वार्षिक प्रतिवेदन

ANNUAL REPORT

2013 - 14

केन्द्रीय रेशम जननद्रव्य संसाधन केन्द्र

Central Sericultural Germplasm Resources Centre

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

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

CREDIT LINE

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Printed at	M/s. Vishruti Prints, Bangalore
Front cover	Activities of CSGRC, Hosur
Back cover	e-herbarium samples of mulberry genetic resources & ISO 9001:2008 certificate

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प्राक्कथन

मुझे केन्द्रीय रेशम जननद्रव्य संसाधन केंद्र के वर्ष 2013-14 की वार्षिक रिपोर्ट को प्रस्तुत करने में प्रसन्नता हो रही है। यद्यपि यह रिपोर्ट उपलब्धियों का संक्षिप्त संकलन है लेकिन यह, शोधकर्ताओं, जननद्रव्य स्टॉक संरक्षणवादियों, नीति नियोजकों तथा फसल सुधार गतिविधियों में शामिल उन सभी लोगों के लिए एक महत्वपूर्ण दस्तावेज के रूप में सहायक हो सकती हैं। आज के मौजूदा पालतू रेशमकीट का जैव विविधता, हजारों वर्षों की अवधि से अधिक मनुष्य, कीट तथा पर्यावरण के सहभागिताओं का परिणाम है जिसके दौरान रेशमकीड़ों ने जीवित रहने के लिए संघर्ष किया तथा कठोर जलवायु परिस्थितियों को अपनाया और जो शेष रह गये वे रेशम उत्पादन के उत्पादन प्रणाली का एक अनिवार्य घटक बन गया। प्रजातियों के भीतर उत्तरजीविता के इस प्रतियोगिता में परिवर्तनशीलता को जन्म दिया है तथा इस प्रकार के विभिन्न वर्ण की आबादियों के साथ गठित किया गया । इस प्रकार के समग्रता में विविध पालतु रेशमकीट जननद्रव्य के बारे में पता करना बहुत ही चुनौतीपूर्ण है। केन्द्रीय रेशम जननद्रव्य संसाधन केंद्र ने स्वदेशी तथा विदेशी आनुवंशिक संसाधनों को अच्छी तरह से लक्षण वर्णित, प्रलेखित रखने के लिए तथा उन्हें उनके समुचित उपयोग के लिए संबंधित उष्णकटिबंधीय क्षेत्र में स्व स्थाई बनाने के लिए इन चुनौतियों से साझा किया है।

इस अधिदेश के साथ कार्य कर, इस केंद्र के वैज्ञानिकों ने एसडब्ल्यूजीआरर्स की जिनोटाइपिक पहचान के लिए कार्यप्रणाली से संबंधित सॉफ्टवेयर का विकास किया है तथा विभिन्न वर्षप्रजता अर्थात द्विप्रज एवं बहुप्रज के लिए संरक्षण सूचना प्रणाली तथा शहतूत के पौधों के विभिन्न पारीस्थितिक प्रारूप जो विभिन्न भौगोलिक क्षेत्रों के मूल निवासी हैं, रेशमकीड़ों का एक अच्छा पोषक अशन निर्मित करता है। रेशमकीट एवं शहतूत में उंगलियों के निशान के डीएनए, उच्च जल की पहचान करने एवं नाइट्रोजन की उपयोग दक्षता, क्षारीय एवं लवणता स्थितियों के सहिष्णुता के आधार पर कोर संग्रह के विकास को शामिल करते हुए केंद्र ने चार प्रमुख परियोजनाओं को पूरा किया है। उपरोक्त अनुसंधान के निष्कर्षों के अतिरिक्त, पैतृक स्टॉक को बिना किसी हानी के लंबी अवधि के संरक्षण हेतु रेशमकीट के

अंडों के शीतसंरक्षण के लिए प्रारंभिक प्रयास किए गए। रेशमकीट एवं शहतूत दोनों में अभिनव कार्य के एक दीर्घकालिक दृष्टिकोण पर नव अनुसंधान परियोजनाओं को तैयार करने हेतु विचार किया गया है। जो अच्छी गुणवत्ता वाले रेशमकीट के बीज उत्पादन हेतु बाइमोडल शलभ के उद्भव के साथ जुड़े बीज उद्योग में सुधार के लिए सूखा एवं ठंड सहिष्णुता में शामिल जीन की पहचान करने के लिए, तथा शहतूत जननद्रव्य के अनुकूलन रणनीतियों के मूल्यांकन व वन्य के जीन से एकीकृत करने के लिए तथा उचित पूर्व प्रजनन के रणनीतियों के माध्यम से खेती के जननद्रव्य के लिए नहीं अपनाया है।

मैं अपने सभी सहयोगियों को उनके योगदान तथा उपलब्धियों के लिए सराहता हूँ तथा बधाई देता हूँ। केन्द्रीय रेशम जननद्रव्य संसाधन केन्द्र के प्रभारी निदेशक के रूप में प्रभार लेना मेरे लिए सम्मान तथा खुशी की बात है। इस केंद्र के अनुसंधान सलाहकार समिति के सदस्यों से प्राप्त बहुमूल्य मार्गदर्शन एवं सुझावों के लिए हम आभार व्यक्त करते हैं। सकारात्मक दृष्टि से प्राप्त सुझावों का स्वागत है।

एम.एम.बोरपुजारी
प्रभारी निदेशक

दिनांक: 03 सितंबर 2014

PREFACE

I am pleased to present the Annual Report of Central Sericultural Germplasm Resources Centre for the year 2013-14. Though the report is a brief compilation of achievements, it can serve as an important document for researchers, germplasm stock conservationists, policy planners and all those who are involved in crop improvement activities. Domestic silkworm biodiversity existing today is the result of interactions man, insect and environment over a period of thousands of years during which silkworm insects struggled for survival and adapted under harsh climatic conditions and the survived ones become an essential component of the sericultural production system. This competition for survival has given rise to the variability within the species and thus populations with varied characters were formed. It is very challenging to know in totality about such diversified domestic silkworm germplasm. Central Sericultural Germplasm Resources Centre has shared these challenges to keep the indigenous and exotic genetic resources well characterized, documented and make them self sustained in the respective tropical zone for their proper utilization.

Working with this mandate, scientists of this centre have developed software's dealing with methodology for genotypic identification SWGR's and conservation information system for different voltinism *viz*., multivoltine and bivoltine and different ecotypes of mulberry plants which are native of different geographical regions forming a good nutritive feeds of silkworms. The centre has completed four major projects in silkworm and mulberry including collaborative projects with inter-institutions covering development of core collection of mulberry accessions based on DNA fingerprints, identification for high water and nitrogen use efficiency, tolerance to alkaline and salinity conditions. Apart from the above research findings, initial efforts were made for the cryo preservation of silkworm eggs for long-term preservation without any loss to the surrogate parental stocks. A long-term vision of innovative work in both silkworm and mulberry has been contemplated by formulating new collaborative research projects with various institutes covering the use of genomic sequences to identify genotypes associated with bimodal moth emergence to improve seed industry for good quality silkworm seed production,

identification of genes involved in drought and cold tolerance and assessment of adaptation strategies in mulberry germplasm and to integrate the genes from wild and unadopted to the cultivated germplasm through appropriate pre breeding strategies.

