ग में बेहतर प्रदर्शन करते हुए पाए गए।
- परियोजना **एआईई:06003 एसआई**:: बॉम्बिक्स मोरी एल. के रेशमकीट आनुवंशिक संसाधनों का मूल्यांकन आंतरिक प्रजनन न्यूनता और उनके संरक्षण के के तहत , द्विप्रज रेशमकीट परिग्रहण में से बीबीआई-0324, बीबीआई-0349, बीबीआई-0378, बीबीआई-0262 और बीबीई-0364 और बहुप्रज जर्मप्लाज्म में से बीएमआई-0076, बीएमआई-0083, बीएमआई-0084, बीएमआई-0081 और बीएमआई-0073 सभी मूल्यांकन किए गए आर्थिक लक्षणों के लिए अभिप्रायपूर्ण सर्वश्रेष्ठ निष्पादन हेतु शीर्ष प्रदर्शनकर्ता के रूप में पाए गए।
- परियोजना **एआईटी:06006 एमआई:**"बीएमएनपीवी और बीएमबीडीवी के प्रति सहिष्णु रेशमकीट आनुवंशिक संसाधनों की पहचान करने के लिए मार्कर- सहायप्रदत्तजाँच" के तहत, बीएमबीडीवी सहिष्णुता के लिए विशिष्ट प्राइमरों का उपयोग करके 191 बाइवोल्टाइन रेशमकीट परिग्रहणों के पीसीआर प्रवर्धन ने प्रतिरोधी एलील वाले 5 बाइवोल्टाइन परिग्रहणों का खुलासा किया। जैवपरख अध्ययनों में बीएमआई-0076, बीएमआई-0077 औरबीबीई-0190 अभिगमों के लिए क्रमश: 70, 69 और 42% प्यूपल उत्तरजीविता दर्ज की गई। BmNPV सहिष्णुता के लिए स्क्रीनिंग के लिए बहु-विषाणुज सहिष्णुता विशिष्ट 8 एसएसआर मार्कर, अर्थात् ATT, LIP283, ATK285, GDH306, IDH216, PTP242, PTP284 और ANK165 पर विचार किया गया।
- **एआईजी:06007 एमआई** नामक परियोजना: रेशमकीट (बॉम्बिक्स मोरी एल) जननद्रव्य में आनुवंशिक विविधता के आणविक लक्षण वर्णन और मूल्यांकन के तहत, 170 परिग्रहणों से डीएनए को निकाला और शुद्ध किया गया। एसएसआर मार्करों का उपयोग करके रेशमकीट परिग्रहणों की समजीनी/ समयुग्मी प्रकृति की जांच की गई। चार आबादी (पीएम, निस्तारी, सीएसआर -2 औरएसके -6) के डीएनए को प्राइमरों SAT346 और SAT1423 के साथ प्रवर्धित किया गया।
- अनुसंधानकार्य/सहयोगी अनुसंधान परियोजनाओं के लिए विभिन्न सीएसबी संस्थानों / विश्वविद्यालयों / संगठनों के 5 मांगकर्ताओं को कुल 7 बहुप्रज (59 डीएफएल) और 24 द्विप्रज (24 डीएफएल) रेशमकीट अभिगमों की आपूर्ति की गई।

1. RESEARCH HIGHLIGHTS

During the year 2021-22, CSGRC, Hosur continued its scientific pursuit towards systematic management of the vast quantum of seri-genetic resources available at the centre and ensured its disease-free conservation and utilization. The centre carried out conservation and evaluation of its 489 silkworm germplasm stock for inbreeding depression. Conservation of 1317 mulberry genetic resources was carried out. The gist of achievements of mulberry and silkworm division during the period is as follows:

MULBERRY DIVISION:

- Under the project "**PIE 06001S SI**: Collection, characterization, evaluation, conservation and supply of mulberry genetic resources", top performing mulberry accessions for different traits were identified, viz. ME-0285, ME-0119, ME-280, ME-281 and ME-282, for growth and yield parameters ME-0135, ME-0267 and ME-0285 performed better with 9 multiple traits and ME-0284 and ME-0268 with more than 7 multiple desired traits which may be utilized in crossbreeding programmes as potential parents.

- Under the project "**PIG-06004SI:** Studies on cytological status of mulberry genetic resources", out of 136 accessions studied so far for metaphase preparation using shoot tips, 127 accessions were found to be diploid, 4 triploid, 3 tetraploid, 1 hexaploid and 1 decosaploid (2n=22x=308). Intraspecific diversity of studied accessions revealed 79% belonging to *Morus indicia*, 14% to *M. macroura*, and 17% to other species of the genus *Morus.*

- Under the project "**PIG-06005 SI:** Molecular characterization of mulberry genetic resources for the identification of duplicates and their effective utilization", PCR was carried out for 42 suspected duplicates using 41 SSR primers No polymorphism was observed among the accessions which corroborates with the duplicates identified based on morphological descriptors.

- Under the project "**PIT-08004 MI**: Study on epigenetic and autophagy modifiers on induction of haploid microspore embryogenesis in mulberry", a combination of 2,4-D (2 mg l-1) and Kinetin (0.03 mg l-1) showed a positive impact on anther culture. V1, and ME-0173 were performing better than S13 under dark incubation of about 90 days. The lower nucleus to cytoplasm ratio (N/C ratio) was considered to identify embryogenic (Em) and non-embryogenic (NEm) cells.
- A total of 110 mulberry accessions comprising 28 exotic and 82 indigenous in the form of cuttings/grafted saplings were supplied to 4 indenters of different CSB Institutes / Universities/Organizations for collaborative research projects, DBT-CSB network projects and fruit evaluation, etc.

SILKWORM DIVISION:

- Under the project "**AIE:06002MI:** Evaluation of bivoltine silkworm genetic resources for tolerance to abiotic stress in selected hot spots", 10 bivoltine accessions were evaluated at different test centres for summer and autumn seasons. Accessions BBI-0338 and BBI-0301 performed better at CSR&TI, Berhampore, BBI-0336 and BBI-0339 at RSRS, Jammu and BBI-0334 and BBE-0184 at REC, Chitradurga.

- Under the project "**AIE:06003SI**: Evaluation of silkworm genetic resources of *Bombyx mori* L. with reference to inbreeding depression and their conservation", the silkworm accessions BBI-0324, BBI-0349, BBI-0378, BBI-0262 & BBE-0364 among bivoltine and BMI-0076, BMI-0083, BMI-0084, BMI-0081 & BMI-0073 from the multivoltine germplasm were found as top performers with significant best performance for all the evaluated economic characters.

- Under the project "**AIT:06006MI**: Marker-assisted screening to identify silkworm genetic resources tolerant to *Bm*NPV and *Bm*BDV", PCR amplification of 191 bivoltine silkworm accessions with primers specific to *Bm*BDV tolerance revealed 5 bivoltine accessions carrying the resistant allele. Bioassay studies recorded 70, 69 and 42% pupal survival for accessions, BMI-0076, BMI-0077 and BBE-0190 respectively. 8 SSR markers for multiviral tolerance, viz. ATT, LIP283, ATK285, GDH306, IDH216, PTP242, PTP284 and ANK165 were considered for screening for *Bm*NPV tolerance.

- Under the project entitled, "**AIG:06007MI:** Molecular characterization and assessment of genetic diversity in silkworm (*Bombyx mori* L) germplasm", DNA was extracted and purified from 170 accessions. Isogenic /homozygous nature of the silkworm accessions was examined using SSR markers. DNA from four populations (PM, Nistari, CSR-2 & SK-6) was amplified with primers Sat346 and Sat 1423.

- A total of 7 multivoltine (59 dfls) and 24 bivoltine (24 dfls) silkworm accessions were supplied to 5 indenters of different CSB Institutes/Universities/Organizations for research work/collaborative research projects.

2. परिचय

केंद्रीय रेशम जननद्रव्य संसाधन केंद्र (केरेजसके), होसूर केंद्र रेशम बोर्ड (केरेबो) द्वारा एक विशेष संस्थान है, जिसके अधिदेश में शहतूत रेशम आनुवांशिक संसाधनों को इकट्ठा करने, लक्षण वर्णन, मूल्यांकन और संरक्षण के साथ-साथ उक्त पहलूओं पर जागरूकता और कर्मियों को प्रशिक्षण देने शामिल है। प्रजनकों की अधिकारों के रक्षा के लिए संसाधन पंजीकरण समिति द्वारा विभिन्न संस्थानों मेंविकसित रेशमआनुवांशिकसंसाधनों को पंजीकृतकरनेहेतु इस केंद्र को केरेबो द्वारा अधिकृत किया गया हैं। केंद्र को क्रमशः राष्ट्रीय पादप आनुवांशिक संसाधन ब्यूरो (रपअसब), भकृअप, नई दिल्ली और राष्ट्रीय कृषि कीट संसाधन ब्यूरो (रककसब), भकृअप, बेंगलुरु द्वारा शहतूत और रेशमकीट जननद्रव्य के लिए "नेशनल एक्टिव जर्मप्लाज्म साइट्स" के रूप में मान्यता प्राप्त है। इस केंद्र में संरक्षित संसाधनों को पूर्वोक्त संस्थानों द्वारा राष्ट्रीय अभिगम संख्याएं दी गई हैं। केरेजसकेहोसुर बेहतर प्रदर्शन करने वाले पैतृक स्टॉक की पहचान के उद्देश्य से विभिन्न स्वदेशी संसाधनों के मूल्यांकन के लिए कई आंतरिक और सहयोगी परियोजनायेँ लागू कर रहा है जो फसल सुधार में प्रजनकों की सहायता करेंगे।

अधिदेश

- संग्रह, संरक्षण, प्रलेखन, मूल्यांकनका उपयोग करना और रेशम जननद्रव्य संसाधनों पर अनुसंधान।
- अन्य के रे बो अ व प्र संस्थानों के सहयोग से हितधारकों के लिए जननद्रव्य का सतत उपयोग।
- रेशम जननद्रव्य संसाधनों के संरक्षण और उपयोग पर हितधारकों की जागरूकता और प्रशिक्षण का सृजन।

गतिविधियाँ

- *शहतूत और रेशमकीट जननद्रव्य की खोज, संग्रह और परिचय।*
- *आनुवांशिक संसाधनों के उपयोग को बढ़ावा देने के लिए लक्षण वर्णन, वर्गीकरण, प्रारंभिक मूल्यांकन, राष्ट्रीय अभिगमन और जननद्रव्य संग्रह की सूची बनाना।*
- *रेशम उत्पादन विषयक आनुवांशिक संसाधनों के दीर्घकालिक राष्ट्रीय भंडार के रूप में सेवा करना।*
- *जननद्रव्य संसाधनों के पंजीकरण और संदर्भ केंद्र के लिए नोडल एजेंसी के रूप में कार्य करना।*
- *जननद्रव्य के परीक्षण / मूल्यांकन के लिए अंतर-संस्थागत सहयोग में प्रमुख भूमिका।*
- *आनुवंशिक संसाधनों के आयात और निर्यात का समन्वय।*
- *राष्ट्रीय डेटाबेस और हर्बेरियम/रेशम आनुवंशिक संसाधनों के प्रदर्शन के रूप में सेवा करें।*
- *जरूरतमंद संगठनों को उनकी आपूर्ति के माध्यम से जननद्रव्य के उपयोग को बढ़ावा देना।*
- *रेशम उत्पादन विषयक जननद्रव्य संसाधन प्रबंधन में प्रशिक्षण देना।*

रेसल्ट्स फ्रेमवर्क डोकुमेंट [आर एफ डी]

दृष्टिकोण : रेशम आनुवंशिक संसाधनों के पंजीकरण, मूल्यांकन, संरक्षण के लिए नोडल एजेंसी बनना।

मिशन

भारत में रेशम आनुवंशिक संसाधनों को पंजीकृत करना,फसल सुधार कार्यक्रम के लिएरेशम आनुवंशिक संसाधनों के उपयोग को सुविधाजनक बनाने के लिएअनुसंधान गतिविधियाँ, राष्ट्रीय भावी पीढ़ी को विलुप्त होने से बचाने के लिए रेशम आनुवंशिक संसाधनों का संरक्षण।

रोड मैप

लघु अवधि योजनाएं

1. विभिन्न राज्यों में अस्पष्टीकृत क्षेत्रों का सर्वेक्षण करें और आनुवंशिक स्टॉक को समृद्ध करने के लिए नए शहतूत आनुवंशिक संसाधनों के संग्रह के लिए अलग-अलग देशों से मार्ग का पता लगाएं।
2. विविधता और जीन समृद्धि के केंद्रों में शहतूत आनुवंशिक संसाधनों के सीटू संरक्षण में संवर्धन।
3. तनाव के प्रति सहिष्णु संसाधनों की पहचान के लिए हॉटस्पॉट क्षेत्रों में आनुवंशिक संसाधनों का मूल्यांकन।
4. शहतूत आनुवांशिक संसाधनों की सुरक्षा के लिए जलवायु लचीला रेशम उत्पादन को अपनाना।
5. आनुवंशिक वृद्धि के लिए पूर्व प्रजनन कार्यक्रमों का कार्यान्वयन।
6. अजैविक और जैविक तनाव के लिए रेशमकीट आनुवंशिक संसाधनों का मूल्यांकन।
7. मार्करों के माध्यम से सेरी-आनुवंशिक संसाधनों का आणविक लक्षण वर्णन।

दीर्घकालिक योजनाएं

1. एनबीपीजीआर, नई दिल्ली / आईएससी, सीएसबी कॉम्प्लेक्स, बैंगलोर के माध्यम से विदेशी शहतूत (मॉरस) प्रजातियों का परिचय।
2. इको फ्रेंडली और जैविक कृषि तकनीकों को अपनाना।
3. शहतूत प्रजनकों द्वारा नवीन जीनों / एलील्स के उपयोग और बेस चौड़ीकरण के साथ-साथ हेटेरोसिस के दोहन के लिए जंगली जीनों के अंतःक्षेपण के लिए प्रीब्रीडिंग कार्यक्रमों का कार्यान्वयन।
4. संरचित और टिकाऊ ऑन-फार्म का कार्यान्वयन और अपने मूल कृषि-पारिस्थितिक वातावरण में भूमि के संरक्षण का इन सीटू संरक्षण।
5. शहतूत और रेशमकीट जीन बैंकों के लिए एक्स सीटू संरक्षण रणनीतियों का उन्नयन, लागत प्रभावी संरक्षण के लिए उन्नत जैव प्रौद्योगिकी के साधनों को अपनाना।
6. आनुवंशिक वृद्धि के लिए पूर्व प्रजनन कार्यक्रम में उपयोग हेतु आणविक उपकरणों का उपयोग करके जंगली और भूमि जाति में होनहार जीन की पहचान।
7. केंद्र के एक आवश्यक अधिदेश के रूप में जीनोमिक्स को शामिल करके विभिन्न अजैविक तनावों / कार्यात्मक लक्षणों के प्रति सहिष्णुता के लिए आणविक साधनों की जांच हेतु आणविक उपकरणों का उपयोग।
8. कठिन श्रम कमी के लिए मेजबान संयंत्र की खेती और रेशम कीट पालन में मशीनीकरण।
9. जलवायु परिवर्तन के लिए लचीलापन हेतु विशिष्ट कार्यात्मक लक्षणों के साथ शहतूत जननद्रव्य की पहचान।
10. लक्षण और मूल्यांकन डेटा के साथ-साथ आणविक आईडी के साथ सेरी-आनुवंशिक संसाधनों के राष्ट्रीय डेटा बेस का विकास।

2. INTRODUCTION

Central Sericultural Germplasm Resources Centre (CSGRC), Hosur is an exclusive institute established by Central Silk Board (CSB) with a mandate to collect, introduce, characterize, evaluate, and conserve mulberry serigenetic resources as well as to create awareness and train personnel on the said aspects. The centre is authorized by CSB to register seri-genetic resources developed by various institutes through the Germplasm Registration Committee to protect authorship rights of the breeders. The centre is recognized as National Active Germplasm Sites (NAGS) for mulberry and silkworm germplasm by the National Bureau of Plant Genetic Resources (NBPGR), New Delhi and National Bureau of Agricultural Insect Resources (NBAIR), Bengaluru, respectively. The germplasm conserved at this centre are assigned national accession numbers by the aforesaid institutes. CSGRC Hosur has been implementing several in-house and collaborative projects for evaluating serigenetic resources aiming at identification of better performing parental stock that will aid breeders in crop improvement.

Mandate

1. *Collection, conservation, documentation, evaluation, utilization of sericultural germplasm resources for research.*
2. *Sustainable utilization of germplasm for stakeholders in collaboration with other CSB R&D institutes.*
3. *Creation of awareness and training of stakeholders on conservation and utilization of sericultural germplasm resources.*

Activities

- Exploration, collection and introduction of mulberry and silkworm germplasm.
- Characterisation, classification, preliminary evaluation, national accessioning and cataloguing of germplasm collection for promoting utilization of genetic resources.
- Serve as long-term national repository of sericultural genetic resources.
- Act as nodal agency for registration and reference centre for germplasm resources.
- Play lead role in inter-institutional collaboration for testing / evaluation of germplasm.
- Co-ordinate import and export of genetic resources.
- Serve as the national database and herbarium / display of sericultural genetic resources.
- Promote utilization of germplasm through their supply to needy organizations.
- Impart training in sericultural germplasm resource management.

Vision: To become the nodal agency for registration, evaluation and conservation of serigenetic resources.

Mission: To register the seri-genetic resources in India, research activity facilitating utilisation of serigenetic resources for crop improvement programme, conservation of serigenetic resources, national posterity and prevention of extinction.

Road map

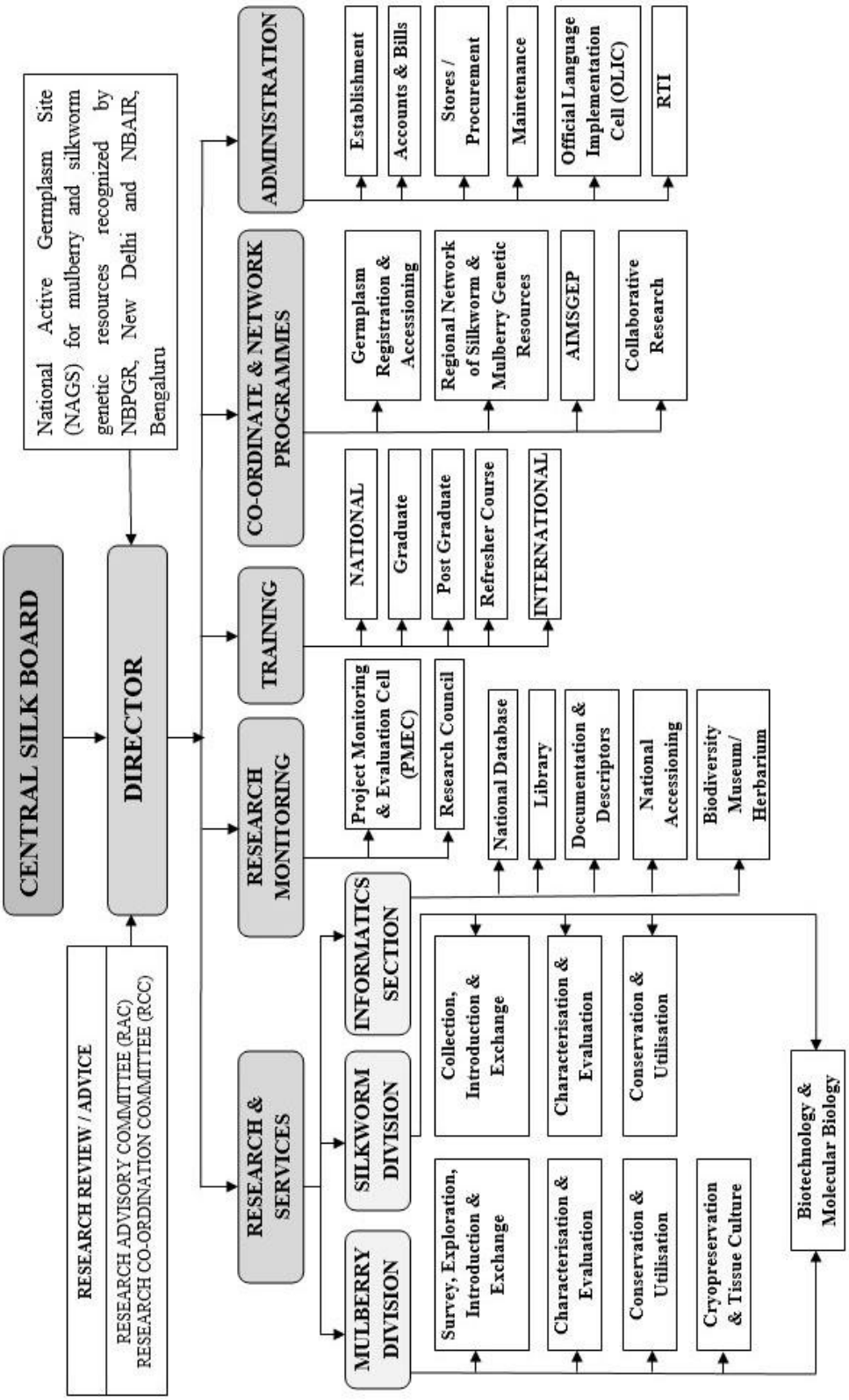
Short term plans

1. Survey of unexplored areas in different states and exploration of avenues from different countries for collection of new mulberry genetic resources to enrich the genetic stock.
2. Promotion of *in situ* conservation of mulberry genetic resources at the centers of diversity and gene richness.
3. Evaluation of seri-genetic resources in hotspot areas to identify resources tolerant to biotic and abiotic stress.
4. Adoption of climate resilient sericulture to protect seri-genetic resources.
5. Implementation of pre-breeding programmes for genetic enhancement.
6. Molecular characterization of seri-genetic resources through markers.

Long term plans

1. Introduction of exotic mulberry (*Morus*) species through NBPGR, New Delhi / ISC, CSB Complex, Bangalore.
2. Adoption of eco-friendly and organic farming techniques.
3. Implementation of prebreeding programs for introgression of wild genes into the agronomic varieties to facilitate the use of novel genes/alleles by mulberry breeders and for base broadening as well as the exploitation of heterosis.
4. Implementation of structured and sustainable on-farm and *in situ* conservation of landraces in their native agroecological environments.
5. Upgradation of *ex situ* conservation strategies for mulberry and silkworm gene banks adopting advanced biotechnological tools with backup for cost-effective conservation.
6. Identification of promising genes in the wild and landraces using molecular tools for utilization in the pre-breeding programme for genetic enhancement.
7. Utilization of molecular tools for screening seri-genetic resources for tolerance to different abiotic stresses / functional traits by including genomics as an essential mandate of the centre.
8. Mechanization in host plant cultivation and silkworm rearing for drudgery reduction.
9. Identification of mulberry germplasm with specific functional traits for resilience to climate change.
10. Development of a National Database of seri-genetic resources with molecular IDs along with characterization and evaluation data.

3. ORGANISATION CHART OF CSGRC, HOSUR



4. LIST OF RESEARCH PROJECTS

CODE	TITLE OF PROJECT	DURATION
Mulberry Division		
Single Institutional		
PIE-06001SI	Collection, characterization, evaluation, conservation and supply of mulberry genetic resources.	Nov.18-Oct.21
PIG-06004SI	Studies on the cytological status of mulberry genetic resources.	Mar.20-Feb.23
PIG-06005SI	Molecular characterization of mulberry genetic resources for the identification of duplicates and effective utilization.	Mar.20-Feb.23
Multi-institutional		
PIC 01003 CN: NW4B	Sugar-mimic alkaloids in mulberry and their role in modulating host plant-insect interactions (CSB-DBT funded multi-component network project: Genetic enhancement of mulberry through genomic approaches)	Jun.18-Jun. 21
PIB - 3629	Development of mulberry genotypes suitable for rainfed hill farming in North - West India (RSRS, Jammu with CSGRC, Hosur)	Jan.18-Dec. 21
PIB – 3586	Development of superior mulberry varieties through controlled hybridization for North-West Indian states (CSR&TI Pampore with CSGRC Hosur)	Mar.17-Feb.22
PIT–08004MI	Studies on epigenetic and autophagy modifiers on induction of haploid microspore embryogenesis in mulberry (SBRL Kodathi with CSGRC Hosur)	Mar.20-Feb.23
Silkworm Division		
Single Institutional		
AIE-06003 SI	Evaluation of silkworm genetic resources of Bombyx mori. L, with reference to inbreeding depression and their conservation.	Dec.19-Nov.22
Multi Institutional		
AIE-06002MI	Evaluation of bivoltine silkworm genetic resources for tolerance to abiotic stress in selected hotspots (CSGRC Hosur with CSR&TI Mysuru, CSR&TI Berhampore & CSR&TI Pampore)	Apr.19-Mar.22
AIT-06006 MI	Marker assisted screening to identify silkworm genetic resources tolerant to *Bm*NPV and *Bm*BDV	Nov.20-Oct.23
AIG-06007 MI	Molecular characterization and assessment of genetic diversity in silkworm (*Bombyx mori* L)	Mar.21-Feb.24

5. OUTCOME OF CONCLUDED RESEARCH PROJECTS

PIE-06001 SI: Collection, characterization, evaluation, conservation and supply of mulberry genetic resources – Phase IX (November 2018 to October 2021)

G. Thanavendan (PI), M. C. Thriveni, Raju Mondal, S. Masilamani (up to May 2019),
G. Ravikumar (from July 2020), Geeth N. Murthy (up to August 2020),
Shabana Banu (Project Assistant, April to October 2021)

Objectives

- To collect new mulberry germplasm
- To characterize mulberry genetic resources
- To evaluate mulberry genetic resources
- To conservation of mulberry genetic resources in the *ex-situ* field gene bank
- To update the mulberry germplasm information system
- To supply mulberry genetic resources for utilization

Materials and Methods

Field location and Field Gene Bank (FGB) of mulberry

Field experiments were initiated in the *ex situ* field gene bank of CSGRC, Hosur was used and it is located at 12^{o} 45" North Latitude, 77^{o} 51" East Longitude, and at an altitude of 942.0 m above mean sea level (MSL). The chemical fertilizer application and intercultural operations were carryout according to SOP recommendation, which was applied after pruning of the mulberry germplasm. Germplasm was inspected at frequent intervals intercultural operations and hand weeding/ irrigations were carried out as needed. The experimental layout was a randomized complete block design, and the accessions were replicated on four plants (Tikader and Anandarao, 2001). A recommended standard package of practices was applied for the maintenance of the uniform growth of plantations in dwarf tree form (Thangavelu *et al*., 2003 and Qadri *et al*., 2008). Field and nursery experiments were carried out during different seasons, viz., summer (S1), rainy (S2), and winter (S3) to study different parameters/ traits of mulberry germplasm, and detailed studies were conducted as below:

1	Experimental Design	Randomized Block Design (RBD)
2	No. of plants	4 trees per accession
3	Plant Spacing	10 x 10 ft or 3 x 3m
4	Pruning and training of plants	As dwarf tree
5	No. of pruning per year	3 times
6	Observation of insect pests and diseases in different seasons	No. of insects or percent infestations was recorded in 30, 45 and 60 days after pruning (DAP)

Characterization and evaluation of mulberry genetic resources (MGRs)

A new set of planted mulberry genetic resources (75 accessions) were allowed for three years in the *ex situ* field gene bank for establishment and supply for further multiple utilizations. The Institute accession numbers were allotted for newly established accessions. New plantations were pruned after attaining 3 years of maturity and the data was recorded in prescribed plant traits morphology

(32 descriptors), anatomy (15 descriptors), reproductive (24 descriptors), and propagation (23 descriptors) (Saraswati *et al*., 2016). Biochemical (5 descriptors), growth and yield-related traits (12 descriptors) (Thangavelu *et al*., 1997; Tikader and Ananda Rao, 2001) and DUS descriptors guidelines were followed as described by Protection of Plant Varieties and Farmers' Rights (PPV&FRA) Act, 2001, New Delhi.