I congratulate and appreciate all my colleagues for their contributions and achievements. It is my honour and pleasure to take charge of Central Sericultural Germplasm Resources Centre as Director I/C. We wish to acknowledge the valuable guidance and suggestions received from members of Research Advisory Committee of this Centre. Any suggestion or improvement is welcome.

M.M. BORPUZARI
DIRECTOR I/C

Date : 03.09.2014

1. EXECUTIVE SUMMARY

Central Sericultural Germplasm Resources Centre (CSGRC), Hosur is the premier institute for conservation and utilization of Seri-biodiversity in the country. The centre is also recognized as a National Active Germplasm Site (NAGS) for mulberry by National Bureau of Plant Genetic Resources (NBPGR), New Delhi and for silkworm by National Bureau of Agriculturally Important Insects (NBAII), Bangalore.

Biodiversity mapping, collection, characterization and conservation of mulberry and silkworm in different geographical regions of India have been given greater inputs by CSGRC which involves activities including ensuring the representation of maximum diversity in the *ex situ* collections, pest-free conservation, characterization, evaluation, maintenance of active collections and documentation. Effective utilization of these genetic resources in crop improvement programmes rests mainly on its systematic characterization and evaluation, and identification of potentially useful germplasm high yield, alkaline and saline stress tolerance, water and nitrogen use efficiency. CSGRC has been constantly carrying out research and development to equip serigenetic resources management activities employing both field plantation and biotechnological means of conservation through cryopreservation. Scientific aspects of seri genetic resources management such as analysis of genetic diversity, genetic integrity, population structure, species relationships, identification of trait specific promising accessions employing traditional and biochemical and molecular markers have also been carried out. The progressive development and the significant achievements are well documented in the CSGRC website silkgermplasm.com.

Mulberry Division

Five research projects were implemented in the mulberry division during the year and out of this three mulberry projects have been concluded. Towards enrichment of mulberry *ex situ* field bank, 15 diverse mulberry accessions collected from survey and exploration from Goa, Pondicherry were added to the *ex situ* field gene bank thus raising the total accession to 1269 (Exotic:270 and Indigenous-999). For long-term conservation, 125 mulberry accessions were (dormant buds) cryopreserved using dehydration and slow freezing protocol. Obtained national accession numbers for 31 new mulberry accessions from NBPGR, New Delhi.

Twenty two new mulberry germplasm accessions were characterized and evaluated in the *ex situ* field gene bank and promising mulberry accessions were identified for utilization (Erect morpho types *viz*., MI-0890, MI-0908, MI-0910, MI-0911; Leaf length more than 21 cm *viz.*, MI-0899, MI-0898, MI-0902, MI-0909, MI-010; Leaf thickness more than 205 µm *viz*., MI-0895, MI-0896, MI-0898, MI-0891, MI-0901, multiple desirable anatomical parameters for drought tolerance *viz*., MI-0896, MI-898, MI-0901, MI-0891, leaf yield more than 3 kg/plant- MI-0943, MI-0939, MI-0940, MI-0928, MI-0941 and total biomass more than 8kg/plant *viz*., MI-0943, MI-0939, MI-0938, MI-0940, MI-0928, high rooting more than 90 % and other multiple traits *viz*., MI- 0938 and MI-0935). Among 60 accessions evaluated under ARBD, 10 mulberry accessions *viz*., MI-0633, MI-0529, MI-0539, MI-0622, MI-0788,

MI-0747, MI-0773, MI-0673, MI-0581 and MI-0827 recorded with higher leaf yield with more than 0.5 kg/plant.

Seventeen high performing mulberry accessions were identified using field screening techniques for water use efficiency (WUE) *viz*. MI-0214, MI-0768, ME-0016, MI-0025, MI-0332, ME-0244, ME-0107, MI-0699, MI-0026, MI-0256, MI-0477, ME-0125, MI-0298, MI-0762, MI-0437, MI-0763, MI-0314 which are being used as parents in strategic trait based crossings for developing drought tolerant mulberry varieties. Two efficient mulberry accessions *viz*., MI-0685 and MI-0683 were identified for low nitrogen input condition. Seventeen efficient and responder mulberry accessions *viz*.,MI-0256, MI-0332, MI-0768, MI-0762, MI-0477, MI-0622, MI-0226, MI-0657, MI-0763, MI-0346, MI-0025, MI-0699, MI-0314, MI-0214, MI-0670, MI-0827 and MI-0161 were identified for under both high and low nitrogen input condition.

Using and field screening and micro-plot technique, twenty accessions *viz*. MI-0437, MI-0376, MI-0327, MI-0670, MI-0657, MI-0012, MI-0476, MI-0242, MI-0129, MI-0245, MI-0161, MI-0763, MI-0716, MI-0310, MI-0145, MI-0497, MI-0499, MI-0027, MI-0139 and MI-0764 were identified for salinity tolerance at EC 8 dS/m and eighteen accessions *viz*. MI-0226, MI-0670, MI-0836, MI-0652, MI-0762, MI-0449, MI-0764, MI-0437, MI-0716, MI-0822, MI-0310, MI-0248, MI-0702, MI-0190, MI-00643, MI-0499, MI-0788 and MI-0466 were identified for alkalinity tolerance at pH 9.0.

A core set of 150 mulberry accessions with maximum diversity were identified using molecular tools in collaboration of CSRTI, Mysore which could be utilized for undertaking MAS breeding activities for crop improvement and conservation programmes. The mulberry germplasm database for a total of 1122 accessions maintained in the Mulberry Germplasm Information System (MGIS) for utilization. Mulberry catalogue (vol-5) with 150 mulberry accessions published. Seventy six mulberry accessions were supplied to different institutes for utilization.

Silkworm Division

Four research projects were implemented in the silkworm division during the year and out of this one project has been concluded. Six authorized silkworm breeds were collected and added to the gene bank thus the present status of silkworm collections are 464 which include 79 multivoltines 365 bivoltines and 20 mutants. National accession numbers were obtained for all the 464 silkworm genetic resources from NBAII, Bangalore.

Confirmatory characterisation was done for all 458 SWGRs during the conservation rearings and maintained true to type as per passport data. The 77 MV accessions conserved through five conservation rearings (87 to 91) and so far they have completed 91 generations. All the 361 BV accessions conserved in three batches. The I, II and III batch accessions have completed 20, 17 and 11 generations respectively. The 20 mutant accessions were conserved in two conservation rearings and they have completed 24 - 25 generations**.**

The evaluation data recorded during the conservation crops for all the 458 accessions were updated and maintained in the SGIS database. 243 BV accessions were supplied to 12 indenters in 24 spells and 22 MV accessions were supplied to 3 indenters in 6 spells for PG research, evaluation and as breeding resource materials. Eleven bivoltine accessions were evaluated in eight network centers in two seasons under AISGEP-II. Accessions BBI-0348 performed better in 7 centers, BBI-0290 in 6 centers followed by accession BBE-0329 and BBE-0216 in 4 centers and BBI-0338 in 3 centers in spring season and BBE-0268 performed better in 7 centers followed by accession BBE-0266 in 6 centers and BBE-0263 in 5 centers and BBE-0338 in 4 centres, in the autumn season.