Sampling for the presence of arthropod insect pests and foliar fungal diseases in MGRs

The main objective is to assess the insect damage level of mulberry germplasm which is caused by two kinds of insects viz., chewing (leaf roller, hairy caterpillar and stem borer) and the piercing-sucking (mealybug, whitefly, and thrips) insect pests were recorded at 30, 45 and 60 days after pruning (DAP) of the plants from 4 randomly selected shoots in each direction of accession. The number of insects on each selected plant was counted and the percentage damage index was calculated. The methodology was followed in leaf roller, hairy caterpillar and stem borer (Singh, 2012) and the incidence of piercing and sucking insect pests was used as standard methodology as explained by Prabhakar *et al*., 2013; Gundappa and Shukla, 2016 and Akter *et al*. 2019. Finally, the plant germplasm screening and scoring of different types of germplasm were followed according to Devina and Devi, 2021).

Besides, the incidence of major foliar diseases of the mulberry germplasm was graded based on visual symptoms by selecting (from top to bottom) 4 randomly selected shoots of each branch in an accession. Four such branches were observed from four directions of selected accession for each plant. The grades for disease severity (PDI%) were calculated as described by Saraswat, 2001; Capucho *et al*., 2011; Maji *et al*., 2009; Ghosh *et al*., 2012; Dutta *et al*., 2013.

Conservation and supply of MGRs

The mandate of this centre includes collection, introduction, conservation, evaluation and supply for utilization of mulberry genetic resources. The conserved genetic resources are precious and hence there is a need to review the requirement for these genetic resources submitted by various institutes (Indenters) under the purview of the Germplasm Supply Committee constituted by the Central Silk Board at CSGRC. In this context, norms are formulated for the supply of MGRs as described below:

i. The indenter must enter into an agreement i.e. Material Transfer Agreement (MTA) undertaking not to utilize the material for commercial purposes.
ii. The committee will examine the proposal with respect to the information supplied particularly the eligibility criteria. Incomplete indents may be sent back to the concerned applicant and only indents which qualify will be placed before the committee for consideration.
iii. After approval of the committee, the supplier is to intimate the concerned head of the institute for payment and collection.

Updation of mulberry germplasm information system (MGIS)

To realize the importance of systematic data maintenance of mulberry germplasm on long-time perspective this centre has developed an information system named Mulberry Germplasm Information System (MGIS) incorporating various facilities for data storage along with retrieval facilities. While developing the system the standard packages are taken considered with National Bureau of Plant Genetic Resources (NBPGR), ICAR, New Delhi and CIMMYT, Mexico, to make it user friendly with scope for broad-spectrum applications.

Results

Objective: 1. To collect new mulberry germplasm

During the project period, a total of 27 mulberry germplasm samples were collected, 21 from Nokrek biosphere of Meghalaya, CSRTI, Pampore (J&K)-(3), CSRTI, Berhampore (2), and CSRTI, Mysore (1). Survey, exploration and collection of new mulberry germplasm from untapped areas of Nokrek, (Tura forest range), Meghalaya was successfully completed as per the project milestone. The newly collected mulberry germplasm was raised in nursery beds under shade net conditions for better growth and development of saplings. Among the collected new cuttings, two accessions (genotypes) failed to sprout, 19 germplasm is having more than 75% of sprouting. Since, 1991 82 survey and explorations were conducted in different geographical regions of India- arid and semi-arid regions of Rajasthan, cold deserts of Leh-Ladakh, Himalayan region including centre of diversity for different *Morus* species particularly in Uttaranchal and Uttar Pradesh, saline regions of Andaman Islands, Central and South India. The details of total mulberry germplasm collected from various states of India and abroad conserved till date (Table 1) in *ex situ* field gene bank are presented below:

Table 1. State-wise survey and collection of mulberry species from India (1990-2020)

SN	States	No of Surveys	Mulberry species collected
1	Andhra Pradesh + Telangana	1	*M. indica*
2	Arunachal Pradesh	3	*M. laevigata, M.indica*
3	Assam	3	*M. laevigata, M.indica*
4	Bihar	1	*M.indica, M. laevigata*
5	Chhattisgarh	2	*M. laevigata, M.indica*
6	Goa	2	*M.indica, M. latifolia*
7	Gujarat	1	*M. indica*
8	Haryana	1	*M. laevigata*
9	Himachal Pradesh	5	*M. indica, M. serrata,M.alba & M. laevigata*
10	Jammu and Kashmir (UT) + Leh and Ladak (UT)	3	*M.indica, M.alba, M.serrata, M. laevigata*
11	Jharkhand	1	*M.indica, M. laevigata M. alba*
12	Karnataka	2	*M.indica,M. alba*
13	Kerala	4	*M.indica, M. laevigata*
14	Madhya Pradesh	5	*M. laevigata M.indica, M. alba*
15	Maharashtra	4	*M.indica,M. laevigata, M. alba*
16	Manipur	1	*M. laevigata*
17	Meghalaya	7	*M. laevigata, M.indica, M.serrata*
18	Mizoram	1	*M. laevigata, M.indica*
19	Nagaland	1	*M.indica*
20	Odisha	1	*M.indica*
21	Punjab	3	*M.indica, M. alba, M. laevigata*
22	Rajasthan	4	*M.indica, M. laevigata M. alba*
23	Sikkim	3	*M. laevigata M.indica*
24	Tamil Nadu	5	*M.indica, M.serrata,M.alba, M. laevigata*
25	Tripura	1	*M.indica*

SN	States	No of Surveys	Mulberry species collected
26	Uttar Pradesh	4	*M.indica, M. laevigata M. alba*
27	Uttarakhand	2	*M. serrata, M.indica,M.alba, M. laevigata*
28	West Bengal	4	*M. laevigata M.indica, M. alba*
29	Andaman &Nicobar Islands	3	*M. laevigata*
30	New Delhi	3	*M.indica, M. laevigata*
31	Pondicherry	1	*M.indica, M. laevigata*
Total survey and explorations		**82**	

Objective 2. To characterize mulberry germplasm

Expt. 1: Variability of different reproductive traits in exotic mulberry germplasm

Among the 26 accessions characterized for different reproductive traits, maximum coefficient of variation (55.74%) was recorded in female inflorescence (Table 2). The number of flowers/ catkin varied from 27 to 57.60 in males and 26 to 41.40 in females. Maximum stigma length (4.18 mm) was recorded in ME-0277 and the highest stamen length (3.6 mm) was recorded in ME-0278.

Table 2. Summary statistics for different reproductive traits in exotic mulberry germplasm

Parameters	Mean	Min.	Max.	SD	SE	CV%
Male inflorescence length (cm)	2.41	1.90	3.98	0.78	0.35	32.25
Female inflorescence length (cm)	1.09	0.86	1.54	0.19	0.06	17.48
Male inflorescence diameter (cm)	0.88	0.66	1.34	0.24	0.11	27.11
Female inflorescence diameter (cm)	0.93	0.58	2.56	0.52	0.15	55.74
No. of flowers/catkin (male)	36.93	27.00	57.60	10.62	4.75	28.75
No. of flowers/catkin (female)	33.66	26.00	41.40	5.19	1.50	15.42
Male peduncle length (cm)	1.16	0.62	1.52	0.36	0.16	31.21
Female peduncle length (cm)	0.89	0.62	1.20	0.17	0.05	19.16
Stamen length (mm)	3.18	2.50	3.60	0.40	0.18	12.64
Anther length (cm)	1.34	1.22	1.46	0.09	0.04	6.95
Style length (mm)	0.20	0.14	0.32	0.05	0.01	25.29
Stigma length (mm)	3.72	3.14	4.18	0.32	0.09	8.57
Fruit length (cm)	1.60	0.88	2.52	0.47	0.13	29.26
Fruit diameter (cm)	0.94	0.40	1.46	0.32	0.09	34.06
Fruit weight (g)	0.86	0.35	1.49	0.39	0.11	45.44

Expt. 2: Variability for anatomical characterization of exotic mulberry germplasm

During the third year, a total of 26 exotic MGRs were characterized with 14 different anatomical traits viz., stomatal size (sq.µm), stomatal frequency/no./sq.mm), upper cuticular thickness (µm), lower cuticular thickness (µm), upper epidermal thickness (µm), lower epidermal thickness (µm), leaf thickness (µm), no. of chloroplast/stomata, palisade and spongy thick(µm), P/S ratio, idioblast length, diameter and frequency (µm) were selected and three replicated data was collected in three seasons (summer, rainy, and winter) for the studied accessions in year-3, stomatal size varied from 247.14 to 481.45 sq. µm with CV 14.64%, stomatal frequency varied from 519.34 to 1117.73 no./sq.mm with 18.93 % CV. Lower cuticular thickness (µm) varied from 1.52 to 7.78 with a higher CV% of 36.16. On the other hand, leaf thickness (µm) showed the lowest CV% of about 9.58% (Table 3). For the anatomical traits, CV% ranged from 9.58 to 36.16 for the year-3 accessions.

Table 3: Summary statistics of exotic accessions for different anatomical traits in year 3

Parameters	Mean	Min.	Max.	SD	SE	CV%
Stomatal size (sq.µm)	335.22	247.19	481.45	9.11	49.06	14.64
Stomatal frequency (sq.mm)	804.72	519.34	1117.73	28.29	152.35	18.93
Upper cuticular thickness (µm)	7.59	3.22	11.94	0.35	1.88	24.79
Lower cuticular thickness (µm)	3.92	1.52	7.78	0.26	1.42	36.16
Upper epidermal thickness (µm)	28.07	19.18	37.96	0.85	4.56	16.24
Lower epidermal thickness (µm)	10.13	5.96	14.38	0.38	2.06	20.38
Leaf thickness (µm)	193.09	161.6	229.62	3.44	18.51	9.58
No. of chloroplast/stomata	12.72	10.34	16.58	0.25	1.36	10.66
Palisade thickness (µm)	65.89	44.65	95.69	1.84	9.9	15.02
Spongy thickness (µm)	78.6	49.58	98.24	2.04	11.01	14.01
P/S ratio	0.95	0.62	1.58	0.03	0.18	19.39
Idioblast length (µm)	42.67	28.73	67.5	1.98	10.66	25.00
Idioblast diameter (µm)	43.56	34.7	58.33	1.02	5.47	12.56
Idioblast frequency (µm)	27.96	19.38	40.63	0.93	5.03	17.98

Expt. 3: Variability for morphological characterization of exotic mulberry germplasm

Among the 26 mulberry accessions were characterized for different morphological characters. Out of 26, 11 are erect (47.83%), 10 spreading (43.38%) and 2 are semi-erect (2.70%) in their branching nature (Table 4).

Table 4: Details of morphological characterization for 23 exotic accessions

Parameters	No. of acc.	%	Parameters	No. of acc.	%
Branching nature			**Curve or straightness of the branch**		
Drooping	1	4.35	Slightly curved	19	82.61
Erect	21	91.3	Straight	4	17.39
Spreading	1	4.35	**Colour of mature shoot**		
Colour of young shoot			Brown	3	13.04
Brown	1	4.35	Greenish brown	3	13.04
Green	21	91.3	Grey	5	21.74
Light green	1	4.35	Grey brown	10	43.48
Stipule nature			Grey green	2	8.70
Free – lateral	23	100	**Stipule duration**		
Leaf lobation type			Caducous	10	43.48
Medium lobed	3	13.04	Persistent	13	56.52
Shallow lobed	5	21.74	**Leaf nature**		
Unlobed	15	65.22	Heterophyllous	9	39.13
Leaf colour			Homophyllous	14	60.87
Deep green	9	39.13	**Leaf surface**		
Green	6	26.09	Rough	2	8.7
Light green	8	34.78	Slightly rough	17	73.91
Leaf texture			Smooth	4	17.39
Chartaceous	17	73.91	**Leaf apex**		
Coriaceous	5	21.74	Acuminate	23	100
Membranaceous	1	4	**Leaf base**		
Leaf margin			Cordate	19	82.61
Dentate	1	4.35	Lobate	1	4.35
Serrate	22	95.65	Truncate	3	13.04

12 accessions are having straight branches (52.17%) and 11 are slightly curved (47.83%). Most of the accessions are having free-lateral stipules with caducous nature (95.65%). The remaining accessions are foliaceous and persistent (4.35%). The leaf nature was homophyllous in 14 accessions (60.87%) and heterophyllous in 9 accessions (13.13%). Most of the accessions were having serrate leaf margin (96.65%) and one accession (4.35%) with dentate margin.

Objective 3. Evaluation of MGRs

Expt. 1: Evaluation of exotic mulberry genetic resources for propagation traits

During the period, the exotic accessions tested for propagation traits and descriptive statistics are presented in Table 5. The rooting ability varied from 0 to 77.36% among the 26 accessions tested. The accession nos *viz.*, ME-0045, ME-0224, ME-0225, ME-0260, ME-0277, ME-0278, ME-0279, Me-0280 and ME-0281are poor in sprouting and rooting ability during all the seasons were evaluated in nursery conditions. The highest coefficient of variation was recorded for fresh stem weight and shoot length (81.04 & 74.31%) followed by other traits. The length of the longest root varied from 2.5 cm in ME-0137 to 28.5 cm in ME-0285. The numbers of roots ranging from 9.33 to13.56 were recorded across the season. The top better ranking accessions for different propagation traits with multiple traits analysis are presented in Table 6.

Table 5. Variability for propagation traits among the different exotic accessions

Parameters	Mean	Min.	Max.	SD	SE	CV%
Bud sprouting (%)	35.00	8.59	95.84	30.07	3.95	85.91
Shoot length (cm)	25.73	8.59	87.59	19.12	2.51	74.31
Total leaves/plant (Nos.)	19.22	5.00	96.00	11.60	1.52	60.36
Shoot wt. F (g)	38.95	6.83	89.13	18.92	2.48	48.58
Shoot wt. D (g)	13.75	1.79	32.96	6.85	0.90	49.83
Stem wt. F (g)	4.38	0.76	12.51	3.39	0.44	67.23
Stem wt. D (g)	1.45	0.24	4.25	1.17	0.15	81.04
Stem dia (cm)	0.75	0.29	1.91	0.39	0.05	52.20
Leaf wt. F (g)	12.08	0.00	40.42	7.96	1.04	65.89
Leaf wt. D (g)	3.41	0.00	13.67	2.45	0.32	71.74
Root wt. F (g)	9.11	3.00	22.00	5.03	0.66	55.26
Root wt. D (g)	4.23	1.00	12.00	3.10	0.41	73.26
Total roots / saplings (Nos.)	7.64	2.00	20.00	3.05	0.40	39.90
Longest root length (cm)	23.91	10.00	48.00	7.32	0.96	30.62
Root volume (ml)	6.79	2.00	25.00	4.83	0.63	71.04
Leaf moisture content (%)	68.49	10.67	86.59	14.61	1.92	21.33
Root moisture content (%)	70.07	58.49	86.59	5.44	0.71	17.76
Stem moisture content (%)	56.95	2.35	89.96	23.72	3.12	41.65
Root shoot ratio	1.33	0.81	2.00	0.26	0.03	19.84
Leaf area (sq. cm)	154.16	10.25	392.00	97.10	12.75	62.98
Survival (%)	37.83	6.00	100.00	32.94	4.33	87.07

Table 6. Top performing five exotic accessions for different traits

Acc. No.	No. of traits	Trait No. (Value)
ME-0285	11	1(86.67), 2(98), 4(76.667), 5(18), 6(11.889), 7(48), 8(43), 9(13), 11(7.667), 13(8.333), 17(0.225)
ME-0267	10	1(88.33), 2(68.667), 4(68), 5(17.333), 6(11.204), 7(26.667), 8(41.333), 9(12), 11(7.333), 13(11)
ME-0278	8	1(98.33), 2(74.333), 4(50), 5(17.741), 7(25.333), 8(24.667), 9(11.667), 17(0.29)
ME-0284	6	2(76), 4(44.667), 7(22.667), 9(9.333), 16(44.444), 17(0.219)
ME-0282	6	2(65.667), 5(16.704), 6(10.407), 9(9.667), 11(7), 13(8.333)

Expt. 2: Evaluation of exotic mulberry genetic resources for biochemical parameters

For biochemical analysis of exotic mulberry accessions, a total of five parameters like soluble protein (%) fwt, soluble carbohydrate (% fr. Wt), chlorophyll a (mg/g fr.wt), chlorophyll b (mg/g fr.wt), total chlorophyll (mg/g fr.wt) were selected and three replicated data were collected across the three seasons (summer, rainy, and winter). Soluble protein varied from 9.28 to 11.53 with CV 5.93%, for soluble carbohydrate varied from 2.85-4.99 with 11.55% CV, for chlorophyll a varied from 1.97-2.0 with 3.11% CV, for chlorophyll b varied from 0.48-1.72 with 56.26% CV, and for total chlorophyll varied from 2.46-3.92 with 16.49% CV (Table 7). For the biochemical traits, CV% ranged from 3.11-56.2 for the different accessions were evaluated across the season. The top better ranking accessions for different biochemical constituents with multiple traits analysis are represented in Table 8.

Table 7. Variability for biochemical traits among different Exotic accessions

Parameters	Min	Max	Mean	SE	SD	CV%
Soluble protein (%) fr. wt.	9.28	11.53	10.01	0.11	0.59	5.93
Soluble carbohydrate (%) fr. wt.	2.85	4.99	3.86	0.08	0.45	11.55
Chlorophyll a (mg/g fr. wt)	1.97	2.2	2.07	0.01	0.06	3.11
Chlorophyll b (mg/g fr. wt)	0.48	1.72	0.73	0.08	0.41	56.26
Total chlorophyll (mg/g fr. wt)	2.46	3.92	2.8	0.09	0.46	16.49

Table 8. Top performing five accessions for different traits of exotic mulberry germplasm

Acc. No.	No. of traits	Trait No. (Value)
ME-0285	5	2(32.88), 1(51.72), 3(9.961), 5(66.896), 4 (12.183)
ME-0119	5	1(556.928), 2(13.33), 5(69.73), 3(82.374), 4(26.475
ME-0280	5	5(41.378), 3(63.21), 4(6.80), 1(72.79), 2(31.01)
ME-0281	5	2(44), 4(15.70), 1(49.424), 5(9.099), 3(6.513)
ME-0282	4	1(51.72), 3(9.96), 2(6.89), 5(32.18)

Expt. 3: Evaluation of exotic MGRs for better growth and yield performance

High variability was observed for the growth and yield performance of different exotic accessions, which were studied during the period. A significant variation was observed in all the yield-related parameters that were studied. The results revealed that highest CV% was observed in total leaf yield/plant (62.56%) followed by the weight of lamina (61.40%) as presented in Table 9. Among the better performing mulberry accessions viz. ME-0135, ME-0267, ME-0285 are better performed with 9 multiple traits and ME-0284 and ME-0268 performed better with more than 7 multiple desired traits which may be utilized in crossbreeding programmes as potential parents (Table 10).

Table 9. Variability of growth and yield parameters in exotic accessions

Parameters	Mean	Min	Max	SD	SE	CV%
No. of branches (no.)	21.47	14.00	40.00	7.72	1.58	35.96
Length of the longest shoot (cm)	166.25	120.00	211.33	25.90	5.29	15.58
Internodal distance (cm)	5.09	3.17	7.27	1.09	0.22	21.47
Lamina length (cm)	18.97	11.33	27.83	4.91	1.00	25.87
Lamina width(cm)	15.40	9.33	22.77	3.76	0.77	24.39
Petiole length (cm)	5.34	3.00	10.07	1.69	0.35	31.69
Petiole width (cm)	0.38	0.20	0.60	0.12	0.03	32.13
Wt. of single leaf (g)	5.58	1.36	12.85	3.49	0.71	54.41
Wt. of lamina (g)	4.81	1.20	11.51	2.95	0.60	61.40
Total shoot length (cm)	2510.60	1046.00	5508.00	1220.28	249.09	48.61
Total leaf yield (kg)	2.12	0.44	4.07	1.15	0.24	62.56
Total stem yield (kg)	2.29	0.52	4.75	1.26	0.26	55.26
Wt. of 100 leaves. (g)	490.43	121.67	1062.53	296.48	60.52	60.45
L:P ratio by length	4.72	3.63	6.88	0.79	0.16	16.76
L:P ratio by wt.	8.21	5.29	11.55	1.55	0.32	18.92
Petiole wt. (g)	0.76	0.15	2.44	0.58	0.12	55.57
Total MC %	72.50	63.78	75.85	2.84	0.58	3.92
MC % after 6 hours	63.11	43.27	70.62	6.70	1.37	10.62
MRC %	66.02	43.69	78.66	9.44	1.93	14.29
Moisture loss (%)	9.39	4.77	20.50	4.12	0.84	43.81
Biomass (kg)	4.41	0.96	8.58	2.39	0.49	54.14
Leaf shoot ratio	0.94	0.52	1.60	0.21	0.04	22.30
Laminar index	87.14	80.48	91.19	2.71	0.55	3.11

Table 10. Better performing exotic accessions for growth and yield parameters in Year-3

Acc. No.	No. of traits	Trait No. (Value)
ME-0135	9	4(27.833),8(12.373),11(3.52),12(3.353),17(75.85),18(70.62),19(76.54),21(6.87), 23(80.78)
ME-0267	9	1(36.333),6(4.167),10(5180),11(3.83),12(4.75),14(5.4),15(9.38),21(8.58),22(0.81)
ME-0285	9	3(3.17),6(3),7(0.2),13(169.77),14(6.88),15(10.98),16(0.21),20(15.19),22(0.63)
ME-0284	8	3(3.72), 5(9.333), 6(3.5), 7(0.2), 9(1.203), 13(121.67), 16(0.15), 20(14.75)
ME-0268	8	1(40), 5(11.3), 7(0.233), 9(1.67), 10(5016), 12(3.923), 21(7), 22(0.79)

Evaluation of MGRs against major insect pests and fungal diseases

Monitoring for pests is a fundamental step in creating proper integrated pest management (IPM) for sustainable sericulture. Insect pests are monitored through a variety of monitoring tools such as pheromone traps, light traps, yellow sticky traps, pitfall traps and suction traps etc. However, the mulberry germplasm concerned insect pests were recorded through visual observation of each accession at fortnight intervals started by 30, 45 and 60th DAP.

I. Chewing insect pests

Identification of mulberry accessions with biotic stress tolerance-related traits associated with insect pests is a prerequisite for developing new mulberry varieties. Towards this direction, 75 mulberry accessions were selected during the 9th phase and infestation variability (CV%) is higher during the rainy season 74.40%, 55.42% of leaf roller, hairy caterpillar and the stem borer infestation variability of summer season (80%) (Table 11) and top-ranking accessions were indicated year-wise showed that resistance to moderate resistance level to insect pests are presented in Table 12.

Table 11. Descriptive statistics for major chewing insect pests in different mulberry germplasm

Insect pests	Seasons	Mean	Min	Max	SD	SE	Variance	CD 5%	CV%
Leaf roller *Diaphania pulverulentalis*	Summer	8.58	2.77	25.00	5.58	1.05	31.13	2.16	64.99
	Rainy	8.60	2.00	27.00	6.40	1.21	40.97	2.48	74.40
	Winter	10.58	2.92	29.67	6.74	1.27	45.47	2.61	63.72
Hairy caterpillar *Spilosoma oblique Euproctis fraterna*	Summer	11.92	3.00	28.00	7.97	1.51	63.52	3.09	66.89
	Rainy	14.24	5.00	34.00	7.89	1.49	62.31	3.06	55.42
	Winter	16.02	7.00	31.00	6.41	1.21	41.08	2.49	40.01
Stem borer *Apriona germari*	Summer	10.67	2.00	28.00	8.53	1.61	72.83	3.31	80.00
	Rainy	13.46	3.00	31.00	9.45	1.79	89.36	3.67	70.22
	Winter	15.23	4.00	34.00	9.32	1.76	86.83	3.61	61.18

Table 12. Evaluation of mulberry genetic resources in different seasonal incidence against major chewing Insect pests and top-ranking accessions

S.N.	Acc. No.	Leaf roller, *Diaphania pulverulentalis* (No. of shoots infested per plant)	Hairy caterpillar[#] (No. of skeletonized leaves per plant)	Stem borer, *Apriona germari* (No of holes present or fecal galleries per plant)
Year-1 (2019)		**Damage Index (%)**		
1.	MI-0838	20.68(4.55)	19.58 (4.42)	28.64 (5.35)
2.	MI-0858	21.65 (4.65)	22.64 (4.76)	29.34 (5.42)
3.	MI-0966	22.64 (4.76)	23.22 (4.82)	30.66 (5.54)
4.	MI-0973	27.49 (5.24)	25.69 (5.07)	31.46 (5.61)
5.	MI-0974	28.46 (5.33)	27.22 (5.22)	33.48 (5.79)

Year-2 (2020)		**Damage Index (%)**		
6.	MI-0997	16.64 (4.08)	19.64 (4.43)	21.64 (4.65)
7.	MI-1000	18.88 (4.35)	22.98 (4.70)	24.86 (4.99)
8.	MI-0985	20.44 (4.52)	24.22 (4.92)	25.18 (5.02)
9.	MI-1006	24.92 (4.99)	25.46 (5.05)	29.66 (5.45)
10.	MI-0992	27.66 (5.26)	27.68 (5.26)	32.68 (5.72)
Year-3 (2021)		**Damage Index (%)**		
11.	ME-0285	18.84 (4.34)	15.48 (3.93)	14.66 (3.83)
12.	ME-0119	22.17 (4.71)	18.64 (4.32)	15.33 (3.92)
13.	ME-0135	24.58 (4.96)	20.28 (4.50)	18.33 (4.28)
14.	ME-0282	27.42 (5.24)	22.49 (4.74)	21.40 (4.63)
15.	ME-0267	29.48 (5.43)	23.84 (4.88)	24.34 (4.93)

[#] Hairy Caterpillar-*Spilosoma obliqua* and Tussock caterpillar, *Euproctis fraterna*

Note: Pooled mean of three seasons in each accession with three replications; Figures in parenthesis are original values; Score value (Damage index):1-10: Highly resistant; 11-20: Moderately resistant 21-30: Tolerance; 31-40: Susceptible; > 40: Highly Susceptible

II. Sucking insect pests

During the project period to evaluate 75 selected accessions against sucking insect pests. In this connection, to explore the tolerant or resistance accessions were screened in the *ex situ* field gene bank of targeted mulberry genotypes. Table 13 revealed that variability of the infestations was more during the summer period of CV 78.4%, 68.93%, 79.91% of mealybugs, thrips and whiteflies respectively and top-ranking accessions were identified and selected based on the calculated percent damage index and it is represented in Table 14.

Table 13. Descriptive statistics for major sucking insect pests

Insect pests	**Seasons**	**Mean**	**Min**	**Max**	**SD**	**SE**	**Variance**	**CD (5%)**	**CV%**
Mealybugs *Maconellicoccus hirsutus & Paracoccus marginatus*	Summer	35.78	2.00	100.00	28.05	3.22	86.85	6.41	78.40
	Rainy	23.91	4.00	89.36	15.64	1.79	44.54	3.57	65.41
	Winter	66.86	0.00	100.00	19.19	2.20	68.41	4.39	28.71
Thrips *Pseudodendrothrips mori*	Summer	5.46	2.92	22.67	3.22	0.37	10.35	0.74	68.93
	Rainy	7.35	2.00	21.33	3.62	0.42	13.12	0.83	49.31
	Winter	5.35	1.26	20.00	2.80	0.32	27.83	0.64	52.28
Whiteflies *Aleurodes* sp.	Summer	11.93	0.00	50.00	9.54	1.09	90.92	2.18	79.91
	Rainy	7.19	3.00	26.00	3.39	0.39	11.52	0.78	47.18
	Winter	10.50	1.00	31.00	6.69	0.77	44.73	1.53	63.70

Table 14. Evaluation of mulberry genetic resources in different seasonal incidences against major sucking insect pests and top-ranking accessions

#	Acc. No.	Mealy bugs[$] (No. of shoots infested per plant)	Thrips, *Pseudodendrothrips mori* (No. of leaves infested per shoot)	Spiraling whitefly, *Aleurodes* sp. (No. of nymph & adults per 3 leaves)
Year-1 (2019)		**Damage Index (%)**		
1.	MI-0857	13.54 (3.68)	14.65 (3.83)	22.67 (4.76)
2.	MI-0837	15.27 (3.91)	20.25 (4.50)	24.66 (4.97)
3.	MI-0962	16.52 (4.06)	22.88 (4.78)	27.16 (5.21)
4.	MI-0973	19.44 (4.41)	24.25 (4.92)	31.22 (5.59)
5.	MI-0966	24.28 (4.93)	26.62 (5.16)	35.88 (5.99)
Year-2 (2020)		**Damage Index (%)**		
6.	MI-0980	10.54 (3.25)	17.56 (4.19)	11.92 (3.45)
7.	MI-0985	11.28 (3.36)	21.78 (4.67)	13.68 (3.70)
8.	MI-1006	13.24 (3.64)	24.48 (4.95)	14.38 (3.79)
9.	MI-1001	19.57 (4.42)	25.82 (5.08)	16.79 (4.10)
10.	MI-0992	24.64 (5.14)	26.96 (5.14)	21.86 (5.19)
Year-3 (2021)		**Damage Index (%)**		
11.	ME-0268	24.84 (4.98)	19.84 (4.45)	29.84 (5.46)
12.	ME-0137	25.31 (5.03)	21.58 (4.65)	30.58 (5.53)
13.	ME-0264	27.11 (5.21)	25.07 (5.01)	33.64 (5.80)
14.	ME-0119	29.48 (5.43)	27.48 (5.24)	34.48 (5.87)
15.	ME-0282	30.92 (5.56)	30.12 (5.49)	39.42 (6.28)

[$]Pink mealybugs (*Maconellicoccus hirsutus*) & Papaya mealybugs (*Paracoccus marginatus*)

Note: Pooled mean of three seasons in each accession with three replications; Figures in parenthesis are original values; Score value (Damage index):1-10: Highly resistant; 11-20: Moderately resistant 21-30: Tolerance; 31-40: Susceptible; > 40: Highly Susceptible.

III. Foliar fungal diseases

Among the mulberry diseases, the leaf spots, leaf rust and powdery mildew are associated with mulberry germplasm are more prone and the incidence of the various seasons was recorded during the project study. The disease incidence observation was recorded each genotype for all the seasons at an interval of fifteen days viz., 30, 45 and 60th days after pruning of mulberry accessions.

The results indicated that all the mulberry accessions were infected with various fungal diseases in the different seasons presented in Table 15. The variability (CV%) of disease incidence is 68.63, 88.17, and 83.65 of summer, rainy and winter season respectively in leaf spot prevalence. The powdery mildew disease was more prevalent (87.39 & 69.45) during the winter season and followed by the rainy season. However, the percent disease index varied across the mulberry accessions were screened under *ex situ* field conditions. The top-ranking accessions were identified and selected based on the calculated percent disease index and it is classified in Table 16.

Table 15: Descriptive statistics for different mulberry genetic resources in different seasonal incidence against major foliar fungal diseases

Fungal diseases	Seasons	Mean	Min	Max	SD	SE	Variance	CD 5%	CV%
Leaf spot, *Cercospora moricola*	Summer	18.85	0.00	53.64	12.94	1.49	167.37	2.98	68.63
	Rainy	15.47	0.12	66.67	13.64	1.58	186.08	3.14	88.17
	Winter	10.11	0.10	55.14	11.37	1.31	129.32	2.62	83.65
Leaf rust, *Cerotolium fici*	Summer	16.87	1.25	57.69	12.52	1.45	156.73	2.88	74.20
	Rainy	61.46	38.31	101.15	13.83	1.60	191.20	3.18	32.50
	Winter	33.63	2.54	85.06	25.28	2.92	638.99	5.82	75.17
Powdery mildew, *Phyllactinia corylea*	Summer	5.36	0.20	31.54	6.28	0.72	39.39	1.44	27.23
	Rainy	20.54	0.00	61.35	14.27	1.65	203.50	3.28	69.45
	Winter	58.38	33.33	107.66	15.90	1.84	252.74	3.66	87.39

Table 16: Evaluation of mulberry genetic resources in different seasonal incidences against major foliar fungal diseases and top-ranking accessions

#	Acc. No.	Leaf spot *Cercospora moricola*	Leaf Rust *Cerotolium fici*	Powdery mildew *Phyllactinia corylea*
Year-1 (2019)		**Disease Index (%)**		
1.	MI-0900	26.46(19.85)	18.85 (10.44)	28.44 (22.68)
2.	MI-0972	27.04 (20.67)	20.74 (12.54)	23.80 (16.29)
3.	MI-0844	29.76 (24.64)	25.58 (18.64)	23.37 (15.74)
4.	MI-0966	29.25 (23.88)	25.75 (18.87)	20.74 (12.54)
5.	MI-0974	29.41 (24.11)	27.19 (20.88)	22.10 (14.16)
Year-2 (2020)		**Disease Index (%)**		
6	MI-0992	25.28 (18.24)	25.80 (18.95)	27.03 (20.66)
7	MI-0985	26.87 (20.44)	26.25 (19.57)	27.86 (21.84)
8	MI-1003	28.57 (22.88)	29.90 (24.86)	28.89 (23.24)
9	MI-0987	30.94 (26.44)	31.07 (26.64)	29.02 (23.44)
10	MI-1000	31.37 (27.11)	63.43 (27.44)	29.89 (24.84)
Year-3 (2021)		**Disease Index (%)**		
11	ME-0285	18.94 (10.54)	20.12 (11.84)	24.96 (17.81)
12	ME-0268	27.57 (21.43)	22.43 (14.57)	31.19 (26.82)
13	ME-0282	30.38 (25.58)	23.95 (16.48)	31.87 (27.87)
14	ME- 0137	31.65 (27.54)	28.30 (22.48)	33.55 (30.54)
15	ME- 0284	32.75 (29.28)	30.87 (26.34)	34.13 (31.48)

Objective: 4 To conserve mulberry genetic resources in the *ex situ* FGB

During the phase 25 new mulberry collections were added and a total of 1317 were conserved in the *ex situ* FGB that comprises 285 exotic and 1032 indigenous mulberry accessions. The details of country and state-wise mulberry germplasm collection (Table 17) are described below:

Table 17. List of country wise and state wise collections of MGRs

SN	National	Nos.
1	Andaman & Nicobar	15
2	Arunachal Pradesh	4
3	Andhra Pradesh + Telangana	10
4	Assam	11
5	Bihar	9
6	Chhattisgarh	4
7	Goa	11
8	Gujarat	16
9	Haryana	13
10	Himachal Pradesh	36
11	Jammu & Kashmir + Leh &Ladak	41
12	Jharkhand	17
13	Karnataka	161
14	Kerala	71
15	Madhya Pradesh	12
16	Maharashtra	33
17	Manipur	12
18	Meghalaya	37
19	Mizoram	8
20	Nagaland	9
21	New Delhi	3
22	Orissa	1
23	Pondicherry	4
24	Punjab	18
25	Rajasthan	65
26	Sikkim	15
27	Tamil Nadu	86
28	Tripura	3
29	Uttar Pradesh	146
30	Uttaranchal	8
	TOTAL	**1032**

SN	International	Nos.
1	Afghanistan	3
2	Australia	2
3	Bangladesh	5
4	China	55
5	Cyprus	1
6	Egypt	3
7	France	32
8	Hungary	1
9	**India**	**1032**
10	Indonesia	8
11	Italy	8
12	Japan	72
13	Myanmar	7
14	Nepal	1
15	Pakistan	8
16	Papua New Guinea	1
17	Paraguay	4
18	Philippines	1
19	Portugal	1
20	Russia	1
21	South Korea	6
22	Spain	2
23	Sri Lanka	2
24	Thailand	11
25	Turkey	1
26	USA	4
27	Venezuela	1
28	Vietnam	5
29	Zimbabwe	11
	Unidentified	28
	GRAND TOTAL	**1317**

Indigenous (1032) + Exotic (285) = 1317

Objective 5: To supply mulberry genetic resources for utilization

During the project period, a total of 1289 mulberry accessions comprising of 257 exotic and 1032 indigenous were supplied to 26 indenters for different purposes like screening for root rot resistance, discovery of QTLs, project works of PG, Ph.D. students, etc were presented in Table 18.

Table 18. Details of mulberry germplasm supply during April-2018 to March-2022

SN	Name of Indenter	No. of accessions			Purpose
		Indigenous	Exotic	Total	
1	The Director CSR&TI, CSB, Mysuru	0	1	1	For yield trial of project PIE 01022 SI
2	The Director SBRL, CSB, Bengaluru	3	8	11	For project of PRP-08002 MI
3	The Scientist-D and Head RSRS, CSB, Jammu	11	2	13	PRT evaluation in project PIB-3629
4	The Director ICAR-IGFRI, Jhansi Uttar Pradesh- 284003.	21	9	30	Evaluation of fodder quality
5	The Professor and Head DOS, GKVK-UAS Bengaluru- 560 065.	47	8	55	PG Education, screening and evaluation of breeding genotypes.
	Supply during 2021-22	**82**	**28**	**110**	

Objective 6: To update the MGIS database

Every season recorded parameters are updated in MGIS database (Fig.1-4) which helps in organizing, storing, retrieving and disseminating the valuable information as per the specific needs of scientists and other stakeholders of sericulture industry. All the data of different accessions evaluated in IX phase (75 nos.) were documented in systematically. The newly uploaded (Table 19) accession information are useful for the crop improvement programme and also organizing, storing, retrieving and disseminating the valuable information as per the specific needs of the concern for the development of new varieties through hybridizations.

Table 19. List of accessions updated to MGIS database

Year wise	List of mulberry accessions updated	New accessions Nos. and passport information added
Year-1	MI-0813, MI-0814, MI-0815, MI-0816, MI-0837, MI-0838, MI-0839, MI-0841, MI-0844, MI-0856, MI-0857, MI-0858, MI-0859, MI-0860, MI-0869, MI-0877, MI-0878, MI-0900, MI-0966, MI-0970, MI-0972, MI-0973, MI-0974, MI-0975 & MI-0977.	MI-1008, MI-1009, MI-1010, MI-1011, MI-1012, MI-1013, MI-1014, MI-1015 and MI-1016,
Year-2	MI-0980, MI-0981, MI-0985, MI-0986, MI-0987, MI-0988, MI-0989, MI-0990, MI-0991, MI-0992, MI-0993, MI-0994, MI-0995, MI-0996, MI-0997, MI-0999, MI-1000, MI-1001, MI-1002, MI-1003, MI-1004, MI-1005, MI-1006 and MI-1007.	Nil
Year-3	ME-0045, ME-0119, ME-0126, ME-0135, ME-0137, ME-0171, ME-0224, ME-0225, ME-0240, ME-0242, ME-0243, ME-0257, ME-0260, ME-0263, ME-0264,	MI-1017, MI-1018, MI-1019, MI-1020, MI-1021, MI-1022, MI-1023, MI-1024, MI-1025, MI-1026, MI-

	ME-0267, ME-0268, ME-0277, ME-0278, ME-0279, ME-0280, ME-0281, ME-0282, ME-0283, ME-0284 and ME-0285.	1027, MI-1028, MI-1029, MI-1030, MI-1031and MI-1032.

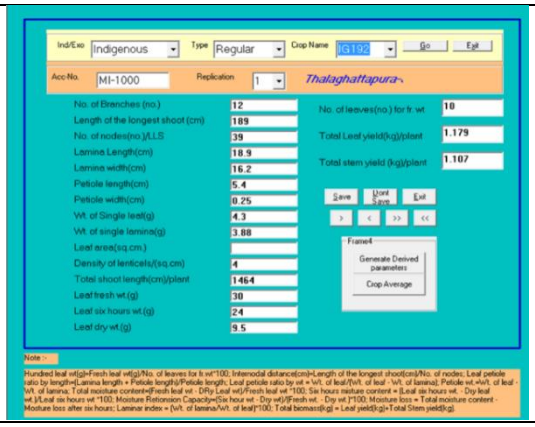


Fig.1- Growth and Yield parameters

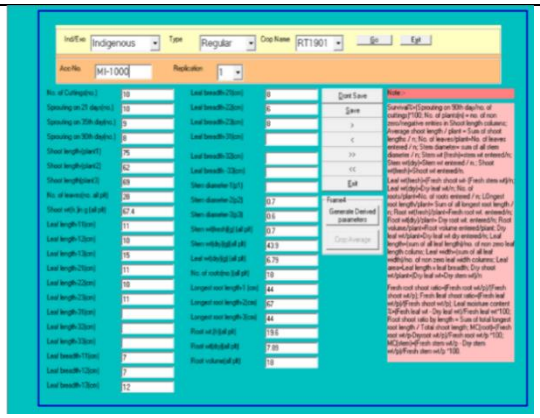


Fig. 2- Reproductive parameters

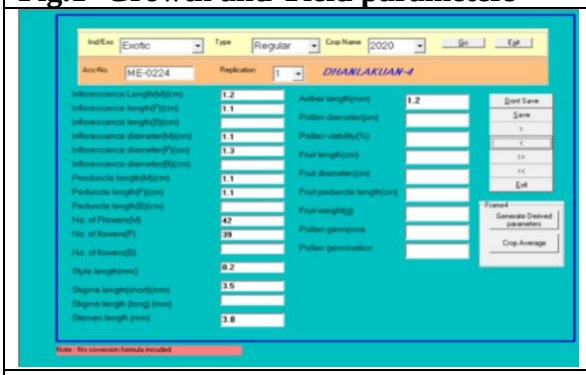


Fig. 3- Propagation Parameters

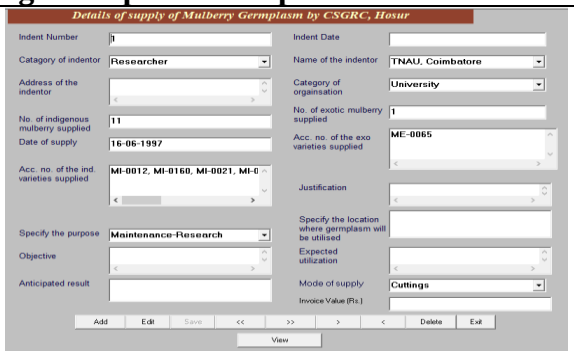


Fig. 4- Supply of mulberry germplasm

AIE-06002MI: Evaluation of bivoltine silkworm genetic resources for tolerance to abiotic stress in selected hotspots (April, 2019 – March, 2022)

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SBRL, Kodathi: *Tulsi Naik K S;* ***REC Chitradurga:*** *Sreenivasulu Y,*
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Introduction

CSGRC Hosur being the exclusive repository of 369 bivoltine accessions, the centre is mandated to maintain, characterize and evaluate the silkworm genetic resources (SWGRs) for identification of better performing breeds which is a continuous process. Many of the bivoltine accessions have been evaluated under various programs, best performers identified and recommended. In light of current rapid vagaries of climatic changes, regular screening of available bivoltine germplasm resources under various abiotic stress conditions is the need of the hour. In this context, it is proposed to screen selected bivoltine accessions and identify accessions tolerant to high temperature using SSR markers identified for thermo tolerance. Based on the screening results, around 10 promising bivoltine accessions with marker linked to thermo tolerance and better economic traits will be selected and evaluated under different agroclimatic conditions *viz.* Tropical -High temperature and low humidity under RSRS, Jammu and REC Chitradurga; Sub tropical - High temperature and high

humidity under RSRS Jammu and Temperate under CSRTI, Berhampore. The identified better bivoltine performers tolerant to abiotic stress will be recommended so as to provide wider choice for breeders to include in breeding programmes aimed at development of improved hybrids for commercial use.

Objectives:

- To screen and select bivoltine germplasm resources with the presence of markers linked to thermo tolerance.
- To evaluate selected bivoltine germplasm resources against abiotic stress and identify suitable bivoltine breeds to target selected hot spots

Methodology:

Objective 1: To screen and select bivoltine germplasm resources with presence of markers linked to thermo tolerance (First year)

All the bivoltine silkworm germplasm resources available at CSGRC, Hosur, was assessed, based on the economic parameters viz. ERR/No., ERR/wt. (kg), Pupation rate %, Single cocoon wt. (g), Single shell wt. (g) and Shell ratio %, Average filament length and denier, 40 bivoltine accessions were shortlisted (Table-20).

Table 20: Details of the short listed bivoltine germplasm accessions

#	Accn. No	Wt. of 10 larvae(g)	ERR/ No.	ERR/10000 By wt. (kg)	Pupation rate (%)	Single cocoon wt(g)	Single shell wt(g)	SR%
1	BBE-0026 NAN NAUNG 6D	30.278±2.29 (18.49)	9729±85.87 (2.16)	11.842±0.70 (14.53)	95.228±1.14 (2.94)	1.285±0.05 (8.91)	0.196±0.01 (17.87)	15.125±0.58 (9.33)
2	BBE-0030 SANISH E1(P)	31.667±1.92 (14.87)	9660.667±141.9 (3.60)	13.208±0.77 (14.30)	96.292±1.48 (3.77)	1.244±0.04 (6.97)	0.199±0.01 (10.46)	15.973±0.39 (6.01)
3	BBI-0044 (NB4D2)	33.302±1.51 (11.10)	9618.833±85.36 (2.17)	13.275±0.35 (6.46)	94.458±1.14 (2.95)	1.323±0.029 (5.46)	0.236±0.01 (5.72)	17.842±0.58 (8.02)
4	BBI-0086 (KPG-A)	29.675±1.59 (13.13)	9705.333±88.18 (2.23)	12.317±1.15 (22.78)	95.945±0.85 92.16)	1.279±0.04 (7.79)	0.212±0.01 (12.05)	16.526±0.43 (6.37)
5	BBI-0133 (AT-4)	32.43±1.67 (12.62)	9512.167±177.5 (4.57)	12.425±0.51 (10.14)	96.753±0.56 (1.42)	1.383±0.04 (6.33)	0.258±0.01 (11.29)	18.611±0.44 (5.73)
6	BBI-0137 (IB-9)	34.233±1.74 (12.42)	9740.5±49.69 (1.25)	14.625±0.77 (12.83)	94.692±1.18 (3.05)	1.454±0.06 (9.90)	0.277±0.01 (12.70)	19.004±0.40 (5.14)
7	BBE-0167 KyorieshimPaku(P)	36.142±0.60 (4.06)	9643.667±83.21 (2.11)	13.733±0.50 (8.96)	95.065±1.13 (2.90)	1.446±0.02 (2.69)	0.308±0.01 (7.55)	21.266±0.51 (5.82)
8	BBE-0183 (CSGRC-1)	35.463±1.51 (10.45)	9595±92.89 (2.37)	13.583±0.56 (10.05)	93.828±0.99 (2.57)	1.43±0.03 (4.84)	0.263±0.01 (10.98)	18.357±0.57 (7.57)
9	BBE-0184 (CSGRC-2)	36.585±1.63 (10.91)	9696±153.78 (3.88)	14.258±0.69 (11.93)	97.503±0.57 1.43)	1.483±0.06 (9.28)	0.28±0.01 (11.53)	18.897±0.49 (6.28)
10	BBE-0187 (CSGRC-5)	38.298±2.33 (14.92)	9236±217.38 (5.77)	13.992±0.64 (11.15)	89.132±3.39 (9.32)	1.452±0.06 (9.41)	0.259±0.01 (11.80)	17.827±0.53 (7.21)
11	BBE-0197 (A)	37.352±1.88 (12.30)	9648.5±82.46 (2.09)	15.333±0.77 (12.32)	94.86±1.13 (2.92)	1.509±0.08 (12.89)	0.274±0.02 (14.93)	18.083±0.34 (4.65)
12	BBE-0222 (JC2M)	40.188±1.89 (11.20)	9668.833±129.63 (3.28)	16.55±0.64 (9.41)	94.433±1.68 (4.35)	1.564±0.06 (9.58)	0.271±0.01 (8.41)	17.348±0.20 (2.78)
13	BBE-0272 (G146)	37.385±1.54 (10.08)	9524.5±153.59 (3.95)	15.517±1.25 (19.70)	91.748±1.86 (4.96)	1.526±0.06 (10.02)	0.309±0.02 (13.33)	20.178±0.28 (3.45)
14	BBI-0299 (NS6)	38.523±1.299 (8.20)	9722.5±129.22 (3.26)	15.042±0.73 (11.82)	95.085±1.05 (2.70)	1.518±0.08 (12.53)	0.287±0.02 (13.43)	18.895±0.44 (5.73)
15	BBI-0301 (YS7)	38.235±1.68 (10.75)	9273.833±240.19 (6.34)	15.825±0.69 (10.76)	91.767±3.13 (8.34)	1.535±0.03 (4.85)	0.267±0.01 (11.41)	17.386±0.56 (7.91)
16	BBI-0303 (KSO-1)	36.813±1.46 (9.73)	9701.5±103.48 (2.61)	15.15±0.61 (9.93)	95.505±1.31 (3.36)	1.608±0.06 (8.35)	0.299±0.02 (12.73)	18.549±0.48 (6.33)
17	BBI-0334 (APS-4)	37.703±1.08 (6.54)	9735.167±54.446 (1.37)	16.233±1.05 (15.91)	95.058±1.14 (2.94)	1.48±0.03 (5.20)	0.296±0.01 (8.00)	19.998±0.58 (7.07)
18	BBI-0336	37.842±1.26	9543.833±116.5	15.733±0.72	92.022±2.6	1.529±0.04	0.284±0.01	18.544±0.25