The equilibration time of cryoprotectants for cryopreservation of silkworm eggs was standardized. 40 - 65% survival was observed with CPA mixture (5% DMSO, 10% Glycerol, 5% Ethylene Glycol, and 10% Sorbitol). Electroporation of cryoprotectants was successful at 200 and 500 volts with 80% survival.

Seri genetic resources supply programmes

A total of 302 mulberry accessions (indigenous : 264 and Exotic : 38 were supplied to 11 research institutes/ organization for utilization in the studies on molecular biology and biodiversity conservation. During the year under report, 243 BV accessions were supplied to 12 indenters in 24 spells and 22 MV accessions were supplied to 3 indenters in 6 spells for PG research, evaluation and as breeding resource materials.

Publications: Published 9 research papers, Annual report and 6 seminar research papers.

Human Resource Development: Seven scientists have been trained in various aspects of Internal Audit for ISO certification by M/s. Margadarshan Management & Measurement Pvt. Ltd, Gurgaon. Shri N. Balachandran Sci-C as the designated seed officer has inspected the Registered Seed Producers (3 Nos.) and Registered Chawki Rearers in Hosur Taluk. Sri. Veeranna Gowda, Scientist-C was awarded Ph.D degree in Sericulture from Mysore university. Smt. Anuradha H. Jingade, Scientist C attended training programme on Computational Tools for Animal Genome Resource Data Analysis at NBAGR, Karnal, Haryana, Sheeba, V.S., Junior Hindi Translator assisted Regional Office, Central Silk Board, Chennai in implementation of official language in Hindi by visiting 5 times. Dr. D.Mohan Rama Rao, Shri. N.Balachandran and Smt M.Muthulakshmi Sci-C handled classes on sericultural topics for the sericultural farmers of Tamil Nadu under CDP programme. S. Sekar, AD (Computer) and T.V. Muralidharan, UDC rendered services to rectify the FAS/PRS problems as the Task Force Committee members.

Participation in Seminar/Workshop : Six scientists participated in different seminars. Dr. Veeranna Gowda, Shri N. Balachandran and Smt. M. Muthulakshmi attended and presented papers in National Seminar on Recent Advances in Modern Biology and Sericulture for Women Empowerment and Rural Development (RAMBSWERD).

2. INTRODUCTION

Central Sericultural Germplasm Resources Centre (CSGRC) established during 1991 is the national level organization with a broad mandate to provide vital support to the silkworm breed and host plant variety improvement programme in the form of required sericultural germplasm and also to act as the custodian of India's sericultural germplasm resources. National Bureau of Plant Genetic Resources (NBPGR), New Delhi recognized this centre as "National Active Germplasm Site" for mulberry germplasm and assigned national accession number. National Bureau of Agriculturally Important Insects (NBAII) Bangalore has assigned the national accession number for all the silkworm germplasm maintained in this centre. The centre is mandated to collect, characterize, conserve and promote utilization of serigenetic resources. Central Silk Board has authorized CSGRC to register the serigenetic resources developed by various breeders through the germplasm registration committee to protect the intellectual property rights of the breeder. CSGRC plays an important role in the inter-institutional collaboration for screening, testing and evaluation of serigenetic resources for identifying region and season specific mulberry/silkworm breeds for better productivity through All India Silkworm Germplasm Evaluation Programme (AISGEP).

Mandate

- *Exploration, collection, introduction and conservation of all sericultural germplasm.*
- *National accessioning and registration of sericultural germplasm resources.*
- *Quarantine and phytosanitary certification of all incoming and outgoing germplasm resources.*
- *Characterisation, evaluation and cataloguing of all the sericultural germplasm resources.*
- *Collaborate inter and intra organizational research activities pertaining to germplasm.*
- *Imparting training on germplasm resource management.*
- *Promotion of germplasm utilization within the country.*
- *Co-ordination of inter and intrastate supply and exchange of all sericultural germplasm resources.*
- *To protect sericultural germplasm resources from extinction and preserve such national heritage for posterity.*

Activities

- *To explore, collect and introduce mulberry and silkworm germplasm.*
- *To undertake characterisation, classification, preliminary evaluation & cataloguing of germplasm collection for promoting utilization of genetic resources.*
- *To serve as the long-term national repository of sericultural genetic resources and national accessioning.*
- *To act as a nodal agency for registration and reference centre for important germplasm resources.*
- *To play a lead role in the inter institutional collaboration for screening /testing / evaluation of sericultural germplasm.*
- *To co-ordinate import and export of genetic resources along with quarantine check pertaining to incoming germplasm and issuing phytosanitary certificate for export of germplasm.*
- *To serve as the national database and herbarium/ display of sericultural genetic resources.*
- *To supply the germplasm to all needy organizations.*
- *To impart training in sericultural germplasm resource management.*

Salient achievements

Mulberry Genetic Resources : CSGRC, Hosur has large collection of mulberry germplasm assembled through survey exploration and introduction. The collections include diverse mulberry germplasm resources such as wild, land races, local cultivars and polyploids and advanced cultivars with wide diversity. More than 80 survey and explorations were conducted in different geographical regions of India, i.e. arid and semi arid regions of Rajasthan, cold deserts of 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. Out of this 512 mulberry accessions are identified as diverse and added in the *ex situ* field gene bank. 1125 mulberry accessions have been systematically characterized and evaluated for 100 descriptors on morphology, reproduction, anatomy, growth, yield and biochemical parameters and developed Mulberry Germplasm Information System (MGIS). Thirteen *Morus* species and 80 mulberry land races from different geographical regions were studied using 10 enzymes which revealed 12 isozyme loci and 38 alleles. Higher gene flow and genetic diversity estimated for Indian species for developing conservation strategies. The mulberry *ex situ* field gene bank conserves 1269 mulberry accessions (999 indigenous and 270 exotic) from diverse genetic and geographical regions belonging to 13 *Morus* species collected from 26 countries. Core collection set of 150 mulberry accessions were identified utilizing DNA marker aided analysis for undertaking MAS breeding activities for crop improvement and conservation programmes 328 mulberry accessions have been cryopreserved in the national cryo gene bank (-196° C) of National Bureau of Plant Genetic Resources (NBPGR) at New Delhi and 125 mulberry accessions at CSGRC, Hosur for long-term conservation. National accession numbers have been assigned for 1151 mulberry genetic resources by NBPGR, New Delhi for the genetic identity. Five catalogues were published on mulberry genetic resources with database of 1078 mulberry accessions for 100 descriptors with identification trait specific promising accessions. 35 mulberry accessions (CSRTI, Mysore : 23, CSRTI, Berhampore : 6 and CSGRC : 6) and 8 muga accessions (Ladoigarh) have been registered by the breeders in order to protect the IPR rights. Mulberry Germplasm Information System (MGIS) and National Database on mulberry germplasm was developed and five catalogues were published on mulberry genetic resources with database of 1078 mulberry accessions for more than 100 descriptors with identification trait specific promising accessions. Since inception 786 mulberry indigenous genetic resources (2840 times repeated supply) and 210 exotic genetic resources (1128 times) were supplied to different indenters. The most indented mulberry exotic genetic resources are ME-0065 (49 times supplied) followed by ME-0066 (24), ME-0006 (25), ME-0058 (24) times where as indigenous genetic resources are MI-0173 (49 times), followed by MI-0012 (37), MI-0308 (27), MI-0080 (23), MI-0437 (23). Trait specific promising accessions identified through various evaluation on saline and alkaline tolerance and water and nitrogen use efficiency are being utilized for the development of stress tolerant mulberry varieties.

Silkworm Genetic Resources : The silkworm collections include 464 silkworm genetic resources 79 MV (indigenous-69 & exotic-10) and 365 BV (indigenous- 205 & exotic-160 and 20 mutants) from 9 states of the country and 14 countries across the world and conserved

following standard protocols. NBAII, Bangalore has assigned unique national accession numbers for all the 458 silkworm genetic resources. All the 458 silkworm genetic resources have been characterized and evaluated following standard descriptors and the data has been documented in the SGIS database along with the passport information. Silkworm Germplasm Information System (SGIS) was developed and three volumes of catalogues on silkworm germplasm were published and circulated to all the breeding Institutes and State sericultural research Institutes and people involved in sericultural research and conservation besides the catalogues are made in CD form and available for needy Institutes. In order to protect the IPR rights of breeders the centre has so far registered 43 silkworm races developed by different breeding Institutes which includes CSRTI, Berhampore (5) in 2002, APSSRDI, Hindupur (5), KSSRDI, Bangalore (14), CSRTI, Mysore (16) in 2004 and 2009 and SSTL, Kodathi (1) in 2012. Since inception 217 BV accessions and 72 MV accessions were supplied to 42 Institutions in 326 spells for PG research, evaluation, breeding resources and breed maintenance purposes. The most indented accessions in BV are NB4D2 (91), CSR-2 (75), RS-5 (44), J2P (44) and CA-2 (44) similarly in MV it is PM (100), Nistari (70), G (41), OS-616 (39) and C.Nichi (39) and Karnataka university, Dharwad, TNAU, Coimbatore, RSRS, Sahaspur, RSRS, Jammu, CSRTI,Mysore are the major Institutes to which the silkworm genetic resources were supplied.

Through All India Mulberry and Silkworm Germplasm Evaluation Programme Phase-I (2002-2007), CSGRC, Hosur has identified BBE-222 and BBE-0183 performed better in temperate regions, while BBE-197 for sub-tropical regions and BBE-183 & BBE-187 for tropical regions. Accession BBE-183 showed wider adaptability for both temperate and tropical regions. Hence, BBE-183, BBE-187, BBE-197 and BBE-222 is recommended as the best performing bivoltine silkworm germplasm having wider adaptability to different climatic conditions of India with higher potential for rearing and post-cocoon parameters**.** Similarly under the hot spot evaluation project of bivoltine germplasm for abiotic stress conditions at different agro climatic areas (2003-2007) accessions BBE-0266 and BBE-0178 have performed better than both the local ruling breeds and national control CSR-2 for rearing and reeling parameters at high temperature and high humidity prevailing during the autumn season. Accession BBE-0198 and BBE-0266 were identified for less disease incidence hence these silkworm germplasm accessions can be exploited by breeders to evolve hardy races for autumn rearing. The promising multivoltine accessions identified under high temperature / high humidity and high temperature / low humidity conditions are accessions BMI-0045, BMI-0025, BMI-0027, BMI-0060 for Ananthapur, Chamarajanagar and Salem zones. BMI-0040, BMI-0025, BMI-0027 and BMI-0016 for abiotic and BMI-0027 for biotic stress for Jorhat zone. Presently the All India Silkworm Germplasm Evaluation Programme (AISGEP-II 2011-2014) in under progress wherein the promising accessions identified at CSGRC, Hosur important rearing and post cocoon traits are under evaluation at eight net working centres *viz*. CSRTIs Mysore, Berhampore and Pampore and RSRSs Jammu, Sahaspur, Jorhat and Kalimpong under the second phase.

4. HIGHLIGHTS OF OUTPUT FROM THE CONCLUDED PROJECTS

PIG - 3432: Physiological characterization of selected mulberry genetic resources with reference to water and nitrogen use efficiency (*January 2010 - June 2013*)

K. Jhansilakshmi and A. Ananda Rao

Identification of mulberry accessions with specific traits associated with water and nitrogen use efficiency is a prerequisite for developing mulberry varieties with high input use efficiency. Towards this direction, 120 mulberry accessions were screened under progressive water deficit stress and also under low nitrogen input to identify high performing accessions for different adaptive traits and better performing accessions based on multiple traits. 17 accessions *viz*., MI-0214, MI-0768, ME-0016, MI-0025, MI-0332, ME-0244, ME-0107, MI-0699, MI-0026, MI-0256, MI-0477, ME-0125, MI-0298, MI-0762, MI-0437, MI-0763 and MI-0314 were found to be superior based on multiple traits under water limited conditions. Two accessions *viz*., MI-0685 and MI-0683 showed superior performance only under low N input. 17 accessions viz., MI-0256, MI-0332, MI-0768, MI-0762, MI-0477, MI-0622, MI-0226, MI-0657, MI-0763, MI-0346, MI-0025, MI-0699, MI-0314, MI-0214, MI-0670, MI-0827 and MI-0161 performed well both under low and high N input.

PIE - 3443: Screening of mulberry germplasm accessions for tolerance to abiotic stress (alkalinity and salinity) conditions (October, 2010-December, 2013)

M.M. Borpuzari, K. Jhansilakshmi, S.R. Ramesh and T. Thiyagu

Identification of promising mulberry accessions for salt tolerance at whole plant level using reliable traits like Na^+ exclusion and Na^+ / K^+ ratios will be of immense value in breeding for salt tolerance. In the present study, 100 diverse mulberry accessions were selected based their rooting ability, yield potential and place of collection were screened by imposing salinity stress (EC 6 and 8 dS/m) and alkalinity stress (pH 8.5 and 9.0) in microplots to identify tolerant accessions, as a first step to future breeding efforts. 20 mulberry accessions *viz*., MI-0437, MI-0376, MI-0327, MI-0670, MI-0657, MI-0012, MI-0476, MI-0242, MI-0129, MI-0245, MI-0161, MI-0763, MI-0716, MI-0310, MI-0145, MI-0497, MI-0499, MI-0027, MI-0139 and MI-0764 found tolerant to salinity and showed better performance than check S-776 at EC 8 dS/m. The tolerant accessions continued to grow with very less or no leaf necrosis and resulted in higher biomass and leaf yield/plant. Eighteen alkaline tolerant accessions *viz*., MI-0226, MI-0670, MI-0836, MI-0652, MI-0762, MI-0449, MI-0764, MI-0437, MI-0716, MI-0822, MI-0310, MI-0248, MI-0702, MI-0190, MI-0643, MI-0499, MI-0788 and MI-0466 were identified tolerant to alkalinity at pH 9.0. These accessions showed better performance than check AR-12.