	(APS-8)	(8.14)	6 (2.99)	(11.18)	3 (7.01)	(5.66)	(6.82)	(3.36)
19	BBI-0338 (DD-1)	39.78±0.97 (5.99)	9432.667±176.21 (4.58)	16.417±0.81 (12.13)	92.238±1.94 (5.16)	1.564±0.03 (5.12)	0.317±0.01 (7.44)	20.313±0.68 (8.19)
20	BBI-0339 (DD-2)	39.373±1.61 (10.01)	9678±70.69 (1.79)	16.092±0.85 (12.95)	93.915±1.64 (4.29)	1.595±0.03 (4.48)	0.323±0.01 (6.01)	20.255±0.35 (4.21)
21	BBI-0341 (NK-1)	38.894±0.96 (5.52)	9452.5±121.26 (3.14)	15.225±0.62 (10.00)	92.848±1.17 (3.09)	1.528±0.04 (6.13)	0.277±0.01 (7.15)	18.152±0.25 (3.38)
22	BBI-0342 (NK-2)	38.667±1.61 (10.18)	9672.333±95.82 (2.43)	13.883±1.21 (21.41)	93.253±1.59 (4.18)	1.493±0.04 (7.03)	0.283±0.01 (10.76)	18.921±0.48 (6.26)
23	BBI-0343 (NK-3)	40.253±1.54 (9.36)	9721.667±73.62 (1.86)	16.167±0.60 (9.07)	94.235±1.33 (3.47)	1.605±0.05 (8.31)	0.29±0.01 (10.65)	18.064±0.21 (2.90)
24	BBI-0344 (NP-4)	41.91±0.94 (5.51)	9601.833±90.27 (2.30)	17.675±1.14 (15.80)	93.775±1.20 (3.13)	1.698±0.03 (4.66)	0.341±0.01 (7.00)	20.112±0.44 (5.31)
25	BBI-0345 (NP-5)	39.083±1.02 (6.41)	9493.667±131.19 (3.38)	16.733±0.75 (10.94)	92.353±1.63 (4.32)	1.632±0.04 (5.44)	0.293±0.01 (8.95)	17.955±0.44 (5.95)
26	BBI-0346 (KSO-2)	36.737±1.17 (7.77)	9668±54.241 (1.37)	14.942±1.11 (18.20)	94.877±0.96 (2.47)	1.49±0.07 (10.74)	0.287±0.01 (8.73)	19.271±0.21 (2.70)
27	BBI-0347 (KSO3)	37.397±1.08 (7.08)	9778.833±76.44 (1.91)	14.95±1.04 (17.09)	96.802±0.64 (1.61)	1.528±0.06 (9.16)	0.309±0.01 (10.85)	20.188±0.39 (4.67)
28	BBI-0349 (HND)	40.682±1.78 (10.71)	9463.833±194.54 (5.04)	16.425±1.38 (20.57)	93.108±2.03 (5.34)	1.613±0.07 (11.31)	0.324±0.01 (10.07)	20.111±0.45 (5.46)
29	BBI-0350 (HDO)	37.598±1.14 (7.43)	9544.5±129.93 (3.33)	14.575±0.32 (5.34)	92.942±2.08 (5.48)	1.509±0.03 (5.40)	0.283±0.01 (8.86)	18.721±0.51 (6.65)
30	BBI-0358 (CSR-26)	31.097±2.85 (22.33)	9717.667±136.05 (3.43)	13.55±0.59 (10.75)	95.222±2.09 (5.36)	1.282±0.10 (18.19)	0.233±0.02 (20.39)	18.122±0.23 (3.12)
31	BBI-0359 (CSR-27)	36.205±1.83 (12.38)	9696.667±66.38 (1.68)	13.743±0.83 (14.83)	94.763±1.2 (3.10)	1.387±0.08 (13.26)	0.283±0.01 (12.43)	20.395±0.19 (2.29)
32	BBI-0360 (A3)	39.178±1.65 (10.31)	9411.833±195.05 (5.08)	14.842±0.55 (9.04)	89.657±3.84 (10.49)	1.604±0.07 (10.76)	0.307±0.02 (15.06)	19.076±0.39 (5.02)
33	BBI-0361 (A-CHINESE)	36.59±1.74 (11.63)	9682.667±99.69 (2.52)	15.592±0.65 (10.17)	94.478±1.24 (3.20)	1.535±0.06 (9.80)	0.301±0.01 (10.88)	19.603±0.39 (4.81)
34	BBI-0363 (BHT)	37.463±1.48 (9.69)	9234.5±249.40 (6.62)	14.783±0.51 (8.36)	89.505±2.45 (6.70)	1.545±0.06 (9.66)	0.312±0.02 (13.90)	20.123±0.52 (6.33)
35	BBI-0364 (GHT)	37.543±1.44 (9.36)	9494.167±184.20 (4.75)	15.258±0.87 (13.98)	91.283±2.62 (7.03)	1.511±0.06 (10.35)	0.312±0.02 (12.52)	20.63±0.38 (4.51)
36	BBI-0367 (H-281)	38.602±1.42 (9.03)	9320.667±150.47 (3.95)	14.217±0.99 (17.07)	89.843±2.55 (6.95)	1.555±0.05 (7.30)	0.295±0.02 (12.29)	18.896±0.54 (7.00)
37	BBI-0369 (935 E)	35.935±0.66 (4.48)	9688±67.19 (1.70)	15.092±0.61 (9.85)	94.918±0.51 (1.33)	1.476±0.01 (4.73)	0.291±0.01 (4.72)	19.718±0.40 (5.01)
38	BBI-0370 (SL WU-8)	36.522±0.91 (6.07)	9801.667±28.62 (0.72)	15.692±0.88 (13.77)	96.747±0.87 (2.19)	1.471±0.01 (4.50)	0.299±0.01 (5.04)	20.332±0.36 (4.31)
39	BBI-0377 (APS-12)	37.188±1.02 (6.72)	9614.167±107.47 (2.74)	15.142±0.89 (14.39)	91.825±2.85 (7.59)	1.564±0.04 (6.16)	0.31±0.01 (7.71)	19.786±0.23 (2.80)
40	BBI-0378 (APS-45)	37.012±1.63 (10.78)	9615.667±115.9 (2.95)	16.475±1.30 (19.35)	94.952±1.18 (3.05)	1.564±0.03 (4.25)	0.314±0.02 (13.61)	20.07±1.07 (3.11)

These bivoltine accessions were further screened with SSR markers linked to thermo-tolerance, viz. LFL329; LFL1123; SO809; SO813 (Moorthy *et al*.,2013; Chandrakanth *et al*.,2015) at Seribiotech Research Laboratory, Kodathi and 10 bivoltine accessions showing thermotolerance were selected (Table-21).

Table 21: Details of the microsatellite loci, forward and reverse flanking primer sequences, allelic size

Sl. No	Primer	Locus	Sequence `5-`3	Tolerant allele size	Susceptible allele size
1	1123	LFL1123	FP-AAGTTCTTTACCAGTTCACAGACAGC	230 bp	250 bp
			RP-CGCCATGCAACTGTCGTCAC		
2	0329	LFL0329	FP-GAAATCCGTTTGAAGAATCCACA	200 bp	230 bp
			RP-CATCCGTTGAATGAGTATCGTTTG		
3	S0809	LFL0407	FP-AACATTTGCTTAGGACTGAATTTACAC	230 bp	200 bp
			RP-AATAATAACTTTTACACGCACCTACACTT		
4	S0813	S0813	FP-CCAGGAAATTCCAACCAGTAGCC	520 bp	<500 bp
			RP-ACTTACCACTACACCAGACGGAC		

Objective 2: To evaluate selected bivoltine germplasm resources against abiotic stress and identify suitable bivoltine breeds to target selected hot spots (2^{nd} /3^{rd}year)

Ten bivoltine silkworm accessions with selected thermo-tolerant characters were used for field trials at designated centres of Central Silk Board and analysed the silkworm rearing and silk reeling performance under different environmental stress conditions (Table-22).

Table 22. Details of the trial rearings at different test centres

#	Schedule of activities
1	1^{st} and 2^{nd} trial rearing and reeling of short listed 10 bivoltine accns. at CSGRC,Hosur, RSRS, Jammu and REC, Chitradurga (High temperature and low humidity).
2	1^{st} and 2^{nd} trial rearing and reeling of short listed 10 bivoltine accns. at CSGRC,Hosur, RSRS,Jammu (Moderate temperature and high humidity).
3	1^{st} and 2^{nd} trial rearing and reeling of short listed 10 bivoltine accns. at CSRTI Berhampore (Moderate temperature and high humidity).
4	Collection and consolidation of data on the 1^{st} and 2^{nd} trial rearing and reeling performance from all the test centres, subjecting the data to statistical analysis. Final report preparation.

Results:

Objective 1: To screen and select bivoltine germplasm resources with presence of markers linked to thermo-tolerance.

Based on the overall screening results obtained by utilizing LFL329; LFL1123; SO809; SO813,8 accessions that are showing 100% thermo tolerant and 2 accessions showing >85% thermo tolerant were shortlisted and further grouped into two, i.e. the accessions spinning oval cocoons- BBI-0086 (KPG-A), BBE-0184 (SMGS-2), BBI-0301 (YS-7) and BBI-0339 (DD-2) and the accessions spinning dumbbell cocoons- BBI-0044 (NB4D2), BBI-0334 (APS-4), BBI-0336 (APS-8), BBI-0338 (DD-1), BBI-0343 (NK3) and BBI-0358 (CSR26) (Table-23& Fig.5-9).

Table 23. Details of the selected bivoltine accessions with the presence of thermo-tolerance corresponding to the markers

Sl No.	**Accn No**	**Accn. Name**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**% of tolerance**
	Marker - 1123										
1	BBI-0086	KPG-A	AA	AA	AA	AA	AA	AA	AA	AA	100%
2	BBI-0358	CSR-26	AA	AA	AA	AA	AA	AA	AA	AA	100%
	Marker-S0329										
3	BBI-0044	NB4D2	AA	AA	AA	AA	AA	AA	AA	AA	87%
4	BBE-0184	SMGS-2	AA	AA	AA	AA	AA	AA	AA	AA	87%
	Marker-S0809										
5	BBE-0184	SMGS-2	AA	AA	AA	AA	AA	AA	AA	AA	100%
6	BBI-0301	YS-7	AA	AA	AA	AA	AA	AA	AA	AA	100%
7	BBI-0334	APS-4	AA	AA	AA	AA	AA	AA	AA	AA	100%
8	BBI-0336	APS-8	AA	AA	AA	AA	AA	AA	AA	AA	100%
9	BBI-0338	DD-1	AA	AA	AA	AA	AA	AA	AA	AA	100%
10	BBI-0339	DD-2	AA	AA	AA	AA	AA	AA	AA	AA	100%
11	BBI-0343	NK-3	AA	AA	AA	AA	AA	AA	AA	AA	100%
	Marker-S0813										
12	BBI-0086	KPG-A	AA	AA	AA	AA	AA	AA	AA	AA	100%

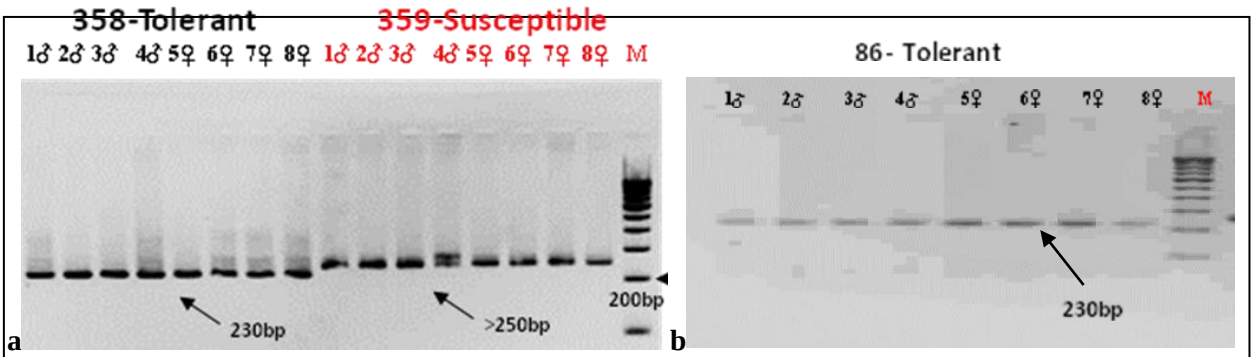


Fig.5. Amplification of SSR marker (LFL1123) in thermo-tolerant BBI-00358and BBI-0086

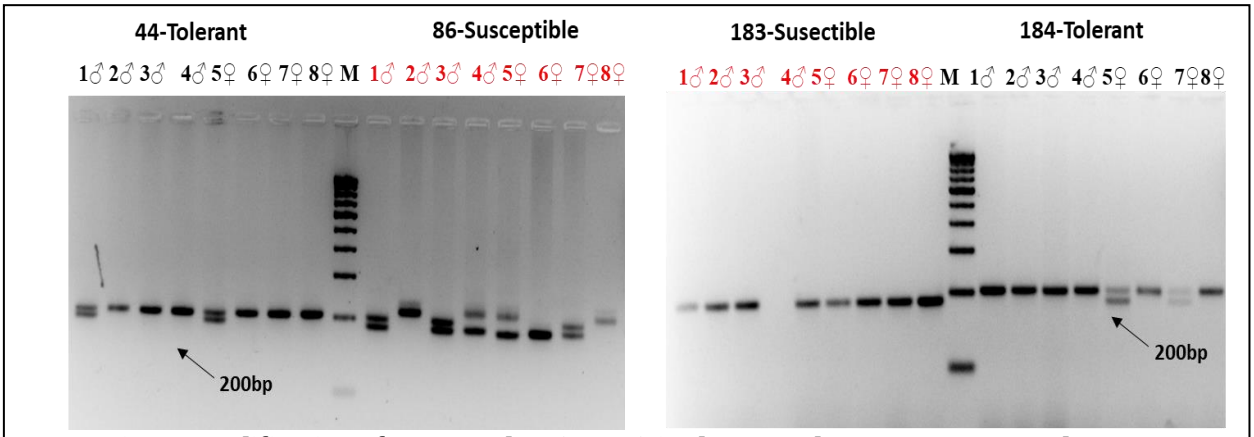


Fig.6. Amplification of SSR marker (S0329) in thermo-tolerant BBI-0044 and BBI-0184

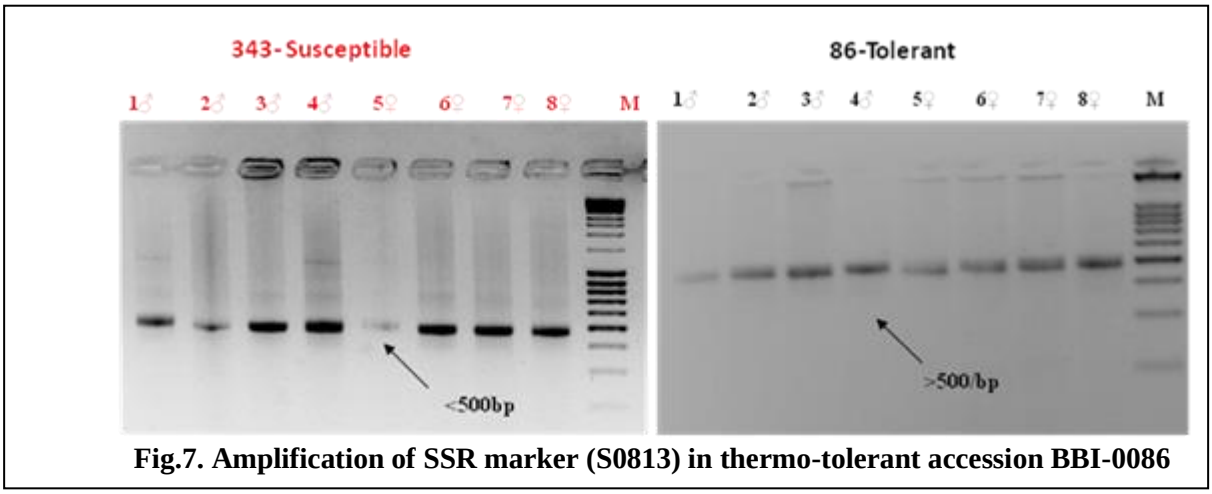


Fig.7. Amplification of SSR marker (S0813) in thermo-tolerant accession BBI-0086

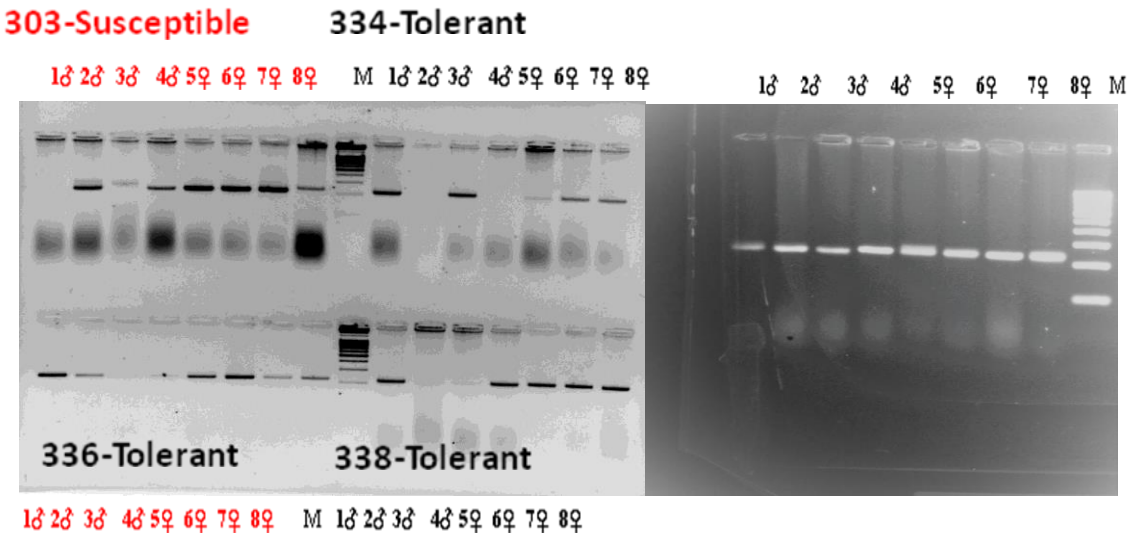


Fig.8: Amplification of SSR marker (S0809) in thermo-tolerant BBE-0184, BBI-0301, BBI-0334, BBI-0336, BBI-0338 and BBI-0343 (res. allele size: 230 bp)

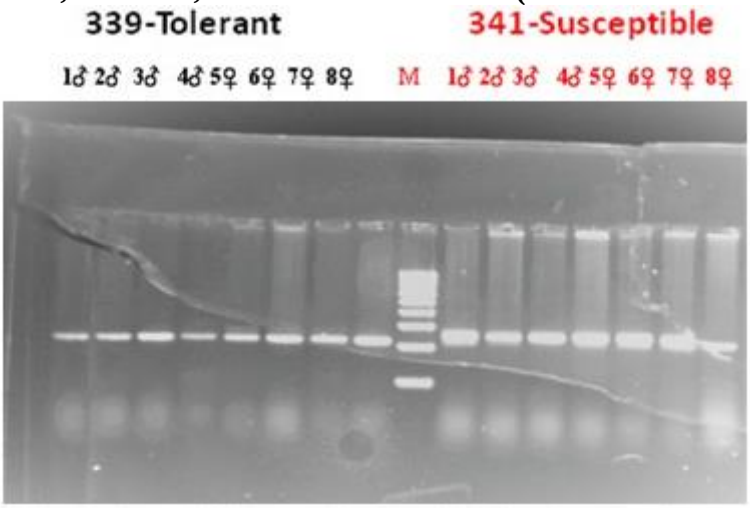


Fig.9: Amplification of SSR marker (S0809) in thermo-tolerant accession BBI-0339 (res. allele size: 230 bp)

Objective 2: To evaluate selected bivoltine germplasm resources against abiotic stress and identify suitable bivoltine breeds to target selected hot spots

Identified bivoltine accessions were evaluated under different agro-climatic conditions *viz.* RSRS, Jammu and REC Chitradurga-High temperature and low humidity; RSRS Jammu - Moderate temperature and high humidity and Moderate temperature and high humidity under CSRTI, Berhampore. The rearing trials were taken up at REC, Chitradurga - April-May'2020 and March-April'2021; RSRS Jammu- June-July'2021 and Sept-Oct'2021, CSR&TI, Berhampore- October-November'2021 and February-March'2022. Rearing trials were conducted simultaneously at CSGRC, Hosur corresponding to each rearing trials conducted at different centres.

Analysed results on the location-wise performance of the oval bivoltine accessions as well as accessions-wise performance irrespective of the locations are presented in Table 24. Among the oval bivoltine accessions evaluated at all centres, the accession YS-7 recorded highest pupation rate (74.76%) and lowest pupation rate was recorded with CSR2 (55.64%).

Table 24. Performance of the oval bivoltine accessions across the locations/seasons

Locations	Larval wt. (g)	ERR/No.*	ERR/wt (kg)	Pupation rate (%)	SCW (g)	SSW (g)	SR (%)
Berhampore	25.72	3852.0(3.47)	4.62	38.52	1.276	0.227	17.83
Chitradurga	38.15	8559.0(3.93)	11.67	83.05	1.418	0.238	16.52
Jammu	42.16	6674.7(3.75)	9.73	61.51	1.466	0.275	18.94
Hosur	40.75	9204.3(3.96)	13.54	91.46	1.610	0.305	18.93
CD@5% (Locations)	**0.793**	**478.0**	**0.599**	**4.506**	**0.042**	**0.008**	**0.364**
Accessions							
KPG-A	34.40	7266.6(3.82)	9.65	70.36	1.286	0.219	17.05
SMGS-2	36.09	7416.3(3.81)	10.13	72.00	1.444	0.260	17.85
YS-7	38.57	7703.7(3.88)	11.22	74.76	1.545	0.271	17.52
DD-2	36.54	7247.5(3.79)	10.37	70.40	1.468	0.274	18.55
CSR2 (c)	37.88	5728.3(3.59)	8.08	55.64	1.470	0.284	19.30
CD@5%(Accessions)	**0.886**	**534.4**	**0.670**	**5.037**	**0.046**	**0.009**	**0.407**
CD @ 5% Location x Accession	**1.772**	**1068.9**	**1.339**	**10.075**	**0.093**	**0.019**	**0.814**

*values in parenthesis are log-transformed values

In case of dumbbell bivoltine accessions, the performance of the accessions irrespective of the locations and seasons are depicted in Table 25. It was found that maximum pupation rate was recorded with DD-1 (81.39%) with 1.480g single cocoon wt., 0.279g single shell wt. followed by APS-4 (pupation rate 78.75%), single cocoon wt. 1.443g and single shell wt. of 0.260g. However overall performance of dumbbell bivoltine accessions is better compared to oval bivoltine accessions.

Table 25:Performance of the dumbbell bivoltine accessions across the locations/accns.

Locations	Larval wt. (g)	ERR/No.*	ERR/wt (kg)	Pupation rate (%)	SCW (g)	SSW (g)	SR (%)
Berhampore	28.36	5312.0(3.68)	7.35	52.68	1.228	0.222	18.13
Chitradurga	35.04	8177.6(3.91)	11.48	78.82	1.411	0.245	17.18
Jammu	41.57	7640.0(3.85)	10.91	70.96	1.457	0.263	18.15
Hosur	40.38	9247.6(3.97)	13.72	91.95	1.657	0.319	19.25
CD@5% (Locations)	**0.504**	**0.021**	**0.432**	**2.908**	**0.020**	**0.006**	**0.346**
Accessions							
NB4D2	36.26	7445.6(3.83)	9.82	71.72	1.287	0.227	17.69
APS-4	36.07	8080.2(3.90)	11.22	78.75	1.443	0.260	17.95
APS-8	35.87	7996.7(3.89)	11.14	77.68	1.461	0.271	18.48
DD-1	36.68	8360.0(3.91)	11.86	81.39	1.480	0.279	18.78
NK-3	36.22	7420.8(3.85)	10.44	71.65	1.505	0.273	17.99
CSR26	34.96	7369.7(3.84)	11.26	70.66	1.408	0.253	17.84
CSR4	38.31	6487.2(3.73)	10.32	63.36	1.482	0.275	18.51
CD@5% (Accessions)	**0.667**	**0.028**	**0.572**	**3.847**	**0.027**	**0.008**	**0.458**
CD @ 5% Location x Accession	**1.334**	**0.056**	**1.144**	**7.694**	**0.053**	**0.015**	**0.916**

*values in parenthesis are log transformed values

Reeling performance:

The reeling performance of the bivoltine accessions reared at CSR&TI, Berhampore, REC, Chitradurga, RSRS, Jammu and CSGRC, Hosur are as follows:

CSR&TI Berhampore: Reeling parameters of bivoltine accessions reared, the accessions APS-4 with AFL 797 m, with 69.28 % reelability and 69.40 % raw silk recovery followed by NK3 with average filament length of 738 m with 70.65 % reelability and 69.08% raw silk recovery (Table 26).