AIT - 3450: Long term conservation of eggs/embryos of silkworm genetic resources (*Bombyx mori*) through cryopreservation

Srinivasa Babu (PI till Sep 2012), Anuradha .H. Jingade (PI), A. Ananda Rao (CI) and G. Lekha (JRF)

Protocol for dechorionation of silkworm eggs was developed. Treatment of silkworm eggs with 2% NaOH for 2 minutes followed by 5% NaOCl for 10 minutes effectively dechorionates the eggs. The equilibration time of cryoprotectants (CPAs) was standardized with 2.5% EG + 2.5% DMSO + 5% Glycerol + 4% Sorbitol and 5% EG + 5% DMSO + 10% Glycerol + 8% Sorbitol with survival of 65%. Schedule for long term preservation was developed for multivoltine eggs with survival of 76% with 2.5% EG + 2.5% DMSO + 5% Glycerol + 4% Sorbitol. Hosa Mysore and Mysore Princess were found to be more tolerant to CPA treatment compared to the other races studied. 36 hours embryonic age found to be chill tolerant and 48 hours found to be chill sensitive.

PIE - 3451: DNA marker aided analysis of mulberry gene bank towards a core assembly for sustainable conservation and enhanced utilization in crop improvement (DBT collaborative project with CSRTI, Mysore)

The development of core subset/panel of diverse mulberry germplasm is an important requirement for effective utilization of mulberry genetic resources in crop improvement programmes by conventional as well as by modern biotechnological approaches besides prioritizing the conservation activities. The identified set of 520 unique mulberry accessions comprising of 389 indigenous and 131 exotic accessions were evaluated over a period of two years and a panel of diverse germplasm (300 entries) and core sub set (150 entries) with maximum genetic and phenotypic diversity were sampled for use in linkage disequilibrium (LD) based association mapping using a panel of diverse germplasm for identification of QTLs for complex traits of economic importance.

5. CONCLUDED RESEARCH PROJECTS

PIG - 3432: Physiological characterization of selected mulberry genetic resources with reference to water and nitrogen use efficiency (*January 2010 – June 2013*)

K. Jhansilakshmi and A. Ananda Rao

Introduction

The major challenge for sustainable sericulture will be to increase crop production with limited water and other inputs particularly Nitrogen. Decreasing N fertilizer utilization is also required to save fossil fuel and to prevent detrimental environmental consequences of excess N fertilizer application. It has harmful consequences, because only 30–50% of the applied fertilizer N are actually captured by crops (Tilman *et al.*, 2002), with most of it

leaching to underground water and/or being emitted in the atmosphere. Emission of N gaseous forms increases greenhouse effect in the atmosphere (in particular nitrous oxide, which has a greenhouse effect 300 fold higher than CO_2); ozone concentration in the troposphere; formation of aerosols and fine particulate matter (Canfield *et al.*, 2010; Galloway *et al.,* 2003 and 2008).

WUE is a complex under multigenic control and these processes can be exploited in breeding (Condon *et al.,* 2004). They are :

i) Moving of more of the available water through the crop rather than it being wasted as evaporation from soil surface.
ii) Acquiring more carbon (biomass) in exchange for the water transpired by the crop.
iii) Partitioning more of the achieved biomass into the harvested product.

For developing mulberry varieties with high input use efficiency, identification of mulberry accessions with specific traits associated with these processes is a prerequisite.

Objectives

- To identify mulberry accessions with high water and nitrogen use efficiency
- To identify characters associated with NUE and WUE and to estimate the genetic variability for associated characters

Methodology

To combine input efficiency with input responsiveness, alternative selection environments were used during the evaluation process as suggested by Banzinger *et al.*, 2000. One hundred twenty diversified mulberry accessions (indigenous- 94 and exotic-26) from the field gene bank were shortlisted based on the characterization and evaluation data of Mulberry Germplasm Information System (MGIS), leaf senescence and other agronomic characters. Saplings were raised and plantation was established.

No. of genotypes	: 120
Design	: Augmented Randomised Block design (ARBD)
Spacing	: 90 x 90 cm
Fertilizer dose	: 100: 50: 50 NPK Kg/ha/yr
Checks	: S-13, V-1 and S-1635

Experiment I: Physiological characterization of mulberry genetic resources for WUE : After establishment period of one year, screening was done for different physiological parameters that are associated with WUE (Water Use Efficiency) and drought tolerance. Plantation was maintained under rainfed conditions and leaf yield during rainy period is considered as non-stress yield. During non-rainy period (January end to May) the crops were given two irrigations i.e. one at the time of pruning and second after 20-25 days after pruning during fertilizer application and maintained without water upto 70 days to impose progressive water deficit stress. This progressive stress is similar to rainfed farmers' condition wherein

they prune mulberry garden with onset of rains in monsoon and apply the fertilizer after sprouting and helps to observe expression of stress adaptive mechanism like osmotic adjustment. Parameters considered for screening of mulberry genetic resources for WUE and drought tolerance were days to sprouting, early vigour (LAI at 25 days), specific leaf area (SLA) (cm2/gdwt), leaf senescence (%), growth during stress period (cm), relative water content (RWC) (%), cell membrane stability, total chlorophyll (mg/g fr. wt), proline (µg/g fr. wt), reducing sugars (mg/g dry.wt), leaf moisture content (%), leaf yield (g), harvest index(%), drought resistance index (DRI).

Experiment II: Physiological characterization for NUE : Before initiation of observations on nitrogen use efficiency, maize crop was raised in between the rows of mulberry to exhaust the nutrients followed by a crop with no nitrogen and estimated the basal available nitrogen in the soil. The nitrogen availability in the soil was (56.19 kg/acre). This was considered along with the N supply for calculating the Nitrogen use efficiency, N uptake efficiency, N utilization of efficiency and N harvest index. In addition to these, total chlorophyll was also estimated. Tolerance to N stress T_N = (Li/Hi)/D where Li and Hi are the leaf yields of ith genotype at low and high nutrition respectively, and D value (= mean of all genotypes under low N / mean of all genotypes under high N) is a measure of experimental stress intensity

Results : High coefficient of variation was observed for leaf senescence, proline content, early vigour, leaf yield/plant, growth during stress period, reducing sugars, drought resistance index under water-limited conditions. Specific leaf area which is surrogate for WUE showed medium variability. Under low N conditions high coefficient of variability was observed for total N uptake, leaf yield/plant (Nitrogen use efficiency), chlorophyll content and plant height whereas medium variability was observed for Glutamine synthetase activity.

Promising accessions under water-limited conditions : 17 accessions *viz*., MI-0214, MI-0768, ME-0016, MI-0025, MI-0332, ME-0244, ME-0107, MI-0699, MI-0026, MI-0256, MI-0477, ME-0125, MI-0298, MI-0762, MI-0437, MI-0763 and MI-0314 were found to be superior based on multiple traits.

Promising accessions based on nitrogen use efficiency : Efficient and non responders - Two accessions *viz*., MI-0685 and MI-0683 showed superior performance only under low N input .