Table 26: Reeling performance of bivoltine accessions reared at CSR&TI, Berhampore

Accn. no.	Accn. name	Avg. filament length (m)	Fil.size (d)	Renditta (kg)	Reelability (%)	Raw silk Recovery (%)	Neatness (%)
BBI-0086	KPG-A	662.50	2.13	9.27	69.89	70.38	92.50
BBI-0301	YS-7	661.00	2.09	7.82	76.17	74.24	92.50
BBI-0339	DD2	569.50	2.14	7.64	69.36	67.29	92.50
BBI-0044	NB4D2	614.00	1.72	9.29	66.37	63.55	90.00
BBI-0334	APS-4	797.00	2.15	8.34	69.28	69.40	92.50
BBI-0336	APS-8	582.50	2.08	9.38	66.36	61.73	87.50
BBI-0338	DD1	671.50	2.06	8.84	67.56	62.05	90.00
BBI-0343	NK3	738.00	2.02	9.00	70.65	69.08	92.50
BBI-0358	CSR26	639.00	1.96	9.24	66.99	57.11	90.00
BBI-0371	SK6	596.00	2.41	10.18	68.92	61.18	90.00
BBI-0372	SK7	602.00	2.43	10.28	69.96	60.48	90.00
Average		648.45	2.11	9.03	69.23	65.14	90.91
SD		69.09	0.20	0.84	2.75	5.24	1.69
CV %		10.66	9.27	9.33	3.97	8.04	1.85

REC, Chitradurga (Unit of CSR&TI, Mysuru): At REC, Chitradurga, among the accessions evaluated, NB4D2 has recorded average filament length of 773.01 m with 82.46% reelability and 63.72% of raw silk recovery followed by DD2 with average filament length of 756.81 m with 83.49% of reelability and raw silk recovery of 57.69% (Table 27).

Table 27: Reeling performance of bivoltine accessions reared at REC, Chitradurga

Accn. no.	Accn. name	Avg. filament length (m)	NBFL (m)	Fil. size (d)	Reelability (%)	Renditta (kg)	Raw silk (%)	Raw silk recovery (%)
BBI-0086	KPG-A	740.33	636.86	2.59	83.21	7.63	15.60	61.22
BBI-0301	YS-7	740.22	634.34	2.59	83.54	7.42	15.47	62.83
BBI-0339	DD2	756.81	653.67	2.53	83.49	7.77	14.38	57.69
BBI-0044	NB4D2	773.01	654.99	2.63	82.46	7.49	16.18	63.72
BBI-0334	APS-4	740.53	622.02	2.60	82.92	7.42	13.81	62.47
BBI-0336	APS-8	751.45	643.24	2.54	82.32	7.69	14.09	63.22
BBI-0338	DD1	746.96	630.39	2.60	82.16	7.79	14.35	58.54
BBI-0343	NK3	726.29	614.05	2.65	81.22	8.30	14.50	51.72
BBI-0358	CSR26	748.13	625.61	2.60	82.36	7.85	14.92	57.96
BBI-0290	CSR2	785.15	690.10	2.64	85.00	7.90	14.60	68.75
BBI-0291	CSR4	719.17	664.56	2.69	81.33	7.48	14.12	66.45
Average		748.01	642.71	2.61	82.73	7.70	14.73	61.33
SD		18.91	21.89	0.05	1.08	0.26	0.74	4.68
CV %		2.53	3.41	1.78	1.30	3.41	4.99	7.63

RSRS, Jammu (CSR&TI Pampore): AtRSRS, Jammu, APS-4 has recorded average filament length of 737.50, with reelability of 70.75%, raw silk of 24.38% followed by DD2 with average filament length of 730.00 m, reelability 74.03 % and raw silk 25.99% (Table 28).

Table 28. Reeling performance of bivoltine accessions reared at RSRS, Jammu

Accn. no.	Accn. name	Avg. filament length (m)	NBFL (m)	Fil.size (d)	Renditta (kg)	Reelability (%)	Raw silk (%)
BBI-86	KPG-A	650.00	492.50	2.42	5.81	60.55	17.54
BBI-184	SMGS-2	642.00	409.00	2.61	4.75	63.88	21.45
BBI-301	YS-7	621.50	412.50	2.45	4.87	70.81	21.32
BBI-339	DD2	730.00	537.50	2.64	4.27	74.03	25.99
BBI-44	NB4D2	670.50	614.00	2.44	4.17	34.96	24.18
BBI-334	APS-4	737.50	552.50	2.49	4.23	70.75	24.38
BBI-336	APS-8	727.50	565.00	2.53	4.07	70.87	26.00
BBI-338	DD1	630.50	403.50	2.48	4.03	67.68	25.19
BBI-343	NK3	525.50	330.00	2.33	5.59	63.35	18.92
BBI-358	CSR26	676.50	470.00	2.53	4.06	74.05	25.32
BBI-290	CSR2	720.00	543.50	2.51	3.64	68.51	27.77
BBI-291	CSR4	635.00	486.50	2.39	5.26	62.61	19.25
Average		663.87	484.71	2.49	4.56	65.17	23.11
SD		60.87	82.99	0.09	0.69	10.51	3.30
CV %		9.17	17.12	3.54	15.08	16.13	14.28

CSGRC, Hosur: At CSGRC, Hosur, DD2 has recorded average filament length of 862.87 m with 81.19 % of reelability and raw silk % of 14.90 followed by NB4D2 with average filament length of 853.59 m, 84.86% of reelability and 14.86 % raw silk (Table 29).

Table 29. Reeling performance of bivoltine accessions reared at CSGRC, Hosur

Accn. no.	Accn. name	Avg. filament length (m)	Denier	Reelability (%)	Renditta (kg)	Raw silk (%)
BBI-0044	NB4D2	853.59	2.45	84.86	6.78	14.86
BBI-0086	KPG-A	779.01	2.37	78.08	7.60	13.28
BBE-0184	SMGS-2	800.73	2.73	85.50	6.51	15.62
BBI-0290	CSR2	790.47	3.18	64.53	6.60	15.35
BBI-0291	CSR4	781.42	2.64	74.95	6.79	14.84
BBI-0301	YS-7	759.92	2.76	68.30	7.63	13.42
BBI-0334	APS-4	837.63	2.43	83.47	8.03	13.00
BBI-0336	APS-8	853.04	2.52	77.91	7.23	14.00
BBI-0338	DD1	829.40	2.61	77.80	7.65	13.27
BBI-0339	DD2	862.87	2.58	81.19	6.77	14.90
BBI-0343	NK3	760.76	2.68	80.68	7.73	12.96
BBI-0358	CSR26	843.27	2.54	76.41	7.62	13.48
Average		812.68	2.62	77.81	7.25	14.08
SD		38.00	0.21	6.31	0.53	0.97
CV %		4.68	8.08	8.11	7.25	6.89

In order to evaluate the location-wise (centre-wise) contributions of each parameter in the rearing performance of the bivoltine accessions, the rearing data of the oval and dumbbell bivoltine accessions were subjected for Principal Component Analysis (PCA) to identify the centre wise better performing oval and dumbbell accessions. Based on the PCA the bivoltine accessions at CSR&TI, Berhampore revealed that, the accession APS-4 followed by APS-8 were correlated with ERR/No., ERR/wt (kg) and Pupation Rate. Whereas YS-7 followed by DD-1 were positively correlated with single cocoon weight., single shell weight and larval weight (Fig.10).

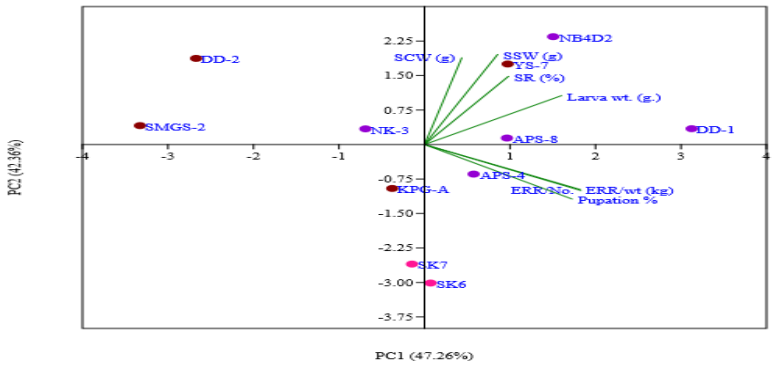


Fig. 10: PCA of the bivoltine accessions tested under CSR&TI, Berhampore

Among the oval bivoltine accessions tested at REC,Chitradurga, SMGS-2 has positive correlation with ERR/No. and pupation rate (%) whereas YS-7 has correlation with single cocoon weight, single shell weight and ERR/ weight (Fig-11). Among dumbbell bivoltine accessions, APS-4 has correlation with ERR/No. and pupation rate (%) (Fig-12).

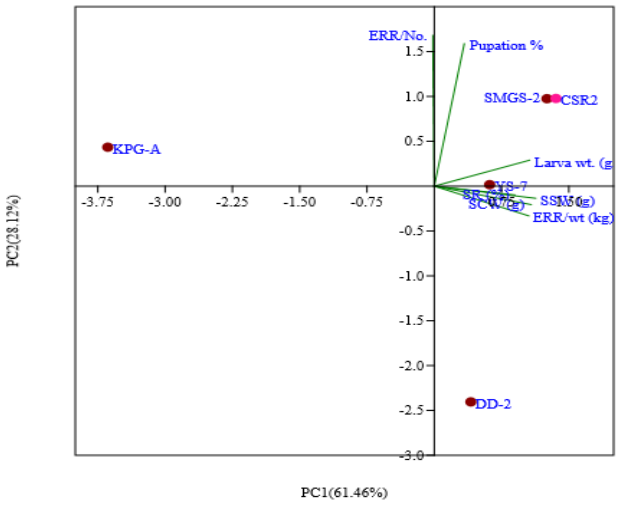


Fig.11: PCA of the oval bivoltine accessions tested under REC Chitradurga

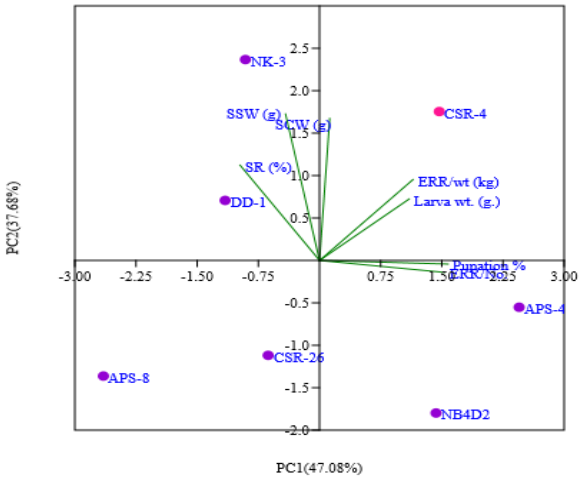


Fig.12: PCA of the dumbbell bivoltine accessions tested under REC, Chitradurga

At RSRS, Jammu, out of oval bivoltine accessions evaluated YS-7 has positive correlation with larval wt., single cocoon wt., single shell wt. whereas SMGS-2 followed by DD2 has correlation with ERR/No. and pupation rate (%) (Fig.13). With regard to dumbbell bivoltine accessions DD1 and APS-8 has correlation with ERR/No. and pupation rate (%). However CSR26 has positive correlation with single shell wt. and shell ratio (%) (Fig.14).

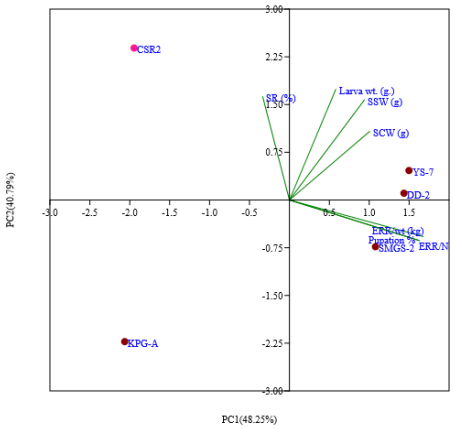


Fig.13: PCA of the oval bivoltine accessions tested under RSRS Jammu

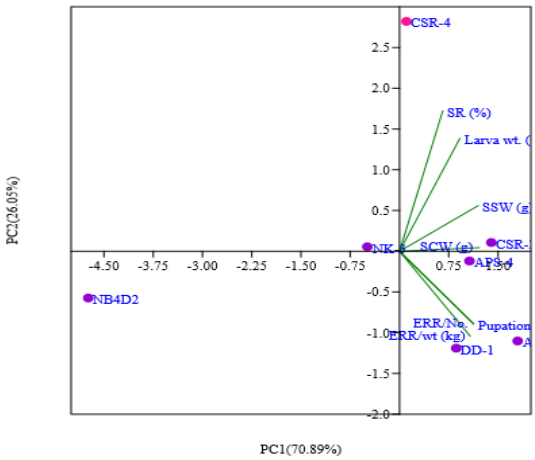


Fig.14: PCA of the dumbbell bivoltine accessions tested under RSRS Jammu

At CSGRC, Hosur, the oval bivoltine accession DD2 performed positive correlation with ERR/wt., ERR/No. and Pupation Rate (%) (Fig-15) whereas among dumbbell bivoltine accessions, APS-4 has correlation with ERR/No. and pupation rate (%) (Fig-16).

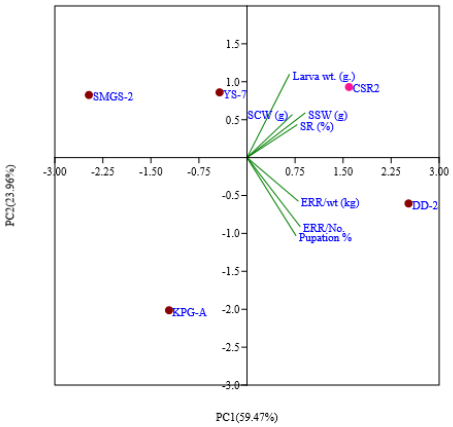


Fig.15: PCA of the oval bivoltine accessions tested under CSGRC,Hosur

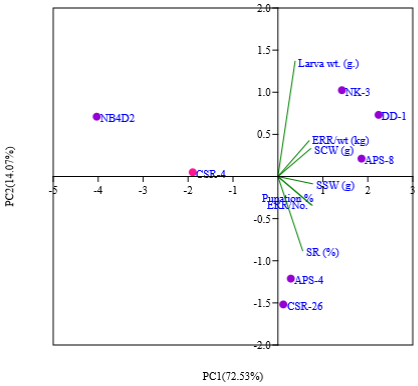


Fig.16: PCA of the dumbbell bivoltine accessions tested under CSGRC,Hosur

The study revealed that the rearing performance of shortlisted bivoltine accessions at CSR&TI, Berhampore, RSRS, Jammu and REC, Chitradurga, under different abiotic stress viz. temperature and humidity was significantly different. The data clearly indicate that adverse temperature and relative humidity affected the growth and development of silkworm larvae. The larval mortality was higher in the treatments taken up at RSRS, Jammu and CSR&TI, Berhampore.

Conclusion:

The present study shows that the larvae to strive for their survival against the abiotic stress environment deplete much of their energy resources in maintaining homeostasis ultimately influencing quantitative and qualitative traits adversely. It canbe concluded that exposure of later age (IV & V instar) silkworm larvae to variations in temperature and humidity (above 25± 1°C and below 70% RH) affect pupation rate. The study revealed that the larval mortality resulted when larvae were exposed to higher temperature (30 and 35°C) and lower RH (55 and 65%).The outcome of the present study indicates that the expression of performance of bivoltine accessions is different in three different abiotic stress conditions which show that the silkworm rearing expression performance is influenced by environmental factors. Based on the data and analyzed results of the test centres clearly revealed the better performing oval and dumbbell bivoltine accessions (Table-30).

Table 30. Centre wise better performing oval and dumbbell bivoltine accessions

CSR&TI, Berhampore	RSRS, Jammu	REC, Chitradurga	CSGRC, Hosur
Dumbbell bivoltine accessions			
BBI-0338(DD-1)	BBI-0336 (APS-8)	BBI-0334(APS-4)	BBI-0336 (APS-8)
Oval bivoltine Accessions			
BBI-0301(YS-7)	BBI-0339(DD-2)	BBE-0184(SMGS-2)	BBI-0339(DD-2)

6. PROGRESS OF RESEARCH PROJECTS

MULBERRY DIVISION: [*Projects continued through 2021-22]*

PIG-06004 SI: Studies on cytological status of mulberry genetic resources (March 2020-February 2023)

Shri. Raju Mondal (PI), Dr. M.C. Thriveni (CI)

Objective

Identification of chromosome number and ploidy level of mulberry genetic resources

Progress

A total of 136 accessions (out of 200 coreset) were studied for metaphase preparation using shoot tips. Out of 136 accessions, 127 accessions consisted of chromosome 2n=2x=28 (diploid), 4 accessions having 2n=3x=42 (triploid), 3 accessions having 2n=4x=56 (tetraploid), and 1 having 2n=6x=84 (hexaploid) and 1 comprised of 2n=22x=308 (decosaploid). Intraspecific diversity of studied accessions was estimated and the result suggests that about 79% belongs to *Morus indicia*, 14% belongs to *M. macroura*, and the remaining 17% belonged to other species of the genus *Morus* (**Figure. 17a**). The ploidy level variability is represented in **Figure. 17b**. However, chromosomes of 27 accessions were not visible, and poor spreading was observed due to high amount of phenolics and alkaloids. Protocol for metaphase plate preparation (mitosis) and karyotype analysis was optimized. Effects of different pre-treatment chemicals, durations, and tissue types were optimized for fixation and chromosome spreading (**Figure 18a-f**). Karyomorphological details for 50 mulberry accessions were completed (**Figure 18g**).

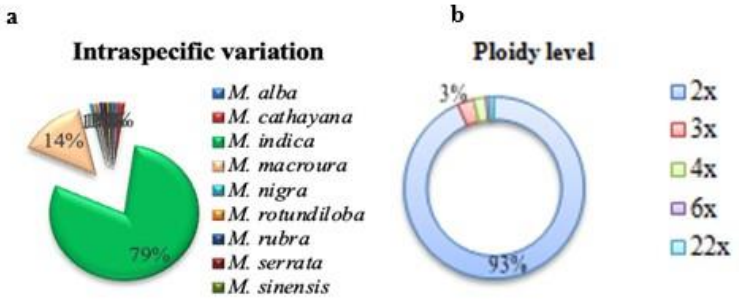


Fig. 17. Diversity at ploidy level (a) and species level (b) of genus *Morus*.

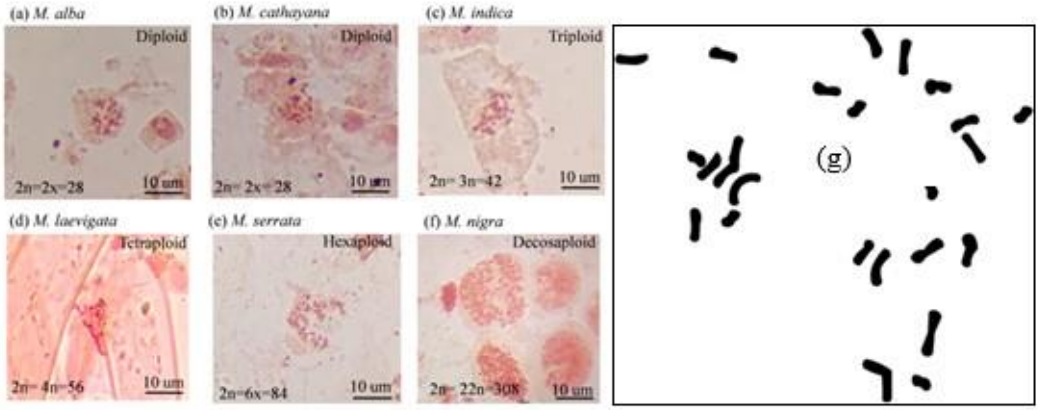


Fig. 18. Chromosome variability (a-f) and karyomorphology (g) of *Morus* spp.

PIG-06005 SI: Molecular characterization of mulberry genetic resources for the identification of duplicates and effective utilization (March 2020-February 2023)

Dr. M.C. Thriveni (PI), Shri. Raju Mondal (CI)

Objective

Identification of duplicates and their demarcation using morphological descriptors and molecular markers

Progress

The project was revised as per the suggestions of 40th RAC held on 23rd August 2021. 323 *Morus indica* accessions were shortlisted for the study. Based on the qualitative morphological descriptors 84 suspected duplicates were identified through multivariate cluster analysis. PCA was carried out to know the grouping of accessions. 50 validated SSR primers were collected from CSRTI, Mysuru. The protocol for DNA extraction was standardized. Isolated genomic DNA from 42 suspected duplicates using CTAB extraction protocol. PCR was carried out using 41 SSR primers followed by 2% agarose gel electrophoresis. The bands were scored for the presence or absence of SSR. The binary data was subjected for cluster analysis. The results support the duplicates that were identified based on morphological descriptors. No polymorphism was observed among the tested accessions. PAGE analysis will be done for the confirmation of duplicates. Screening of remaining accessions and primers is under progress. Representative images of PCR profile are given in Figure 19.

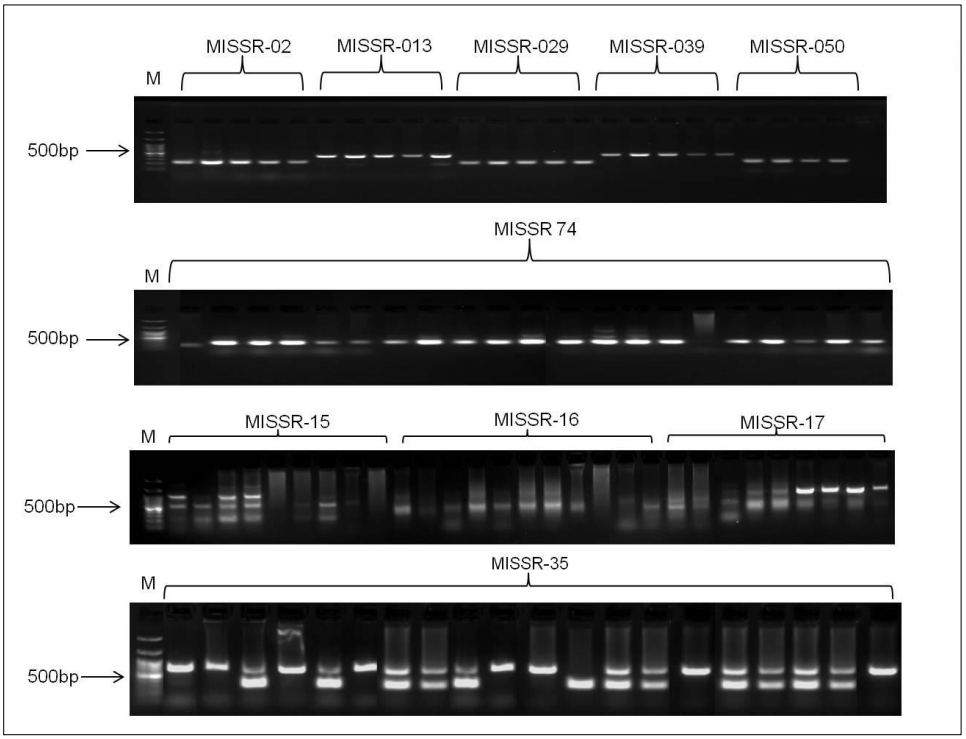


Fig. 19. PCR profiles of *Morus indica* accessions using SSR markers.

***Inter-institutional** [Other institute projects with CSGRC Hosur as collaborator]*

PIT-08004 MI: Study on epigenetic and autophagy modifiers on induction of haploid microspore embryogenesis in mulberry

Dr. A. Ramesha, (PI), Dr. Himanshu Dubey (CI): SBRL- Kodathi; Dr. Prashanth Sangannavar, RCS, CSB; Shri Raju Mondal, CSGRC-Hosur; Sreya Antony (JRF), CSGRC-Hosur

Objective

The project aims to develop a protocol for haploid microspore embryogenesis in mulberry.

Progress

Responses like embryogenesis, and organogenesis (shoot and root) were observed using different concentrations and combinations of PGRs such as 2,4-D, Kinetin, IAA, NAA, and 6BAP (Figure 20 a-b). A combination of 2,4-D (2 mg l^{-1}) and Kinetin (0.03 mg l^{-1}) showed a positive impact on anther culture. V1, and ME-0173 are performing better than S13 under dark incubation of about 90 days (Figure 20 c). The lower nucleus to cytoplasm ratio (N/C ratio) ratio was considered to identify embryogenic (Em) and non-embryogenic (NEm) cells. A significant difference in the number of non-embryogenic (NEm, >98%), and embryogenic (Em<2%) from microspores was recorded after 90 days of culture. Further optimization for regeneration of plantlets from anther is under progress.

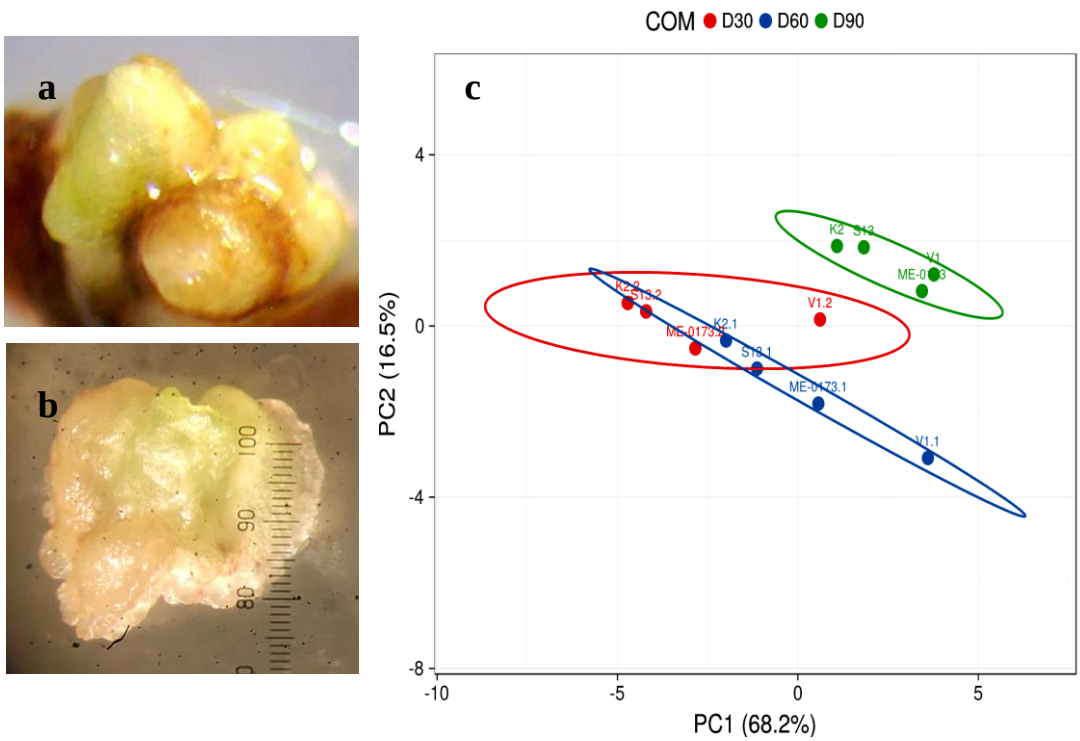


Fig.20: Somatic embryogenesis (a, b) derived from anther culture and (c) effect of dark condition after 90 days of incubation.

PIB-3586: Development of superior mulberry varieties through controlled hybridization for NorthWest Indian states (March 2017-February 2022)

Dr. Rajesh Kumar (PI), Pawan Saini, Aftab A. Shabnam: CSR&TI-Pampore G. Thanavendan, Jhansi Lakshmi: CSGRC-Hosur; K. Vijayan (CSB, Retd.)

Objectives

- Identification of desired parents from germplasm CSR&TI, Pampore and CSGRC, Hosur.
- Hybridization among selected parents with specific targeted traits.
- Evaluation of different F1s cross combinations for- Development of HYVs suited to various agro-edaphic conditions and amenable to different agronomic practices, spacing's / pruning systems under bush and tree form of plantation in tropical/subtropical regions of north-west Indian states with emphasis on early sprouting nature, canopy configuration and rooting ability in cold / temperate/ little-snowing areas.

Progress

There were no milestones to be achieved pertaining to CSGRC during the period.

PIC-01003 CN: NW4b: Sugar-mimic alkaloids in mulberry and their role in modulating host plant-insect interactions (June 2018 to December 2021)

R. Uma Shanker (PI), Nataraja N. Karaba: UAS-Bengaluru; H.V. Thulasiram,NCL- Pune; G. Thanvendan**,** CSGRC, Hosur.

Objectives

- To examine the diversity of sugar-mimic alkaloids in the mulberry germplasm and to identify species rich in sugar-mimic alkaloids
- To study the role of sugar-mimic alkaloids in modulating host plant-insect interactions
- To study the biochemical and molecular basis of tolerance to sugar-mimic alkaloid by some insect pests of mulberry

Progress

There were no milestones to be achieved pertaining to CSGRC during the period.

PIB-3629: Development of drought tolerant mulberry genotype suitable for rainfed hill farming in north-west India (January 2018 to December 2021)

Chhattar Pal (PI), Murali, S., Santoshkumar, M.: RSRS- Jammu; G.Thanavendan, CSGRC-Hosur

Objective

Development of mulberry genotypes to suitable for rainfed hill farming.

Progress

There were no milestones to be achieved pertaining to CSGRC during the period.

Silkworm Division: [*Projects continued through 2021-22*]

AIE-06003SI: Evaluation of silkworm genetic resources of *Bombyx mori* L. with reference to inbreeding depression and their conservation (Dec, 19 - Nov, 22)

D. S. Somaprakash (PI) (upto-29.06.2020), C.M. Kishor Kumar (PI) (upto 31.07.2021), M. Maheswari, G. Punithavathy, G. Lokesh, Jameela Khatoon, and Ritwika Sur Chaudhuri

Objectives

- To evaluate silkworm genetic resources and estimate the level of inbreeding depression.
- To promote utilization of sericultural germplasm for crop improvement programmes.
- To maintain national database on silkworm accessions and catalogue the data generated.

Progress

CSGRC Hosur is conserving mulberry silkworm genetic resources collected from various CSB and other research institutes / universities. Presently, the centre is conserving 489 seri-genetic resources [83 multivoltine (indigenous-73 & exotic-10), 383 bivoltine and 23 mutants (indigenous-223 & exotic-183) with due characterization, evaluation, updation of database and promotion for utilization (Table 31).

Table 31: Phase wise silkworm germplasm resources collection

Year	Phase	Bivoltine	Multivoltine	Mutant	TOTAL
1993-1997	I	169	57	-	**226**
1997-2000	II	103	-	-	**103**
2000-2003	III	40	8	19	**67**
2003-2006	IV	25	7	1	**33**
2006-2009	V	2	1	-	**3**
2009-2012	VI	11	1	-	**12**
2012-2015	VII	15	7	-	**22**
2015-2018	VIII	4	2	3	**9**
2018-2022	IX	14			**14**
Grand Total		**383**	**83**	**23**	**489**

I. Characterization and evaluation of silkworm genetic resources:

Morphological characterization for 489 silkworm genetic resources using 27 descriptors on various growth stages Viz., egg, larva, cocoon, pupa and moth, was carried out to confirm its maintenance true to catalogue data. The data generated were updated regularly in the Silkworm Germplasm Information System [SGIS] database.

a. Morphological characterization of Silkworm Genetic Resources:

The variability in the morphological features of different stages of all the silkworm accessions (SWGRs) for each descriptor was found true to catalogue data. The data on the important

morphological parameters of the 83 multivoltine silkworm accessions are presented in Table 32. The characterization on larval stage of multivoltine silkworm accessions revealed three types of larval patterns v*iz.*, plain, marked and mixed. The analysed data revealed that maximum accessions with plain larvae (46 accns, 55.4%) followed by marked (33 accns; 39.8%) and mixed (4 accns; 4.8%). In case of cocoon colour, maximum accessions revealed greenish yellow colour (35 accns; 42.2 %) followed by white (22 accns; 26.5%), chrome yellow (20 accns; 24.1%), yellow cocoons (4 accns; 4.8%) and creamy white (2 accns; 2.4%). Similarly the cocoon shape revealed maximum oval shaped cocoons (31 accns; 37.3%) followed by elongated with narrow constriction (24 accns; 28.9%), spindle shape (19 accns; 22.9%), spatulate (4 accns; 4.8%), dumbbell (3 accns; 3.6%) and elongated (2 accns; 2.4%).

Table32. Morphological trait variations in multivoltine SWGRs

Parameters	Frequency	Percentage
Larval Pattern		
Plain	46	55.4
Marked	33	39.8
Mixed	4	4.8
Cocoon colour		
Greenish yellow	35	42.2
White	22	26.5
Chrome yellow	20	24.1
Yellow	4	4.8
Creamy white	2	2.4
Cocoon shape		
Oval	31	37.3
ENC	24	28.9
Spindle	19	22.9
Spatulate	4	4.8
Dumb-bell	3	3.6
Elongated	2	2.4

In case of bivoltine, the morphological characterisation of the 383 bivoltine silkworm accessions recorded variability for important morphological descriptors which are presented in Table 33. With regard to bivoltine, majority of the accessions revealed plain (227 accns; 61.51%) followed by marked (136 accns; 36.85%), mixed (18 accns; 4.9%) and sex limited (2 accns; 0.5%). The cocoon colour revealed maximum accessions with white cocoons (349 accns; 91.12%) followed by creamish white (7 accns. 1.83%), Golden yellow (5 accns. 1.31%), Greenish yellow (4 accns 1.04%), Flesh yellow (4 accns 1.04%), Dull white (3 accns 0.78%), Flesh (2 accns 0.52%), Mixed (2 accns 0.52%), Off white (2 accns 0.52%), Chrome yellow (1 accn 0.26%).

Similarly, the cocoon shape revealed that maximum accessions with oval (129 accns 34.96%), elongated faint constricted (61 accns 16.53%), elongated constricted cocoons (52 accns; 14.09%), elongated (41 accns 11.11%), Dumbbell (31 accns 8.40%), oval faint constriction (29 accns 7.86%), Elongated oval (19 accns 5.15%), Elongated faint constriction (15 accns 4.07%), spindle (6 accns 1.63%).

Table 33. Morphological trait variations in bivoltine SWGRs

Traits	Frequency	Percentage
Larval pattern		
Plain	227	61.51
Marked	136	36.85
Mixed	18	4.87
Sex limited	2	0.54
Cocoon colour		
Chrome Yellow	1	0.26
Creamish White	7	1.83
Dull white	3	0.78
Flesh	2	0.52
Flesh Yellow	4	1.04
Golden Yellow	5	1.31
Greenish Yellow	4	1.04
Mixed	2	0.52
Off-white	2	0.52
White	349	91.12
Yellow	4	1.04
Cocoon shape		
Dumbell	31	8.40
Elongated constricted	52	14.09
Elongated Faint Contricted	61	16.53
Elongated	41	11.11
Elongated Oval	19	5.15
Elongated Oval Faint constriction	15	4.07
Oval Faint Constriction	29	7.86
Oval	129	34.96
Spindle	6	1.63

II. Evaluation of silkworm genetic resources for growth and reproductive traits

a. Evaluation of multivoltine SWGRs for growth and reproductive traits:

The data on the rearing and reeling performance of the five crops of multivoltine accessions was compiled and analysed. The variability in economic traits and the individual trait-wise performance of the accessions along with mean and CV % is presented in Table 34. The analysed data depicts that minimum fecundity was recorded as 354(BMI-0032),and maximum as 473 (BMI-0084), maximum weight of 10 larvae was 36.84g (BMI-0083) and minimum was 19.40g (BMI-0031), ERR by no. was minimum in accession BMI-0080 (8727) and maximum in BMI-0018 (9697), whereas, accession BMI-0047 recorded minimum ERR by wt. (7.88 kg) and BMI-0084 maximum ERR by wt. (14.14 kg). Minimum single cocoon weight, single shell weight and SR%, respectively were recorded in accessions BMI-0047(0.82 g), BMI-0047(0.089 g) and BMI-0047 (10.92%), whereas accession BMI-0083 recorded maximum single cocoon weight (1.466g), single shell weight (0.247 g) andBMI-0076 SR% (19.61 %).

The minimum average filament length was recorded with BME-0047 (288 m) and maximum with BMI-0073 (658 m). With regard to non-breakable filament length, the minimum was recorded with BMI-0058 (229 m) and maximum was with BMI-0076 (619 m). And the minimum denier recorded with BMI-0021 (1.73) and maximum with BMI-0084 (3.08). Trait -wise top performing multivoltine accessionsare presented in Table 35.

Table 34. Economic trait-wise range of variability in multivoltine SWGRs

Traits	Mean	Min	Max	SD	SE	CV%
Fecundity (No.)	405.7	354.0	473.0	22.69	2.51	5.59
Hatching (%)	97.12	93.66	98.09	0.53	0.06	0.54
Wt. of 10 Larvae (g)	23.40	19.40	36.84	3.25	0.36	13.91
Total larval duration (h)	537	512	602	24.11	2.66	4.49
V Larval duration (h)	119	98	174	15.39	1.70	12.98
ERR (No.) (10000 larvae)	9394	8727	9697	177.19	19.57	1.89
ERR (wt. in kg)	9.62	7.88	14.14	1.12	0.12	11.62
Pupation rate (%)	92.04	85.40	95.83	1.95	0.22	2.12
Single Cocoon Wt (g)	1.012	0.820	1.466	0.11	0.01	10.91
Single Shell Wt (g)	0.136	0.089	0.247	0.03	0.00	19.86
Shell Ratio (%)	13.50	10.92	19.61	1.43	0.16	10.55
Average filament length (m)	450	288	658	80.80	8.92	17.97
Non Breakable filament length (m)	391	229	619	88.91	9.82	22.75
Filament size (d)	2.18	1.73	3.08	0.24	0.03	10.86

Table 35. Trait-wise top performing multivoltine SWGRs

Trait	Range	Accession No.
Fecundity (No.)	473-433	BMI-0084, BMI-0083, BMI-0081, BMI-0024, BMI-0078, BMI-0076, BMI-0082, BMI-0073, BMI-0065, BMI-0039
Hatching (%)	98.09-97.64	BMI-0024, BMI-0073, BMI-0082, BMI-0042, BMI-0083, BMI-0076, BMI-0061, BMI-0033, BMI-0070, BMI-0084
Wt. of 10 Larvae (g)	36.84-25.92	BMI-0083, BMI-0084, BMI-0078, BMI-0080, BMI-0081, BMI-0066, BMI-0076, BME-0048, BMI-0074, BMI-0044
ERR (By No.)	9697-9627	BMI-0018, BMI-0068, BMI-0037, BMI-0034, BMI-0079, BMI-0033, BMI-0038, BME-0050, BMI-0035, BMI-0004
ERR (By Wt.) Kg.	14.14-10.86	BMI-0084, BMI-0083, BMI-0081, BMI-0080, BMI-0044, BMI-0024, BMI-0009, BMI-0025, BME-0048, BMI-0076
Pupation rate (%)	95.83-94.42	BMI-0034, BMI-0068, BMI-0037, BMI-0079, BMI-0018, BMI-0033, BME-0050, BMI-0004, BMI-0038, BMI-0035
Single cocoon wt.(g)	1.470-1.131	BMI-0083, BMI-0084, BMI-0080, BMI-0081, BMI-0066, BME-0048, BMI-0078, BMI-0026, BMI-0001, BMI-0076
Single shell wt. (g)	0.250-0.162	BMI-0083, BMI-0084, BMI-0076, BMI-0080, BMI-0081, BMI-0078, BMI-0073, BMI-0074, BMI-0001, BME-0048
SR %	19.61-15.34	BMI-0076, BMI-0083, BMI-0084, BMI-0081, BMI-0074, BMI-0080, BME-0012, BMI-0073, BMI-0078, BMI-0079
Filament length (m)	657.67-570.67	BMI-0073, BMI-0076, BMI-0078, BMI-0074, BMI-0083, BMI-0081, BMI-0084, BMI-0044, BMI-0066, BMI-0007
Non breakable filament length (m)	619.33-508	BMI-0076, BMI-0044, BMI-0073, BMI-0066, BMI-0008, BMI-0043, BMI-0009, BMI-0007, BMI-0024, BME-0030
Denier (d)	1.73-1.94	BMI-0021, BMI-0059, BMI-0053, BMI-0037, BMI-0008, BME-0015, BMI-0042, BME-0049, BME-0013, BMI-0073

The multiple trait evaluation for the rearing and reeling traits (Table 36) revealed that, accession BMI-0076 ranked first with best performance for 9 traits followed by BMI-0083 and BMI-0084 with 8 traits, BMI-0081 and BMI-0073 with 7 traits, BMI-0078 for 6 traits and BMI-0080 with 5 traits.

Table 36. Top performing multivoltine SWGRs for multiple traits

Accession No.	No. of traits	Trait No. and Values
BMI-0076	9	1(440), 2(97.73), 3(28.42), 7(10.86), 9(1.131), 10(0.221), 11(19.61), 12(649.67), 13(619.33),
BMI-0083	8	1(452), 2(97.73), 3(36.84), 7(14.03), 9(1.466), 10(0.247), 11(17.42), 12(614.67),
BMI-0084	8	1(473), 2(97.64), 3(35.98), 7(14.14), 9(1.41), 10(0.234), 11(17.11), 12(598.67),
BMI-0081	7	1(449), 3(30.24), 7(11.87), 9(1.178), 10(0.184), 11(16.32), 12(605),
BMI-0073	7	1(436), 2(98.02), 10(0.171), 11(15.4), 12(657.67), 13(582.67), 14(1.94),
BMI-0078	6	1(446), 3(31.44), 9(1.155), 10(0.176), 11(15.37), 12(623.67),
BMI-0080	5	3(31.09), 7(11.42), 9(1.229), 10(0.193), 11(16.18),

Figures in parantheses indicates the actual value of the traits

1. Fecundity (Nos.), 2. Hatching (%), 3. Wt of 10 larvae (g), 4. Total Larval duration (hrs.) 5. V instar duration (hrs.) 6.ERR/No. 7.ERR/Wt. (kg) 8. Pupation Rate (%) 9.Single cocoon weight (g) 10. Single shell weight (g) 11. Shell ratio (%)12. Average filament length (m)13. Non breakable filament length (m) 14. Filament size (d)

b. Evaluation of bivoltine silkworm genetic resources for growth and reproductive traits:

Under the study, the rearing as well as reeling parameters of the 383 bivoltine silkworm genetic resources was collected, compiled. The analyzed data revealed that among the accessions, the fecundity ranged from 172(BBI-0347) to 581(BBE-0043), hatching percentage from 77.33% (BBI-0347) to 99.72% (BBE-0196), the larval weight for 10 larvae ranged from 20.11 g (BBI-0209) to 46.32 g (BBI-0363). In case of total larval duration it ranged from 513h (BBE-0169) to 636 h (BBE-0236). Accession BBE-00169 has recorded minimum fifth age larval duration (85 h), while maximum was in BBE-0236 (184 h). The ERR by no. was minimum in BBE-0329 (6240) and maximum in BBE-0225 (9920). Accession BBI-0399 recorded minimum ERR by wt. (8.45kgs), whereas BBI-0376 recorded maximum (19.65 kgs). Similarly, the pupation rate ranged from a minimum of 54.80% (BBI-0305) to a maximum of 99.60% (BBE-0225). Accession BBI-0140 recorded minimum single cocoon weight (0.748 g) and maximum in BBI-0343 (1.933 g). The accession BBI-0140 recorded minimum single shell weight(0.090 g) and BBI-0364 recorded maximum shell weight of 0.399(BBI-0364). Maximum shell ratio % was recorded in BBE-0364 (23.08%) and minimum of shell ratio % with BBI-0093 (11.280 %). The minimum average filament length was 306metres in BBI-0092 and the maximum average filament length was 1280metres in BBI-0290. The minimum denier of the bivoltine accession recorded was 1.82 (BBE-0209). The coefficient of variation was highest for V instar larval duration (17.03%) followed by single shell weight (15.91%) and fecundity (15.85%) which reflects the high variability for the traits among the accessions (Table 37).

Table 37. Economic trait-wise range of variability in bivoltine SWGRs

Traits	Mean	Min	Max	SD	CV%
Fecundity(No.)	406	172	581	64.29	15.85
Hatching (%)	96.12	77.33	98.72	2.21	2.30
Wt. of 10 V Instar larvae (g)	35.73	20.11	46.32	3.67	10.27
Total larval duration (h)	573	513	636	33.06	5.76
V age larval duration(h)	137	85	184	23.30	17.03
ERR by no. (10000 larvae)	9285	6240	9960	644.48	6.94
ERR by wt.(kg)	14.20	8.45	19.65	2.24	15.76
Pupation rate (%)	90.33	54.80	99.60	7.32	8.10
Single cocoon wt(g)	1.485	0.908	1.933	0.15	10.20
Single shell wt(g)	0.268	0.126	0.399	0.04	15.91
Shell ratio %	18.18	11.28	23.08	1.81	9.93
Average Filament Length (m)	870	306	1280	119.52	6.16
Non breakable filament length (m)	775	176	1232	170.95	8.82
Filament size (d)	2.44	1.82	3.57	0.29	0.01

The better performing bivoltine accessions shortlisted based on top performing as well as multiple trait analysis for individual and multiple important economic traits are presented along with the range values in Tables 38 and 39, respectively.

Table 38. Top performing bivoltine germplasm accessions for individual traits

Trait	Range	Accession No.
Fecundity (no.)	581-507	BBE-0043, BBI-0326, BBE-0016, BBI-0044, BBE-0006, BBE-0010, BBE-0023, BBE-0034, BBI-0068, BBE-0182, BBI-0290, BBE-0018, BBI-0378, BBI-0082, BBI-0080, BBE-0035, BBE-0014, BBE-0040, BBE-0015, BBE-0007, BBE-0008, BBI-0359, BBE-0038, BBI-0324, BBE-0019
Hatching %	98.72-98.00	BBE-0196, BBE-0199, BBI-0064, BBE-0183, BBE-0179, BBE-0252, BBI-0397, BBE-0170, BBE-0148, BBI-0111, BBI-0349, BBI-0069, BBI-0292, BBI-0083, BBI-0398, BBI-0070, BBI-0291, BBI-0100, BBE-0280, BBE-0197, BBI-0271, BBI-0060, BBI-0082, BBE-0269, BBE-0214
Wt. of 10 grown larvae(g)	46.32-41.21	BBI-0382, BBI-0349, BBI-0343, BBI-0385, BBI-0301, BBI-0364, BBI-0381, BBI-0362, BBI-0363, BBI-0342, BBI-0128, BBI-0367, BBI-0344, BBI-0360, BBI-0068, BBI-0282, BBI-0345, BBI-0378, BBI-0132, BBI-0129, BBI-0368, BBE-0164, BBI-0379, BBI-0377, BBI-0376
Yield/10,000 larvae by no.	9960-9860	BBE-0225, BBI-0304, BBI-0114, BBI-0298, BBE-0202, BBE-0184, BBE-0262, BBI-0248, BBI-0276, BBE-0183, BBI-0138, BBI-0406, BBE-0216, BBE-0200, BBI-0089, BBE-0160, BBE-

Trait	Range	Accession No.
		0159, BBE-0226, BBE-0261, BBE-0196, BBE-0050, BBI-0403, BBI-0282, BBI-0085, BBI-0296
Yield/10,000 larvae by wt.(kg)	19.65-17.75	BBI-0376, BBI-0348, BBI-0345, BBE-0223, BBI-0360, BBI-0342, BBI-0343, BBI-0349, BBI-0377, BBI-0344, BBE-0221, BBE-0240, BBE-0212, BBI-0385, BBE-0144, BBI-0271, BBI-0371, BBI-0369, BBE-0216, BBI-0357, BBI-0379, BBI-0338, BBI-0133, BBI-0380, BBI-0136
Pupation rate (%)	99.60-97.40	BBE-0225, BBI-0298, BBE-0184, BBI-0114, BBI-0248, BBI-0276, BBI-0296, BBI-0138, BBI-0403, BBE-0202, BBE-0196, BBE-0262, BBI-0406, BBE-0261, BBI-0089, BBI-0304, BBE-0216, BBE-0183, BBI-0085, BBI-0405, BBE-0226, BBE-0179, BBI-0337, BBI-0400, BBE-0150
Single cocoon wt.(g)	1.930-1.728	BBI-0343, BBI-0382, BBI-0344, BBI-0360, BBI-0342, BBI-0345, BBI-0341, BBI-0139, BBE-0003, BBI-0357, BBI-0376, BBI-0349, BBE-0154, BBI-0383, BBI-0385, BBI-0339, BBI-0335, BBI-0338, BBI-0324, BBI-0301, BBI-0364, BBE-0332, BBI-0381, BBI-0133, BBI-0068
Single shell wt. (g)	0.400-0.340	BBI-0364, BBI-0324, BBI-0344, BBI-0338, BBI-0377, BBI-0376, BBI-0367, BBI-0378, BBI-0375, BBI-0368, BBI-0374, BBI-0366, BBI-0385, BBI-0382, BBI-0339, BBI-0381, BBI-0343, BBE-0332, BBI-0349, BBI-0360, BBI-0345, BBI-0335, BBI-0370, BBI-0362, BBI-0340
Shell Ratio (%)	23.08-20.88	BBI-0364, BBE-0197, BBE-0262, BBI-0378, BBI-0388, BBI-0324, BBI-0377, BBI-0368, BBE-0187, BBI-0374, BBI-0366, BBE-0244, BBE-0180, BBI-0375, BBI-0362, BBI-0367, BBE-0179, BBI-0370, BBI-0359, BBE-0182, BBE-0210, BBI-0327, BBI-0340, BBI-0338, BBI-0326
Average filament length (m)	1280-1043	BBI-0290, BBI-0375, BBI-0359, BBI-0388, BBI-0324, BBE-0332, BBI-0379, BBI-0380, BBI-0378, BBE-0147, BBI-0366, BBI-0172, BBI-0335, BBE-0267, BBI-0364, BBI-0274, BBI-0044, BBI-0127, BBI-0339, BBE-0272, BBE-0262, BBI-0361, BBI-0367, BBI-0358, BBE-0006
Non breakable filament length (m)	1232-1016	BBI-0375, BBI-0324, BBE-0147, BBI-0359, BBI-0172, BBE-0267, BBI-0290, BBI-0274, BBI-0044, BBE-0272, BBE-0262, BBI-0358, BBE-0006, BBE-0216, BBE-0164, BBI-0138, BBI-0134, BBE-0332, BBI-0066, BBI-0326, BBI-0273, BBI-0126, BBI-0291, BBI-0137, BBI-0045
Denier (d)	1.82-2.02	BBI-0248, BBE-0218, BBE-0209, BBE-0021, BBE-0026, BBE-0233, BBI-0259, BBE-0195, BBI-0256, BBE-0219, BBE-0005, BBI-0073, BBE-0008, BBE-0194, BBI-0127, BBE-0030, BBE-0176, BBI-0107, BBI-0405, BBE-0158, BBE-0189, BBI-0085, BBI-0356, BBI-0093, BBI-0116

Table 39. Top ranking bivoltine germplasm accessions identified for multiple traits

Acc.No.	No. of traits	Trait No. and values
BBI-0324	6	1(511), 9(1.766), 10(0.386), 11(22.03), 12(1158), 13(1158)
BBI-0349	5	2(98.17), 3(45.58), 7(18.85), 9(1.81), 10(0.351)
BBI-0378	5	1(532), 3(41.76), 10(0.364), 11(22.26), 12(1106)
BBE-0262	5	6(9920), 8(98.2), 11(22.39), 12(1056), 13(1056)
BBI-0364	5	3(43.07), 9(1.742), 10(0.399), 11(23.08), 12(1070)
BBI-0367	4	3(42.15), 10(0.364), 11(21.14), 12(1052)
BBI-0360	4	3(41.94), 7(18.95), 9(1.892), 10(0.348)
BBI-0359	4	1(512), 11(21.08), 12(1208), 13(1098)
BBI-0375	4	10(0.361), 11(21.18), 12(1232), 13(1232)
BBI-0345	4	3(41.82), 7(19.2), 9(1.864), 10(0.348)
BBI-0344	4	3(42), 7(18.65), 9(1.911), 10(0.37)
BBI-0343	4	3(43.88), 7(18.9), 9(1.933), 10(0.353)
BBI-0338	4	7(17.8), 9(1.784), 10(0.37), 11(20.93)
BBE-0332	4	9(1.735), 10(0.352), 12(1138), 13(1034)
BBI-0089	4	1(526), 5(98), 6(9900), 7(98)
BBE-0216	4	6(9900), 7(18), 8(98), 13(1042)
BBI-0376	4	3(41.21), 9(1.812), 10(0.366), 11(19.65)
BBI-0377	4	3(41.26), 7(18.7), 10(0.368), 11(21.97)
BBI-0385	4	3(43.58), 7(18.4), 9(1.795), 10 (0.36)

Figures in parantheses indicates the actual value of the traits

1.Fecundity (Nos.), 2. Hatching (%), 3.Wt of 10 larvae (g), 4. Total Larval duration (hrs.) 5.V instar duration (hrs.) 6.ERR/No. 7.ERR/Wt. (kg) 8.Pupation Rate (%) 9.Single cocoon weight (g) 10. Single shell weight (g) 11. Shell ratio (%)12. Average filament length (m)13. Non breakable filament length (m) 14. Filament size (d)

Data analysis indicated that, accession BBI-0324 performed best for six economic traits followed by BBI-0349, BBI-378, BBE-0262 and BBI-0364 which performed best for five traits. These accessions were followed by BBI-0367, BBI-0360, BBI-0359, BBI-0375, BBI-0345, BBI-0344, BBI-0343, BBI-0338, BBE-0332, BBI-0089, BBE-0216, BBI-0376, BBI-0377 and BBI-0385 for 4 traits.

c. Evaluation for growth and reproductive traits of mutant silkworm genetic resources

Evaluation of 23 mutants revealed the following variability statistics for the important economic traits (**Table 40**). The data on the rearing performance of the mutants revealed higher co-efficient of variation for single shell weight (25.78%), wt of 10 V instar larvae (25.01%), single cocoon weight (15.99%), shell ratio (11.60%) and fecundity (10.95%).