Inefficient responders : Six accessions *viz*., MI-0139, MI-0178, MI-0573, MI-0416, MI-0193 and MI-0533 showed superior performance only under high N input conditions
Efficient and responders : Seventeen accessions *viz*., MI-0256, MI-0332, MI-0768, MI-0762, MI-0477, MI-0622, MI-0226, MI-0657, MI-0763, MI-0346, MI-0025, MI-0699, MI-0314, MI-0214, MI-0670, MI-0827 and MI-0161 performed well both under low and high N input.

Association of leaf yield with other characters : Leaf yield under water stress and drought resistance index had significant positive association with early vigour, growth during stress, chlorophyll content, specific leaf area, reducing sugars, proline and root characters. Days to sprouting and leaf senescence exhibited significant negative association with leaf yield under

stress and DRI. Interestingly, reducing sugars have significant positive association with growth during stress and negative association with days to sprouting i.e. early sprouters had high reducing sugars in the leaf during stress (Table - 1). In mulberry, it seems reducing sugars are playing major role for osmotic adjustment than proline.

Table - 1: Association of different morph-physiological parameters with leaf yield and drought resistance index

Parameter	Correlation with leaf yield under water stress	Correlation with drought resistance index
Days to sprouting	-0.664**	-0.535**
Early vigour	0.789**	0.512**
Relative water content	0.144	0.163
Growth during stress	0.642**	0.510**
Chlorophyll content	0.307**	0.316**
Specific leaf area	0.184*	0.216*
Single leaf weight	0.287**	0.097
Cell membrane stability	0.038	0.094
Leaf senescence	-0.139	-0.280**
Leaf moisture content	0.122	0.081
Reducing sugars in leaf	0.364**	0.187*
Proline content	0.292**	0.060
No.of roots/sapling	0.471**	0.327**
Root weight/sapling	0.431**	0.318**
Root length	0.427**	0.386**
Drought resistance index	0.748**	

** significant at 5%; ** significant at 1%*

Leaf yield under low N is positively associated with N uptake, plant height, %N in leaf, glutamine synthetase activity and total chlorophyll whereas negatively correlated with harvest index (Table - 2). The accessions with high harvest index could not tolerate low N stress under repeated pruning. Mulberry accessions with high response to nitrogen showed high shoot elongation, leaf area expansion and high harvest index under high N input.

Table - 2 : Association of morpho-physiological parameters with leaf yield and tolerance limit to Nitrogen stress

Parameter	Correlation with leaf yield under low N	Correlation with Tolerance limit to N
Plant height	0.764**	0.481**
%N in leaf	0.230*	0.183*
Total chlorophyll	0.181*	0.125
GA activity	0.200*	0.252**
Harvest index	-0.319**	-0.265**
N uptake	0.937**	0.511**

** significant at 5%; ** significant at 1%*

Leaf yield under low N is associated with N uptake, plant height, %N in leaf, glutamine synthetase activity and total chlorophyll whereas negatively correlated with harvest index. The accessions with high harvest index can not tolerate low N stress.

Discussion

Identifying genotypes with adaptive traits for abiotic stress will be of immense importance in development of stress tolerant high yielding varieties. Also, identifying the accessions with different mechanisms of tolerance helps in planning crossing programmes to integrate these mechanisms in a single genotype (through pyramiding of genes) and also increase the probability of transgressive segregation events (Renolds *et al*., 2008) if crosses are designed involving parents with different but potential complementary physiological trait expression. Further, yield improvements under water stress and for stability of leaf yield in the present context of climate change is possible only through utilization of variability for adaptive traits (or physiological parameters associated) in mulberry crop improvement. Presence of wide variability for different physiological parameters clearly indicates the scope for crop improvement.

Inference/Recommendations

- Early vigour along with low SLA and low leaf senescence can be used as rapid screening tools for screening a large no. of accessions/ segregating material for identifying genotypes with effective use of water .
- Proline and reducing sugars accumulation helps to identify genotypes with drought tolerance (Osmotic adjustment) where as lack of these characters but showing high performance under water stress indicates drought avoidance mechanism through better root system
- Exotic mulberry accessions and accessions with very high harvest index can not tolerate low N condition in repeated pruning.
- Accessions with high shoot elongation and leaf area expansion showed high response to N input.
- The crosses *MI-0437 × ME-0125, MI-0437 × MI-0256, MI-0214 × MI-0670, MI-0762 × ME-0016, MI-0762 × ME-0065, ME-0244× MI-0768, MI-0763 × MI-0012, MI-0827 × MI-0012, MI-0685 × MI-0308, MI-0685 × MI-0314, ME-0065 × MI-0670, MI-0835 × MI-0670, MI-0828 × MI-0161, ME-0244 × ME-0065* are expected to give better progeny with drought tolerance characters and can effectively utilize water and nitrogen.

PIE - 3443 Screening of mulberry germplasm accessions for tolerance to abiotic stress (alkalinity and salinity) conditions (October, 2010-December, 2013)

M.M. Borpuzari, K. Jhansilakshmi and S.R. Ramesh

Introduction

Saline and alkaline soils are of widespread occurrence in arid and semi-arid regions. High concentration of salts in the root zone soil reduces the productivity of nearly 6.73 mha of otherwise productive lands in India. Similarly, 25% of the ground water resources in the country are saline and brackish. Continuous use of such water for irrigation to agricultural crops is bound to increase the problem of salinity and sodicity in India. The projections indicate that the country will have 11.7 m ha area affected by salinity and sodicity by 2025.

The effects of salinity on crops include inhibition of growth and production, and ultimately, death (Plaut *et al*., 2013). Besides improving agronomical practices to reduce the salt accumulation in the root zone, there is a need to improve salinity tolerance through crop improvement in perennial crops like mulberry. Several workers have shown that plant tolerance to high concentrations of salt is under genetic control (Epstein 1985; Epstein and Rains 1987; Shannon, 1990; Munns *et al*. 2000). Breeding for salt tolerance in higher plants is widely recognized as an important aspect of improving crop productivity (Epstein *et al.,* 1980) in saline areas. Screening for salt tolerance has been investigated in woody plant species such as Thai neem (Cha-um *et al*., 2004), olive (Marin *et al*., 1995), pine (Khasa *et al*., 2002) and mulberry (Hossain *et al*., 1991; Tewary, 2000; Vijayan *et al.* 2003). Identification of promising mulberry accessions among mulberry genetic resources for salinity tolerance at whole plant level by using reliable traits like Na+ exclusion and Na+ /K+ ratios (Munns and James, 2003; Poustini and Siosemardeh, 2004) will be of immense value in breeding for saline tolerance. In the present study, 100 diverse mulberry accessions were selected based their rooting ability, yield potential and place of collection to investigate the whole plant responses by imposing salinity stress and to identify tolerant accessions, as a first step to future breeding efforts.

Objectives

- Screening of short-listed mulberry accessions along with the promising cultivated checks by imposition of salinity and alkalinity stress to identify tolerant accessions.
- Identification of suitable screening technique and physio-biochemical traits for stress tolerance.