Table 40. Variability in economical traits of 23 mutant genetic stocks

Traits	Mean	Min	Max	SD	CV%
Fecundity (No.)	379	313	448	41.45	10.95
Hatching (%)	95.56	91.36	97.30	1.23	1.28
Wt. of 10 V Instar larvae(g)	23.76	16.10	31.50	3.60	15.17
Total larval duration(h)	582	546	686	35.42	6.09
V^{th} age larval duration(h)	142	106	246	35.42	25.01
ERR. by no. (10000 larvae)	8830	6660	9840	827.11	9.37
ERR.by wt.(kg)	9.36	6.52	13.12	1.55	16.55
Pupation rate (%)	85.43	64.50	97.70	8.43	9.87
Single cocoon weight (g)	1.055	0.740	1.502	0.17	15.99
Single shell weight (g)	0.136	0.083	0.234	0.04	25.78
Shell ratio (%)	12.92	9.44	15.96	1.50	11.60

III. Estimation of Inbreeding Depression in SWGRs

The data on the rearing and reeling performance of both 383 bivoltine and 83 multivoltine accessions were compiled and subjected for Inbreeding depression (IBD). Based on the analysis, it was grouped into three clusters. In case of multivoltine, the high-performance cluster with low inbreeding % covers 3 exotic and 29 indigenous accessions. The medium performance cluster with moderate IBD % includes 7 exotic and 44 indigenous accessions. Whereas the low performance cluster with high IBD % includes 1 exotic and 2 indigenous accessions (Table 41&42).

Table 41. Cluster of multivoltine silkworm germplsam resources based on IBD%

Year	Cluster	Exo/Indig.	Details of the Multivoltine accns.
2021-22	High performance Low IBD (%) (>+5) (32)	Exotic (3)	BME-0013, 0030, 0050
		Indigenous (29)	BMI_0001, 0002, 0004, 0006-0011, 0020, 0024-0026, 0033-0037, 0039, 0040, 0044-0046, 0055, 0060, 0063, 0066, 0069, 0073
	Medium Performance with moderate IBD (%) (-5 to +5) (51)	Exotic (7)	BME-0005, 0012, 0015, 0047-0049, 0052
		Indigenous (44)	0003, 0014, 0016-0019, 0021-0023, 0027-0029, 0031-0032, 0038, 0041-0043, 0053-0054, 0056-0059, 0061, 0062, 0064-0065, 0067-0068, 0070-0072, 0074-0084
	Low performance with high IBD (%) (<-5) (3)	Exotic (1)	BME-0047
		Indigenous (2)	BMI-0077, 0082

Similarly, the analyzed data on the rearing and reeling parameters of 383 bivoltine accessions for inbreeding depression revealed that the high-performance cluster with low IBD% includes 78 exotic as well as 96 indigenous accessions. The medium performance cluster with moderate IBD% includes 81 exotic and 113 accessions. Whereas the low performance cluster with high IBD % includes 1 exotic and 2 indigenous accessions. More attention has been given to those accessions which are showing higher inbreeding depression % so as to bring it medium performance cluster.

Table 42. Cluster of bivoltine silkworm germplsam resources based on IBD%

Year	Cluster	Exo/Indig.	Details of the Bivoltine accns.
2021-22	High performance with Low IBD (%) (>+5) (174)	Exotic (78)	BBE-0005-8,10-12,14-21,22,26-27,39,49,142, 144-149, 151-159,164-166,1701, 174,182-183, 185-187, 189, 192-197,199,202,206, 209,210, 212-213,216, 220-221, 223-224,226,229-231,240-241,244-247,250,251,260-263,268-269,272,288, 332.
		Indigenous (96)	BBI-0044-47,57,62, 70-71, 74, 79, 81, 85, 92, 95-98, 102-103, 105-109, 111-113, 115, 120,122-125,127-129, 133,134,136-139,141,172,204-205, 215,248,257-259, 271,273-275,282,284, 289,290, 292,296,298, 300,301, 302,324,334-335,339, 340, 342-343,345,357,359, 360, 364,366-369,371,373, 375,376,380-383, 385-387.
	Medium Performance with moderate IBD (%) (-5 to +5) (194)	Exotic (81)	BBE-0001-4, 9-13, 15-20, 23-25, 28-38, 40-43, 50,51, 143, 150, 160-163, 167-169, 171, 173, 175-181, 184, 188, 190, 191, 198, 200, 201, 211, 214, 217, 219, 222, 225, 227-228, 232, 233, 236, 238, 242, 252, 261, 262, 264-267, 270, 280, 329.
		Indigenous (113)	BBI-0048,52-56,58-91,63-69,72-73,101,104, 110, 114, 121,126,130,131, 132,135, 140,203,207,208, 234,235, 237,239,243,249,253-256,276-279,281, 283,285-287, 291,293-295,297,299,303-305,325-328,330,336-338, 341, 344, 346-356, 358, 361-363, 365, 370, 372, 374, 377, 379, 384, 388, 389.
	Low performance with high IBD (%) (<-5) (3)	Exotic (1)	BBE-0329
		Indigenous (2)	BBI-0254, 0388

Based on the IBD, if any, adoption of corrective measures will be taken up by rejuvenating the respective accessions either through “settling rearing” i.e. rearing the accessions at the original collection centre by collecting dfls of same set of accessions from the safety back up at the original collection centre and rearing. The selection breeding methods will also be employed if necessary for improving the economic traits

IV. Conservation of silkworm genetic resources:

a. Conservation of multivoltine silkworm genetic resources:

All the 83 multivoltine accessions were conserved by conducting rearing for four conservation crops (124thto 128th generation) and the eggs were preserved at a temperature of 5º C for 35 days with backups for 45 and 60 days in the cold storages (CSP) located at Hosur and Mysuru. The multivoltine accessions were maintained true to type on par with catalogue data without any loss ensuring disease freeness.

b. Conservation of bivoltine silkworm genetic resources:

All the 383 bivoltine accessions were conserved by conducting rearing in three batches and the egg layings were preserved under 10 months hibernation schedule with one crop per year. As a backup, the egg layings of all the three batch accessions were also conserved under 12 month hibernation schedule in the cold storages (CSP) located at Hosur and Mysuru. The accessions were maintained true to type on par with the catalogue data without any loss and ensuring disease freeness. So far, first batch accessions have completed 28 generations, second batch accessions 25 generations and third batch accessions 18 generations from the year 2004.

c. Conservation of mutant SWGRs:

All the 23 bivoltine mutant genetic stocks were conserved following 6 months hibernation schedule @ 2 crops per year. These 23 mutant accessions have completed 40-41 generations. As a back-up, the accessions were conserved under 8 months hibernation schedule in the cold storages located at Hosur and Mysuru. The accessions were maintained true to type on par with the catalogue data without any loss and ensuring disease freeness.

V. Supply and Utilization of SWGRs:

During the year, a total 83 dfls were supplied for academic as well as research purpose (Table 43).

Table 43. Supply of Bivoltine silkworm genetic resources

Sl. No	Name of the Indenter	No.of DFLs supplied		Purpose
		MV	BV	
1	SSTL , Kodathi	47	-	Research &Stock maintenance
2	RSRS,Sahaspur	-	7	Research
3	Vasantrao Naik Marathwada Krishi Vidyapeeth, Maharastra	12	2	Research
4	RSRS,Jammu	-	5	Collaborative project
5	Smt. Latha, KSSR&DI	-	10	Research
Total		**59**	**24**	Research
Grand Total		**83**		

AIT-06006 MI: Marker-assisted screening to identify silkworm genetic resources tolerant to BmNPV and BmBDV (November, 2020-October, 2023)

Ritwika Sur Chaudhuri (PI), G.Punithavathy, G.Lokesh, G. Ravikumar

Objectives

- To identify silkworm resources tolerant to BmNPV and BmBDV using molecular markers
- To quantify the level of resistance/tolerance among selected tolerant genotypes.
- To validate disease tolerance of the accessions through bioassay studies.

Progress

Moth samples were collected from the three bivoltine batches and multivoltine crops during grainage operations of silkworm conservation rearing. Genomic DNA of 5940 samples of 41 multivoltine and 256 bivoltine accessions was isolated by employing Phenol:Chloroform:Isoamyl alcohol method. The DNA was then qualitatively estimated by resolving in 0.8% Agarose Gels. PCR amplification of 191 bivoltine silkworm accessions with primers specific to BmBDV tolerance, viz. aa-trans1 and aa-trans3, revealed 5 accessions, viz. BBE-0014, BBE-0027, BBE-0035, BBE-0190 and BBI-0378 carrying the resistant allele (>40%) in homozygous condition (Table 44 and Figures 21 & 22).

Table 44. BmBDV-tolerant bivoltine silkworm accessions identified through markers

Accession No.	nsd-2/nsd-2	$+^{nsd-2}$/nsd-2	$+^{nsd-2}/+^{nsd-2}$
BBE-0014	40	10	50
BBE-0027	40	0	60
BBE-0035	60	0	40
BBE-0190	80	20	0
BBI-0378	40	20	40

Fig.21. PCR-amplification using aa-trans1 primer reveals resistant allele (~1200 bp); DNA ladder:100bp

Fig.22. PCR-amplification using aa-trans3 primer reveals susceptible allele (~1200 bp); DNA ladder: 100bp

In case of screening for BmNPV tolerance, 8 SSR markers for multiviral tolerance, viz. ATT, LIP283, ATK285, GDH306, IDH216, PTP242, PTP284 and ANK165 was suggested during the 42ndRAC held on 24th February, 2022, instead of the originally proposed Nag65, Nag84 and Nag88 primers. During the period of report, 88 bivoltine accessions were screened using ATT and LIP283 markers.

Bioassay studies were conducted for 2 marker-identified BmBDV tolerant multivoltine accessions, viz. BMI-0076 & BMI-0077, and 1 bivoltine accession-BBE-0190 and recorded 70%, 69% and 42% pupal survival respectively.

AIG-06007 MI Molecular characterization and assessment of genetic diversity in silkworm (*Bombyx mori* L) (March, 2021 to February, 2024)

G. Lokesh (PI), G. Ravikimar, Ritwika Sur Chaudhuri (CSGRC),
Himanshu Dubey, K M Ponnuvel (SBRL)

Objectives

- To characterize silkworm genetic resources based on SNP marker analysis through ddRADseq approach for identification of duplicates.
- Whole genome sequencing (WGS) of indigenous silkworm races/ breeds, Pure Mysore (PM), Nistari, CSR-2 and SK-6 for reference genome and identification of hypervariable SSRs.
- Genetic diversity analysis of silkworm germplasm using SNP/ SSR markers.
- To update and enrich the silkworm genetic resource database based on molecular characterization.

Progress

The project was initiated during April-2021. Male moth samples were collected from 350 bivoltine and 83 multivoltine accessions for DNA extraction. DNA was extracted and purified from 170 accessions. Isogenic /homozygous nature of the silkworm accessions was examined using SSR markers. Initially the DNA from four populations (PM, Nistari, CSR-2 & SK-6) was amplified with two primers Sat346 and Sat 1423. Also the results were recorded based on allelic expression (presence of bands at allele size on 2% agarose gel). The quality of DNA to be used for genome sequencing was standardized from four accessions.

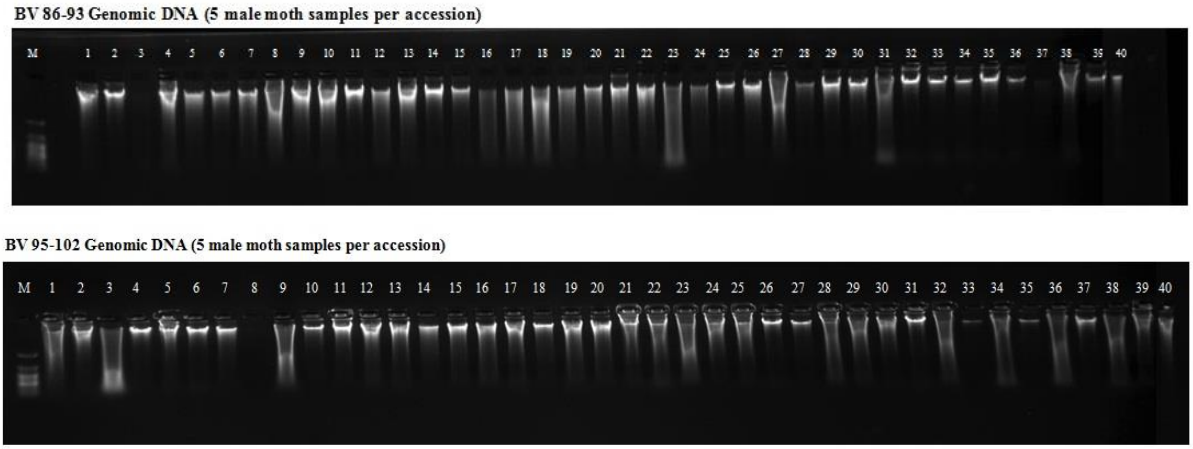


Fig. 23-25: DNA Extraction from male moth of different silkworm accessions

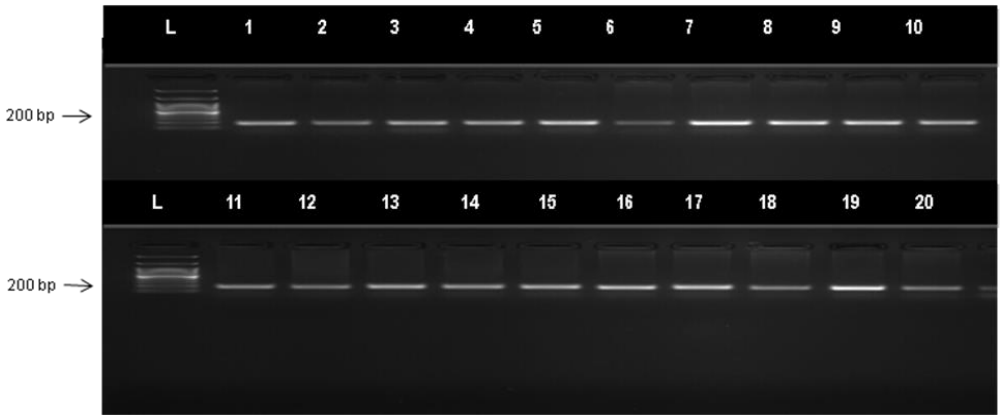


Fig.26. Study of isozygous line in the silkworm germplasm populations using SSR Marker (SAT1423): L- Marker, 1- 5: Pure mysore (PM), 6 – 10: Nistari, 11 – 12: CSR-2, 16 – 20: SK-6

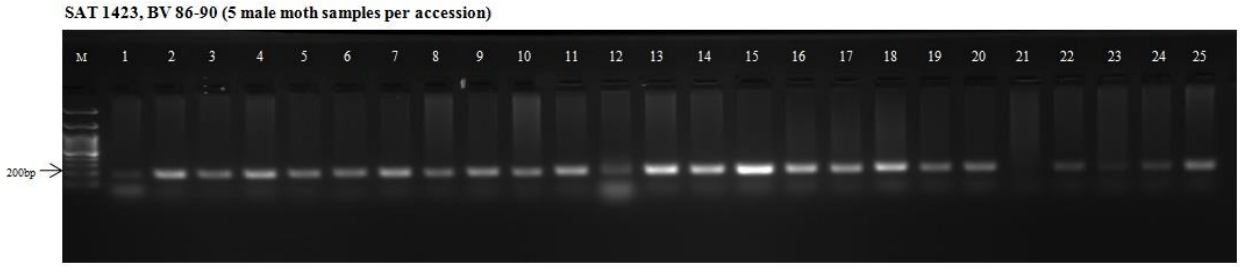
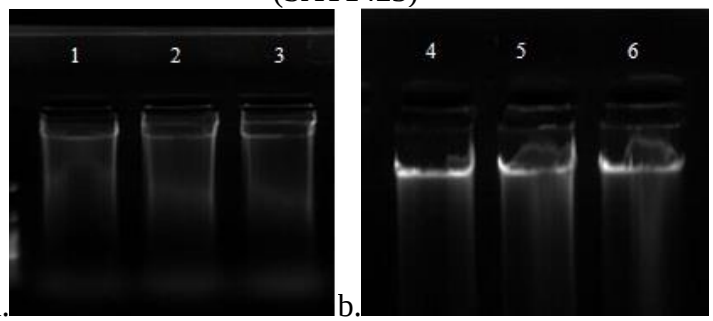


Fig.27. Study of isozygous line in different silkworm germplasm accessions using SSR Marker (SAT1423)



a. b.

Fig. 28. Standardization of DNA quality to be used for further DNA sequencing and analysis*[DNA isolated from posterior silk gland of silkworm larvae (Acc.No. 371-SK6)*
a. Genomic DNA loaded 5uL+2uL gel loading buffer in each well.
b. Genomic DNA loaded=1uL+4 uL sterile water+gel loading dye to each well.]

7. SERVICES RENDERED

Trainings imparted:

1) Hands-on Training in Biochemistry was imparted to five M.Sc. students from Bharathiar University, Coimbatore during August 2021.

2) Training to Sericulture Staff:Smt. G. Punithavathy, Scientist-D and Dr.G.Thanavendan, Scientist-C conducted theory sessions on the topics, viz., Mulberry Garden Maintenance for Seed Crop.Mulberry Cultivation Techniques,Nursery Production and Management in Mulberry,Integrated Pest management in Mulberry, Improved Silkworm Rearing Techniques and Silkworm Disease and Pest Management to 120 field staff (Assistant Inspector of Sericulture & Junior Inspector of Sericulture) of DOS, TN, under SAMETI programme organised by the TNSTI, Hosur.

3) Dr. M.Maheswari and Dr. G. Thanavendan took classes during Technology Orientation Programme at ESSPC, Hosur held from 22nd to 26th November, 2021.

4) Dr. Ritwika Sur Chaudhuri supervised 2 B.Tech. Biotechnology students from Aadhiyaman College of Engineering in carrying out their project work from December, 2021 to January, 2022.

5) Dr. Ritwika Sur Chaudhuri supervised 1 M.Tech Biotechnology student from Karpaga Vinayaka College of Engineering & Technology, Anna University, Chennai from December, 2021 to February, 2022.

6) Dr. G. Lokesh and Shri. Raju Mondal supervised 4 M.Sc. Biotechnology students from Hindustan College of Arts and Science, Coimbatore in carrying out their dissertation work from January to March, 2022.

7) Dr. M.Maheswari and Dr. G. Thanavendan took classes during Skilled Farmer's Training Programme at ESSPC, Hosur held from 21st to 26th February, 2022.

8) Dr. Jameela Khatoon delivered a Lecture in the All India Technical Seminar (Hindi medium) on Post-cocoon technologies:Research, Development and Employment organised by CST&RI, Bengaluru on 21st March, 2022.

Technical audit

Dr. G. Lokesh, Sc-D, carried out the technical audit of the activities at SSPC, Ramanagaram, Karnataka for four days from 6th to 9th September, 2021.

8. TRAINING PROGRAMMES

Trainings undergone:

Name of scientist	Date	Place	Training programme
Shri. Raju Mondal	15-06-2021 to 18-06-2021	National Institute of Agricultural Extension Management, Hyderabad (Virtual)	Extension Management Approaches for Promotion of Sericulture Industry
Shri. Raju Mondal	22-09-2021 to 24-09-2021	C-CAMP, Bengaluru (Virtual)	Introduction to Genomics and Bioinformatics
Dr.G. Thanavendan	15-09-2021 to 24-09-2021	Department of Crop Protection, Agricultural College and Research Institute Eachangkottai, Thanjavur. TN (Virtual)	Biosecurity and Biosafety: Policies, Diagnostics, Phytosanitary Treatments and Issues
Dr.G. Thanavendan, Dr. M.C. Thriveni	28-10-2021 to 30-10-2021	ICAR-IIHR Hessaraghatta, Bengaluru	Hands on training programme on Plant Germplasm Conservation, Management and Registration
All scientists of CSGRC, Hosur	23-11-2021 to 24-11-2021	Central Silk Board, Madiwala, Bengaluru	Hands on training on Application of Statistical Tools in Sericulture Research
Dr. Ritwika Sur Chaudhuri, Shri. S.Sekar & Shri. B. Narendrakumar Mhorilal	09-12-2021	Central Silk Board, Madiwala, Bengaluru	Training on GeM portal
Dr. Ritwika Sur Chaudhuri	03-01-2022 to 07-01-2022	COD, Hyderabad	5 days' Online training programme on Integrated Scientific Project Management for Women Scientists / Technologists

9. PUBLICATIONS

Research papers

1) Thriveni M.C., Mondal R., G. Thanavendan, Ravikumar G. and Sreenivasa B.T. (2021). Characterization of mulberry genetic resources for multiple traits. *Indian Journal of Advanced Botany*, 1 (2) 01-08

2) Mondal, R., Kumar, A. (2021) Crop Germplasm: Molecular and Physiological Perspective Towards Achieving Global Crop Sustainability. *Preprints*, 2021070359 (doi: 10.20944/preprints 202107.0359.v1).

3) Maheswari. M., Lokesh G,, Chaudhuri R.S.., Shivkumar, Bharath Kumar, N., Babulal., Kishor Kumar C.M., and Sreenivasa, B.T. (2021) Evaluation of exotic bivoltine resources to identify promising bivoltine breeds for temperate regions of India. International Journal of Genetics Vol.13(4):821-823 (IF: 1.629).

4) Mondal, R., Kumar, A., & Chattopadhyay, S. K. (2021). Structural property, molecular regulation and functional diversity of Glutamine Synthetase in higher plants: a data-mining bioinformatics approach. *ThePlant Journal*. (DOI:10.1111/tpj.15536) (IF=6.417; H Index=269).

5) Mondal, R., Kumar, A., Shabnam, A.A, and Chaturvedi, A.S. (2021). Elucidation of molecular and physiological mechanism addressing integrated omic approaches for heavy metal stress tolerance in crops. *Crop* and *Pasture Science* (IF=2.3; H Index=89).

6) Mondal, R., Biswas, S., Srivastava, *et al*., (2021) *In silico* analysis and expression profiling of S-domain receptor-like kinases (SD-RLKs) under different abiotic stresses in *Arabidopsis thaliana*. *BMC Genomics*, 1-15 (IF=3.969, H Index=167).

7) Mondal, R., Madhurya, K., Saha, P. *et al*., (2021). Expression profile, transcriptional and post-transcriptional regulation of genes involved in hydrogen sulfide (H_2S) metabolism connecting the balance between development and stress adaptation in plant: a data-mining bioinformatics approach. *Plant Biology* (IF=3.081; H Index=87).

8) Kumar, A., Yadav, A.N., Mondal, R., *et al*., (2021). Myco-remediation: A mechanistic understanding of contaminants alleviation from natural environment and future prospect. *Chemosphere*, 131325. (IF=7.086; H Index=248).

9) Meena, K., Mondal, R., & Mandal, A.B. (2021). Calyx as a novel source of explant for in-vitro plantlet regeneration in flax (*Linum usitatissimum*); *Journal of Applied Biology & Biotechnology* (CiteScore=0.7; H Index=23)

10) Lokesh, G., M. Maheswari, Ritwika S Chaudhuri, S. Sekar, Halagunde Gowda and B. T. Sreenivasa (2022) Estimation of Genetic parameters and variability in the Bivoltine silkworm *Bombyx mori* L germplasm. *Uttar Pradesh Journal of Zoology* (NAAS rating: 4.21).

Book Chapter

1) Mondal R, Antony S, Roy S, Chattopadhyay SK (2021) Programmed Cell Death (PCD) in Plant: Molecular Mechanism, Regulation, and Cellular Dysfunction in Response to Development and Stress. In 'Regulation and Dysfunction of Apoptosis' (Eds Yusuf Tutar) 2, 1-20 (Intech Open).