Methodology

Experimental design: RBD
No. of plants/replication : 5
No. of treatments : 3
(For salinity: Control, EC 6dS/m and EC 8 dS/m
For alkalinity: Control, pH 8.5 and pH 9.0)

Imposition of saline stress: Six month old stem cuttings were collected from *ex situ* field gene bank and planted in the nursery for raising the saplings of selected mulberry accessions along with check variety C.776. Five months old saplings were planted in pots of 40 cm diameter filled with 24 kg soil and in a randomized block design with five replications per treatment. Immediately after plantation, the plants were pruned at 20 cm height (consists of 3-4 buds to sprout). The salinity treatment was effected by irrigating with salt solution of NaCl, Na_2SO_4 and $CaCl_2$ in 7:1:2 ratio. In the treatment pots, soil was salinized prior to planting and imposed stress till leaf harvest by maintaining EC of the saturated soil extract at 6 and 8 dS/m. The control pots were irrigated with normal irrigation water. Irrigation was provided weekly twice up to 45 days after planting and alternate days in later stages of growth to replace evapo-transpirational losses and bring soil moisture levels to field capacity. Fertilizers @2.5:1:0.75 g NPK/plant were applied in the form of ammonium sulphate, single super phosphate and muriate of potash after 20 days of planting The EC of the NaCl solutions was measured directly using a conductivity meter (Model Elico - CM-180) whereas the soil EC was measured using a 1:2 (soil : water, w/v) extract. As, there were no significant differences between control and EC 4 dS/m and very few plants survived after EC 8dS/m in the preliminary experiment, the treatments EC 6 dS/m and EC 8dS/m were considered for this present investigation. In the present study, 102 diverse mulberry accessions were selected based their rooting ability, yield potential and place of collection to investigate the whole plant responses by imposing salinity stress and to identify tolerant accessions, as a first step to future breeding efforts. These were screened in five batches. First three batches were screened in pot experiment and fourth and fifth batches were screened in the field and irrigated with saline water as per the suggestion of RAC.

Imposition of alkalinity stress: Alkalinity screening was done in microplots filled with soil of desired pH. Soil from the problematic areas was brought and prepared to the desired pH. For preparing the soil, initial pH was measured, soil was made to fine powder, spread in uniform layer on polythene sheets and calculated the amount of salt (sodium carbonate and sodium bi carbonates) required to increase the desired pH. Dissolved the salts in water and applied to soil, till it becomes saturated. Cover the soil with polythene sheet. After spraying total solution, the soil is kept moist for 15-20 days to allow the complete reaction of salts. After the soil comes in condition, mixed thoroughly 4-5 times and tested pH before filling to the microplots. Afterwards, pH of the microplots were monitored during screening and maintained the desired pH by adding salt solution of sodium carbonate and bicarbonates.

Parameters recorded

- % leaf necrosis : The area covered by black necrotic spots/areas were estimated through visual scoring before the final leaf harvest
- Plant height : Length of the shoot from the base of the shoot was measured in cm at the end of the crop i.e. at 70 days from pruning
- Leaf yield/plant
- Shoot yield/plant
- Leaf chlorophyll content
- Leaf Na^+ and K^+content
- Root weight, root number and root length were measured after uprooting the plant at the end of the crop growth

Leaf yield response index (LYRI) = Average yield of genotype/ Mean yield of all Genotypes under stress
Tolerance index (TI) = Yield of genotype in stress / Yield of genotype in non-stress soil
Genotypic score = (LYRI x TI)

Observation/Results

Screening for salinity tolerance

Hundred and two mulberry accessions were screened for salinity tolerance and identified 20 mulberry accessions *viz*., MI-0437, MI-0376, MI-0327, MI-0670, MI-0657, MI-0012, MI-0476, MI-0242, MI-0129, MI-0245, MI-0161, MI-0763, MI-0716, MI-0310, MI-0145, MI-0497, MI-0499, MI-0027, MI-0139 and MI-0764 at EC 8 ds/m (Table - 3). These accessions showed better performance than check S-776.

Table-3 : Mulberry accessions tolerant to salinity stress

Sl. No.	Acc. No.	Leaf yield/plant (g)			Tolerance Index		Leaf Yield Response index		Genotypic score		Necrosis%	
		Control	EC 6dS/m	EC 8dS/m	EC 6dS/m	EC 8dS/m	EC 6dS/m	EC 8dS/m	EC 6dS/m	EC 8dS/m	EC 6dS/m	EC 8dS/m
1	MI-0437	124.1	76.1		0.61		1.55		0.95			
2	MI-0376	102.6	69.6		0.68		1.42		0.96			
3	MI-0327	88.0	62.3		0.71		1.27		0.90			
4	MI-0670	103.5	65.0		0.63		1.32		0.83			
5	MI-0657	102.0	64.0		0.63		1.30		0.82			
6	MI-0012	110.1	63.1		0.57		1.28		0.74			
7	MI-0476	54.1	25.2	27.6	0.466	0.511	1.266	2.094	0.59	1.07	5	10
8	MI-0242	85.7	38.9	30.5	0.455	0.356	1.957	2.308	0.89	0.82	2	10-15
9	MI-0129	57.4	39.1	24.4	0.680	0.424	1.963	1.845	1.34	0.78	30	30
10	MI-0245	77.0	24.3	24.1	0.315	0.313	1.220	1.888	0.38	0.59	10-15	'25-30
11	MI-0161	45.8	24.8	15.8	0.541	0.346	1.245	1.198	0.67	0.41	0	10
12	MI-0763	72.9	28.1	19.1	0.385	0.260	1.412	1.446	0.54	0.38	1	5
13	MI-0716	46.4	29.4	37.7	0.634	0.813	1.129	1.449	0.72	1.18	2	5
14	MI-0310	34.1	32.7	27.2	0.958	0.797	1.257	1.045	1.20	0.83	5	5
15	MI-0145	35.5	38.0	27.8	1.071	0.783	1.461	1.069	1.57	0.84	0	1
16	MI-0497	47.2	35.2	31.3	0.746	0.663	1.353	1.202	1.01	0.80	2	5
17	MI-0499	44.3	32.0	29.9	0.723	0.676	1.230	1.150	0.89	0.78	2	5
18	MI-0027	26.5	6.4	22.1	0.242	0.835	0.590	3.119	0.14	2.60	15	15
19	MI-0139	39.1	15.7	14.8	0.402	0.379	1.446	2.093	0.58	0.79	20	25
20	MI-0764	37.9	13.8	13.1	0.363	0.346	1.268	1.849	0.46	0.64	5	25
21	C. 776 (check)	78.0	21.7	14.0	0.278	0.179	1.091	1.440	0.30	0.35	5-10	20

The differences in plant growth and leaf necrosis were more prominent after 40-45 days of planting between the treatments. Initially yellow patches were observed in lower leaves of susceptible accessions which later turned to black necrotic areas. In some accessions, top growth was ceased and in most susceptible accessions like MI-0356, cessation of top growth was followed by death of terminal bud, drying of shoot tip, leaf necrosis and defoliation and finally death of the plant. At EC 6dS/m, though reduction in plant growth and necrosis were observed among the accessions, the differential responses were more clear at EC 8dS/m. The tolerant accessions were continued to grow with very less or no leaf necrosis that resulted in higher biomass and leaf yield/plant. In some accessions, high initial plant

growth and leaf area were observed but leaf necrosis was very high indicating that these accessions are susceptible because of Na^+ accumulation.