Books/Manuals

1) Lokesh, G., Ritwika Sur Chaudhuri, Maheswari, M., Jameela Khatoon, Punithavathy, G. (2021) 'Standard Operating Procedures for maintenance and conservation of silkworm germplasm'. CSGRC.

2) Thriveni MC, Thanavendan G, Mondal R, Jhansilakshmi, K., Saraswathi, P., Sekar, S., Ravikumar G, Sreenivasa BT (2021). Catalogue on mulberry (*Morus* spp.) germplasm, Volume-6, CSGRC.

3) Lokesh, G., Ritwika Sur Chaudhuri, Thanavendan, G., and Maheswari. M (2021) 'Compendium of research projects concluded during 2009 – 2019', CSGRC.

10. PARTICIPATION IN CONFERENCE / SEMINAR / WORKSHOP

1. Participated in 7th Plant Genomics and Gene Editing Congress and 2nd Microbiome for Agriculture Congress: Asia-Malaysia (virtual) and presented a paper on the topic CCAR1: "Conserved and Novel Instinct in Plant System" held on 20th& 21st April, 2021. (Shri. Raju Mondal, Scientist-B).
2. Participated in a Seminar Biodiversity, Restoration, and Sustainable Utilization held at Govt. First Grade College, Ramanagara, Karnataka on 5th June, 2021 (Dr. M.C. Thriveni, Scientist-B)
3. Participated in International E-conference on "Sericulture: Molecules to Materials" held during 12th to 14th August, 2021 and submitted an abstract on the topic, "Significance of mulberry silkworm germplasm conservation for atma-nirbhar sericulture industry in India" (Dr. Ritwika Sur Chaudhuri, Scientist-C & Dr. G. Lokesh, Scientist-D).
4. Attended a Brainstorming session on Silkworm improvement (Virtual) organized by CSR&TI, Mysore held on 18th August, 2021 (Director, Dr. M. Maheswari, Scientist-D, Dr. G. Lokesh, Scientist-D, Smt. G. Punithavathy, Scientist-D Dr. Jameela Khatoon, Scientist-D & Dr. Ritwika Sur Chaudhuri, Scientist-C).
5. Attended a workshop on "Socio Economic Aspects of Sericulture" (Virtual) held on 24th August, 2021 (Smt. G. Punithavathy, Scientist-D).
6. Attended a webinar on Emerging Trends in Plant Protection for Sustainable Vegetable Cultivation held on 25th& 26th August, 2021(Dr.G. Thanavendan, Scientist-C).
7. Attended a webinar on Sericulture Extension Strategies, Problems and Solutions held on 11th September, 2021 (Director).
8. Attended a webinar on Technology commercialization for enabling health and nutrition security with special focus on Fruits and Vegetables held on 20th September, 2021 (Director & Dr. M.C.Thriveni, Scientist-B).

9. Attended a webinar on Strategies and Approaches for Promotion of sustainable sericulture in India held on 22nd September, 2021 (Director).
10. Attended a webinar on e-Pest surveillance and Pest advisory held on 30th September, 2021 (Dr. G. Thanavendan, Scientist-C).
11. Attended Online awareness programme on "Germplasm Registration in Horticultural Crops" organized by ICAR-Indian Institute of Horticulture Research, Hessaraghatta, Bengaluru held on 1st October, 2021 (Dr. G. Thanavendan and Dr. M.C. Thriveni, Scientist-B)
12. Attended a webinar on Mites and Thrips management in mulberry organized by CSR&TI, Central Silk Board, Sriramapura, Mysuru held on 5th October, 2021 (Director & Dr. G. Thanavendan, Scientist-C).
13. Attended a webinar on Leaf roller management in Mulberry organized by KVK (GKVK) Chintamani, UAS, Bengaluru held on 22nd October, 2021 (Director & Dr. G. Thanavendan, Scientist-C).
14. Attended Seri-Stakeholders Brainstorming Webinar on Vision@2047-Silk Sector conducted by CSB, Bengaluru (virtual) held on 27th January, 2022 (Director, Dr. G. Ravikumar, Scientist-D, Dr. G. Lokesh, Scientist-D, Dr. Ritwika Sur Chaudhuri, Scientist-C, Dr. M.C. Thriveni, Scientist-B & Shri. Raju Mondal, Scientist-B)

11. VISITORS

Sl. No.	Date of visit	Name/Institution	Purpose	No.
1	07.04.2021	Mr. P. Arun Kumar, 19B-1 Kamaraj Colony, II Cross, Hosur, TN	To acquire knowledge of Germplasm	1
2	28.04.2021	Nagarjan Yadav A.P, Shaji Uivas, Aseramam Nagar-84, Aseramam, Kollam, Kerala	To acquire knowledge of Germplasm	1
3	29.04.2021	Mohammed Aleemuddeen, Hosur, TN	To acquire knowledge of Germplasm	1
4	09.06.2021	M. Umashankar, Hosur, TN	To acquire knowledge of mulberry plantation	1
5	09.06.2021	S. Raghavan, Hosur, TN	To acquire knowledge of mulberry plantation	1
6	17.06.2021	Dr. Venu, NGO, Nagaland	Visit mulberry plantation for a future project in Nagaland	1
7	03.07.2021	Dr. S. Purushotham, Scientist-D, CSRTI, Mysore, Karnataka	To visit mulberry germplasm	1
8	27.07.2021	Smt. K. Santhi, IAS Director, DOS, TamilNadu	To visit germplasm and discuss field problems	1
9	26.08.21	A. Jagubar BTM, Asst. Director of Agriculture, Pudukkottai, TN	ICM in Mulberry and Silkworm	1

10	26.08.2021	Bakarali V Parbad, AT&PO-Surpur Gujarat	Visited CSGRC while attending Eri sericulture Training	2
11	26.08.2021	S.P. Muruganandhaur, Technical Assit. TN Sericulture Training Institute, Hosur, TN Came with sericulture farmers	To acquire knowledge of mulberry nursery and varieties	30
12	26.08.2021	G. Subashini, Inspector of Sericulture, TNSTI, Hosur, TN. Came with sericulture farmers	Mulberry nursery production, techniques, and awareness program of AKAM	30
13	02.09.2021	G. Subashini, Inspector of Sericulture, TNSTI, Hosur, TN Came with sericulture farmers	Mulberry cultivation and Silkworm rearing techniques training program	30
14	21.09.2021	G. Subashini, Inspector of Sericulture, TNSTI, Hosur, TN Came with sericulture farmers	Mulberry cultivation and Silkworm rearing techniques training program	30
15	27.10.2021	S.P. Muruganandhaur, Inspector of TN Sericulture Institute, Hosur, TN. Came with sericulture farmers	To acquire knowledge of mulberry germplasm	36
16	21.01.2022	V. Sugaraneswari, Salem, TN	To acquire knowledge of mulberry germplasm	1
17	08.02.2022	Dr. N.K. Krishnakumar Former DDG (Hort. Sci.), ICAR, New Delhi	To know about the activities of the centre	1
18	22.02.2022	Dr. S. Prabhu, TA (Sericulture), FC&R, MTP, TNAU, Coimbatore, TN. Came with students	To acquire knowledge of mulberry germplasm (PG and Ph.D. students)	15
19	22.02.2022	Dr. G. Subashini, Adhiyamaan College of Agriculture and Research, Athimugam, Hosur, TN	To acquire knowledge of mulberry germplasm	5
20	09.03.2022	Dr. Vijay Adolkar, Professor & Mr. Sachin Shah, Council Member, Lukenya University, Kenya	To know about the activities of the centre for future collaborations	2
21	23.03.2022	S.P. Muruganandhaur, Inspector. TN Sericulture Institute, Hosur, TN Came with sericulture farmers	Farmer exposure visit	38
			Total Visitors	**229**

12. COMPOSITION OF COMMITTEES

Research Advisory Committee

Dr. Chandish R. Ballal, Former Director & Chairperson, RAC ICAR-NBAIR (erst while PDBC) (ICAR) &\ Former Project Co-ordinator, AICRP on Biocontrol, House no.460, 2nd cross, 9th main, HAL II stage, Bengaluru-560 008	**Chairperson**
Dr. B.T. Sreenivasa, Director, Central Sericultural Germplasm Resources Centre, Hosur	**Member - Convener**
Dr. Anitha Kodaru, Principal Scientist, NBPGR, Regional Station, Rajendranagar, Hyderabad-500 030 (Telangana)	**Member**
Dr. Modhumita Dasgupta, Scientist F, Institute of Forest Genetics and Tree Breeding (ICFRE), Coimbatore- 641 002.	**Member**
Dr. Rajasekharan, P.E, Professor, ICAR-lndian lnstitute of Horticulture Research(llHR), No. 1 41, A6, Janapriya Greenwood, Somashetti Halli, Chikkabanavara Post, Bengaluru -560 090	**Member**
Dr. Manjunatha Gowda, Professor of Sericulture, University of Agricultural sciences, GKVK, Bengaluru- 560 065 (Karnataka)	**Member**
Dr. Ravindra Singh, Scientist-D (Rtd.), Central Silk Board	**Member**
Director (Tech), Central Silk Board, CSB Complex, Bengaluru-560 068	**Member**
SCIENTIST-D & Head, Research Coordination Section, Central Silk Board, Bengaluru-560068	**Member**

Research Council

Director, Central Sericultural Germplasm Resources Centre, Hosur - 635 109	**Chairman**
Scientist-D, PMCE, Central Sericultural Germplasm Resources Centre, Hosur - 635 109	**Member – Convener**

Germplasm Registration Committee

Director (Tech.), Central Silk Board, Bangalore - 560 068	**Chairman**
Director, Central Sericultural Germplasm Resources Centre, Hosur	**Member – Convener**
Director, Central Sericultural Research and Training Institute, Mysuru	Member
Director, Central Tasar Research and Training Institute, Ranchi	Member
Director, Central Muga and Eri Research and Training Institute, Jorhat, Lahdoigarh, Assam.	Member

Germplasm Supply & Exchange Committee

Director (Tech.), Central Silk Board, Bangalore – 560 068	**Chairman**
Director, Central Sericultural Germplasm Resources Centre, Hosur	**Member – Convener**
Scientist-D&Head, Mulberry Division, CSGRC, Hosur	Member
Scientist-D & Head, Silkworm Division, CSGRC, Hosur	Member

13. राजभाषा कार्यान्वयन / Official language implementation:

राजभाषा कार्यान्वयन के तहत एरीएसएसपीसी ,एससएपीसी एवं शीतागार भंडार ,होसूर के साथ चार कार्यशालाओं का आयोजन किया गया।विवरण निम्नानुसार है:

क्रमसं.	दिनांक	विषय	वक्ता
1.	26.06.2021	संगणक पर हिन्दी टंकण, गूगल वॉइस टाइपिंग, गूगल ट्रांस्लिट्रेशन व डिजिटल टूल्स व हिन्दी से संबंधित कई वेब साइट्स का परिचय	श्री. पी. दामोधरन, सहायक निदेशक (रा.भा.) एवं प्रभारी
2.	28.09.2021	स्वयं अभ्यास एवं पत्र लेखन	श्रीमती. शीबा वी एस, क. अनु. (हिन्दी)
3.	31.12.2021	दैनिक पत्राचार के लिए हिन्दी में टिप्पण एवं मसौदा लेखन	डॉ. ऋत्विका सूर चौधरी, वैज्ञानिक-सी (हिन्दी प्रभारी)
4.	30.03.2022	हिंदी वर्णमाला का परिचय और उच्चारण"	श्री बैरवा नरेंद्रकुमार मोहरीलाल, पुस्तकालय और सूचना सहायक

Four workshops were organized under Official language implementation, jointly with Eri SSPC, SSPC and Cold Storage Hosur. The details are as follows:

Sl.No.	Date	Topic	Speaker
1.	26.06.2021	Hindi typing on computer, Introduction to Google voice typing, Google Translation, Digital Tools, Hindi websites.	Shri. M. P Damodharan, Assistant Director (OL) / Incharge, Hindi Teaching Scheme, Bangalore
2.	28.09.2021	Letter Writing-Self Practice	Smt. Sheeba. V. S, Jr. Transl. (Hindi)
3.	31.12.2021	Noting and Drafting for day to day correspondence	Dr. Ritwika Sur Chaudhuri, Scientist-C & Hindi I/C
4.	30.03.2022	Intoduction to Hindi Alphabets and their Pronunciation	.Shri. B Narendrakumar Mhorilal, Lib. & Info Asst.

चारों कार्यशालाएं बहुत ही उपयोगी एवं उदेश्यपूर्ण रही तथा केन्द्र के पदधारिगण टिप्पण ,आलेखन एव पत्राचार को तैयार करने हेतु प्रेरित हुए।b राजभाषा कार्यान्वयन समिति की चार बैठकें 30 जून 2021, 28 सितंबर 2021, 31दिसंबर 2021 एवं 30 मार्च 2022 को आयोजित की गई। उक्त रिपोर्टाधीन अवधि के दौरान प्रगति की समीक्षा की गई।सभी पदधारियों से अनुरोध किया कि वे अपने दैनिक सरकारी कामकाज में हिन्दी को बढावा दे ,जो अधिदिष्टित है।

All the four workshops were very effective and staff of the Centre was inspired and motivated to use Hindi in the preparation of noting, drafting and letters. Four meetings of the Official Language Implementation Committee were organized on 30 June 2021, 28 September 2021, 31 December 2021 and 30 March 2022. The progress of work carried out during the period under report was reviewed. The staffwas requested to put their best efforts in increasing the usage of Hindi in routine official work as mandated.

हिंदी कार्यशाला में प्रतिभागियों द्वारा स्वयं अभ्यास

दिनांक 14.09.2021को भारतीय भाषाओं के सौहार्द दिवस के रूप में हिंदी दिवस मनाया गया। केरेजसंके, ईएसएसपीसी व एसएसपीसी के वैज्ञानिकों / अधिकारियों / कर्मचारियों एवं कुशल श्रमिकों के सहयोग के साथ इस केन्द्र में 14 सितम्बर से 20 सितम्बर तक हिन्दी सप्ताह मनाया गया। हिन्दी सप्ताह के दौरान तीन प्रतियोगिताओं अर्थात स्मृति परीक्षण,वाद – विवाद एवं गायन का आयोजन किया गया। हिन्दी सप्ताह के समापन दिवस पर सांस्कृतिक कार्यक्रम का आयोजन किया गया और निदेशक, सीएसजीआरसी द्वारा प्रतियोगिताओं के विजेताओं को पुरस्कार और प्रमाणपत्र वितरित किए गए।

केरेजसंके, होसूर में मनाया जा रहा हिंदी सप्ताह, सितंबर, 2021

Hindi Day was celebratedon 14.09.2021 as a cordial day of Indian languages. The Hindi Week was organized from 14th September to 20th September 2021 with the support of scientists, officials, employees and field workers of ESSPC and SSPC, Hosur. During the week, 3 competitions viz. Memory test, Debate & Singing competitions were organized. On the concluding day of the week, cultural programme was organized and prizes and certificates were distributed to the winners of the competitionsby Director, CSGRC.

14. OTHER ACTIVITIES

Research Council Meeting

The 65th and 66th meeting of the Research Council was convened on 19th August, 2021 and 9th December, 2021 respectively chaired by Dr.B.T.Sreenivasa, Director, CSGRC, Hosur. The Committee and participants deliberated upon the research work undertaken at the Centre and provided suggestions for improvement.

Research Advisory Committee Meeting

The 41st and 42nd meeting of the RAC of the Centre was organized on 23rd August, 2021 and 24th February, 2022 respectively. The Committee and participants deliberated upon the research work undertaken at the Centre presented by the Scientists of the Centre and action to be taken for improvement were recommended.

Pebrine Monitoring

The Pebrine Monitoring Team consisting of nominated scientists from SSTL and RSRS, Kodathi, SSPC, Dharmapuri and REC, Krishnagiri carried out the mandated microscopic testing during different stages of rearing for incidence of Pebrine. Approximately 13000 moth samples from Bivoltine (3 batches) and 15,000 samples of Multivoltine from four crops were screened.

Celebration of National and International Official Events

1) WORLD ENVIRONMENT DAY

The World Environment Day was celebrated on 5th June 2021 at CSGRC, Hosur. During the celebration, the Director addressed the gathering and emphasized on the rising levels of pollution which is causing a threat to the environment and the climate change. He requested all the participants to grow trees to restore our ecosystem. The Director and the team at CSGRC planted fruit yielding mulberry varieties in the Children's park inside the campus.

2) AZADI KA AMRIT MAHOTSAV

To commemorate "Azadi Ka Amrit Mahotsav" a series of programmes were organised and conducted between July and September 2021 in the CSGRC campus.
An Awareness program on "Utilization of Mulberry and Silkworm Genetic Resources" was conducted on 26th August 2021. Around 30 Sericulture extension staff under Department of Sericulture, Tamil Nadu participated in the programme. Demonstration on "Soil fertility management" was conducted on 2nd September 2021 to a group of 35 extension staff under Department of Sericulture, Tamil Nadu.
An awareness program on "Popularization of Fruit yielding mulberry varieties" was conducted on 20th September 2021. Around 38 extension staff under Department of Sericulture, Tamil Nadu participated in the programme.

3) NATIONAL HANDLOOM WEEK

The National Handloom week was celebrated from 7th to 13th of August 2021 at CSGRC, Hosur. On this occasion the Director, CSGRC, requested everyone to purchase handloom products and promote the same. Slogans and handouts regarding the tradition and importance of Handloom weaving in our country were displayed in the Campus and the staff was motivated to purchase and promote Handloom products. On this occasion the staff of CSGRC wore Handloom attire as a mark of respect to the Indian Handloom Industry. Two staff members namely Shri. R. Gopinathan, Stenographer Grade-I and Shri. Gnanasambandam, Skilled Farm Worker who belong to the family of handloom weavers were honoured and they also shared their experience as members of traditional handloom weaving families.

4) INDEPENDENCE DAY

On 15th August 2021 the Independence Day was celebrated at the Centre and the National flag was hoisted by the Director. The Scientists, Officers, Staff members, Skilled Farm Workers and their families participated in the celebration.

5) VIGILANCE AWARENESS WEEK

Vigilance Awareness Week-2021 was observed at the Centre on the theme Independent India @ 75: Self Reliance with Integrity" from 26-10- 2021 to 01-11-2021. Integrity pledge for the Organization was administered by the Director to all the Officers /Staff /SFW of the Centre (total of 48 employees) on 26-10-2021. The Integrity pledge for the Citizen (84 citizens) was administered by the Director to the stake holders on 27-10-2021. Conducted Sensitization Programme for stake holders on Preventive Vigilance measures and displayed the posters on anti-corruption messages and stressing the vision of a vigilant India in English & in Tamil languages near the entrance of the office.

6) REPUBLIC DAY

Republic Day was celebrated on 26th January, 2022 by all the officers and staff at CSGRC, Campus. In his speech, Director, CSGRC explained the importance of the day for the citizens of India and the historical events that led up to the making of the country's constitution.

7) SWACCH BHARAT

The Swachhata Pakhwada (01.03.2022 to 15.03.2022) was formally inaugurated on 01.03.2022 at CSGRC, Hosur. At the onset, the Swachhata Pledge was undertaken by all the employees. Clean and Green Drive was conducted at CSGRC, Campus. Collected, segregated and disposed /recycled the wastes systematically. To create awareness, motivational quotes on "Cleanliness and Sanitations" were displayed in the CSGRC, Hosur Campus. A programme on Reduce –Reuse – Recycle Programme was also conducted and the process of recycling of wastes was demonstrated.




15. ADMINISTRATIVE AND FINANCIAL REPORT

a. Staff strength as on 31.03.2022

Category	No.
Director	1
Scientific	
Scientist-D	5
Scientist-C	2
Scientist-B	2
Sub-total	**10**
Technical	
Technical Assistant	2
Sub-total	**2**
Administrative	
Asst. Director (Computer)	1
Upper Division Clerk	1
Junior Engineer (Electrical)	1
Library & Information Assistant	1
Junior Translator (Hindi)	1
Assistant Technician	1
Multi-tasking Staff	2
Driver	1
Sub-total	**09**
Total	**21**
Supporting (Skilled Farm workers)	32

b. Research Fellows/Project Assistants

Junior Research Fellow (JRF)	2
Project Assistant	3
Sub-total	**5**

c. Superannuation/Voluntary Retirement from Service/Transfers

Sl. No.	Name & Designation	Remarks
1	Dr. C.M. Kishor Kumar, Scientist-D	Promoted as Director and transferred to CSR&TI, Berhampore on 31.07.2021
2	Shri. J.V. Nataraja, STA	Superannuation on 31.07.2021
3	Shri. T.V. Muralidharan, Asst Supdt.	Transferred to C.O., Bengaluru on 01.09.2021
4.	Smt. K. Gayathri, AD (A&A)	Transferred to CSR&TI, Mysore on 15.10.2021
5.	Shri. R. Gopinathan	Transferred to C.O., Bengaluru on 15.10.2021

d. Personnel posting position as on 31.03.2022

Division / Section	Name	Designation
	Dr. B.T. Sreenivasa	Director
Mulberry	Dr. G. Ravikumar	Scientist-D
	Dr. G. Thanavendan	Scientist-C
	Dr. M.C. Thriveni	Scientist-B
	Mr. Raju Mondal	Scientist-B
Silkworm	Dr. C.M. Kishor Kumar (till 31.07.2021)	Scientist-D
	Dr. M. Maheswari	Scientist-D
	Smt. G. Punithavathy	Scientist-D
	Dr. G. Lokesh	Scientist-D
	Dr. Ritwika Sur Chaudhuri	Scientist-C
	Shri A. Sathyamurthy	S.T.A.
Post Cocoon Technology	Dr. Jameela Khatoon	Scientist-D
	Shri R. Pugalendi	T.A. (R&S)
PMCE	Dr. M. Maheswari	Scientist-D
Computer Section	Shri. S. Sekar	Assistant Director (Comp.)
Administration	Smt. K. Gayathri (till 30.09.2021)	Assistant Director (A&A)
	Shri T.V. Muralidharan (till 31.08.2021)	Asst. Supdt(Admin.)
	Shri R. Gopinathan (till 30.09.2021)	Stenographer (Grade-I)
	Smt. P. Elizabeth Rani	Upper Division Clerk
	Shri J. Selvakumar (till 20.10.2021)	Staff Car Driver (Grade-II)
	Shri P. Nagadurai	Staff Car Driver (Grade-I)
	Shri A. Subramani	Asst. Technician
	Shri V. Gopala	MTS
	Shri M. Muniraju	MTS
Hindi	Smt.V.S. Sheeba	Junior Translator (Hindi)
Library	Shri Bairawa Narendra Kumar M	Lib. & Information Asst.
Electrical Maintenance	Shri. M. Vijayakumar	Junior Engineer

e. Abstract of receipts and expenditure statement for the year 2021-22 [₹in lakhs]

1) From 01.04.2021 to 08.10.2021

Fund Head	GIA received [₹]	Expenditure [₹]	Balance surrendered [₹]
Plan General	41,41,000	40,79,762	61,238
Plan Capital	4,10,000	4,09,778	222
Total (PL)	**45,51,000**	**44,89,540**	**61,460**
Plan Salary (PLS)	2,03,01,000	2,03,00894	106
SCSP	88,50,000	85,56,173	2,93,827
TSP	21,37,000	21,36,654	
Total (PLS)	**3,12,88,000**	**3,09,93,721**	**2,94,279**
Grand total (PL+PLS)	**3,58,39,000**	**3,54,83,261**	**3,55,739**

2) From 09/10/2021 to 31.03.2022 CSGRC, Hosur became aa financially non-delegated unit from 9th October, 2022 due to implementation of TSA (Treasury Single Account) in Central Silk Board. The contingent expenditure from 09.10.2021 to 31.03.2022 was Rs. 3,90,328.00

6. METEOROLOGICAL DATA OF CSGRC, HOSUR APRIL 2021 TO MARCH 2022

Month	Temperature °C			Humidity (%)			Total Rain Fall (mm)	No. of rainy days	Avg. Wind Speed (m/sec)	Wind Direction	Sun Duration (min.)
	Min.	Max	Avg.	Min.	Max.	Avg.					
Apr, 2021	20.40	33.60	27.00	40.86	83.10	61.98	0	0	1.42	S	335
May, 2021	23.30	34.30	28.85	46.83	85.38	66.10	0	0	1.65	SE	347
Jun, 2021	21.30	30.60	25.95	63.16	92.10	77.63	120	15	2.20	WSW	337
Jul, 2021	20.44	27.22	23.83	82.17	91.41	86.79	40	7	2.65	SW	321
Aug, 2021	20.51	28.68	24.59	71.48	94.58	83.03	123	11	1.97	SW	332
Sep, 2021	20.52	28.61	24.56	73.03	91.24	82.13	75	8	1.99	SW	328
Oct, 2021	20.72	28.12	24.42	84.38	94.19	89.28	157	15	1.30	S	313
Nov, 2021	19.60	24.95	22.27	90.20	92.10	91.15	236	17	1.39	SE	261
Dec, 2021	16.98	26.31	21.64	50.46	95.46	72.96	39	3	1.51	SE	293
Jan, 2022	16.60	27.46	22.03	53.06	96.35	74.70	0	0	1.52	SE	306
Feb, 2022	15.89	29.21	22.55	36.60	85.32	60.96	0	0	1.70	SE	329
Mar, 2022	16.16	31.72	23.94	30.72	62.16	46.44	0	0	1.68	SE	343
						Total	**790**	**76**			

Minimum Temperature (February 2022)	15.89°C
Maximum Temperature (April 2021)	34.30°C
Minimum Relative Humidity (March 2022)	46.44%
Maximum Relative Humidity	100%

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For further details please contact

Director

Central Sericultural Germplasm Resources Centre

Central Silk Board, Ministry of Textiles, Govt. of India

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