Screening for alkalinity tolerance

A total of 100 mulberry accessions were screened for alkalinity in micro plots. Eighteen alkaline tolerant accessions *viz*., MI-0226, MI-0670, MI-0836, MI-0652, MI-0762, MI-0449, MI-0764, MI-0437, MI-0716, MI-0822, MI-0310, MI-0248, MI-0702, MI-0190, MI-0643, MI-0499, MI-0788 and MI-0466 were identified tolerant at pH 9.0. These accessions showed better performance than check AR-12 (Table - 4).

Micro plot technique was most suitable for evaluation of salt stress tolerance. Genotypic score (Response index x Tolerance index) along with low leaf necrosis, low leaf Na and Na^+/K^+ ratio can be used as parameters for salinity tolerance whereas genotypic score and leaf chlorophyll stability can be used for screening for alkalinity tolerance.

Table - 4 : Mulberry accessions tolerant to alkalinity stress

Sl. No.	Acc. No	Leaf yield/plant (g)			Tolerance Index		Leaf Yield Response index		Genotypic score	
		Control	pH8.5	pH9.0	pH8.5	pH9.0	pH8.5	pH9.0	pH8.5	pH9.0
1	MI-0226	160.0	130.8	105.0	0.818	0.656	1.26	1.45	1.03	0.95
2	MI-0670	152.0	128.5	102.2	0.845	0.672	1.24	1.41	1.05	0.95
3	MI-0836	139.0	128.6	97.5	0.925	0.701	1.24	1.35	1.15	0.95
4	MI-0652	170.3	122.5	98.1	0.719	0.576	1.18	1.36	0.85	0.78
5	MI-0762	164.0	165.2	92.0	1.007	0.561	1.60	1.27	1.61	0.71
6	MI-0449	135.0	126.5	82.8	0.937	0.613	1.22	1.15	1.15	0.70
7	MI-0764	166.3	128.4	124.4	0.772	0.748	3.13	2.439	2.42	1.82
8	MI-0437	119.3	101.3	99.7	0.849	0.836	2.47	1.955	2.10	1.63
9	MI-0716	128.7	105.3	101.8	0.818	0.791	2.57	1.996	2.10	1.58
10	MI-0822	114.0	109.0	91.9	0.956	0.806	2.66	1.802	2.54	1.45
11	MI-0310	129.9	109.2	107.9	0.841	0.831	2.66	2.116	2.24	1.76
12	MI-0248	104.2	89.3	84.6	0.857	0.812	2.18	1.660	1.87	1.35
13	MI-0702	105.1	95.2	91.3	0.905	0.869	2.32	1.791	2.10	1.56
14	MI-0190	194.3	183.0	110.3	0.942	0.568	1.931	1.927	1.82	1.09
15	MI-0643	107.5	107.4	97.8	0.999	0.909	1.134	1.708	1.13	1.55
16	MI-0499	214.7	214.2	115.0	0.998	0.536	2.260	2.009	2.25	1.08
17	MI-0788	198.0	122.2	110.6	0.617	0.558	1.901	1.931	0.80	1.08
18	MI-0466	127.2	112.3	89.5	0.883	0.704	1.185	1.564	1.05	1.10
	AR 12 (Check)	175.0	121.6	94.3	0.695	0.539	1.18	1.30	0.82	0.70

Discussion

Variation in whole-plant biomass responses to salinity was considered to provide the best means of initial selection of salinity tolerant genotypes (Shannon, 1984; Ashraf and McNeilly, 1987) prior to the evaluation on the basis of specific traits. However, in mulberry which is a foliage crop, compared to biomass, leaf yield and % necrosis seems to be best means of initial selection of salinity tolerance. The major reason for the detrimental effects of low to moderate salt concentrations is the negative osmotic pressure caused by the salts in the root zone (Jacoby, 1994). The accumulation of high concentrations of Na^+ or Cl^- in the leaves generally results in the formation of burning like lesions (Zhu, 2002). High salinity can also injure cells in transpiring leaves, which leads to growth inhibition (Tuteja, 2007). The salt that concentrates in the old leaves makes them die early (Munns *et al.*, 2006). In mulberry, Vijayan *et al*., 2008, also observed burnt like lesions under high salinity.

Accumulation of Na^+ in young leaves ranged from 45-88 ppm among the mulberry accessions tested at EC 8 dS/m. Low leaf Na^+ of MI-0763 and MI-0246 indicates that these accessions have relative high Na^+ exclusion mechanism. The "low-Na^+ strategy" (Flowers and Yeo, 1995; Tattini and Traversi, 2009) appears a key determinant conferring salt-tolerance in these accessions. Low leaf necrosis, highest genotypic score, low Na^+/K^+ ratio of MI-0476 may be due to its ability to tolerate osmotic stress as well as Na^+ exclusion strategy. In general, the mechanisms of salinity tolerance in plants can be categorized to tolerance to osmotic stress, Na^+ exclusion and tissue tolerance (Munns and Tester, 2008). Since osmotic stress causes immediate reduction in cell expansion in roots and young leaves, tolerance to osmotic stress results in less reduction in leaf growth and stomatal conductance. The main site of Na^+ toxicity for most plants is the leaf blade rather than the root tips as Na^+ accumulates in the leaf blades due to continuous translocation and deposition due to transpiration. Thus, it is very important that Na^+ doest not reach the leaf blades in excess. Ion-specific toxicity is seen as an increase in the rate of senescence of older leaves, due to either high leaf Na^+ concentrations or to low tolerance of the accumulated Na^+.

In mulberry, which is a cross pollinated heterozygous plant that can be propagated vegetatively, screening the genetic resources for identifying the parents with the ability to adjust osmotically to high salinity environments and identifying parents with the ability to exclude Na^+ and Cl^- ions from the foliage, and finally combination of these traits through breeding programs seems to be most appropriate for improving the salt tolerance. The identified genotype having both the mechanism in the segregating population after preliminary screening by imposition of salt stress, can be multiplied vegetatively through stem cuttings and can be tested for long time in the hotspots to evaluate its ability for salt tolerance. Screening under field conditions from the initial stage in hotspots may not be of much help due to variation in field for salt stress and requirement of more resources and time.

Substantial variation was observed for tolerance to salinity among the mulberry genetic resources studied. The differential response of mulberry accessions for tolerance offers a good scope for integrating tolerance characteristics into appropriate breeding programs to improve crop productivity on saline soils. In this study, genotypic score reflects

both salinity tolerance and yield potential where as leaf necrosis% and Na^+ indicates sodium toxicity. Hence, genotypic score, % necrosis and leaf Na^+/K^+ ratio can be used as best screens to identify salt tolerant accessions in Mulberry. Further investigation on the localization of Na^+ in plant parts and its possible relation with tolerance will improve the understanding of the mechanism of salt tolerance in mulberry.

- The identified tolerant mulberry accessions to salinity and alkalinity can be used as parents for developing salt tolerant mulberry varieties.
- Micro plot technique was most suitable for evaluation of salt stress tolerance.
- Genotypic score (Response index x Tolerance index) along with leaf necrosis, low leaf Na and Na^+/K^+ ratio can be used as parameters for salinity tolerance whereas genotypic score and leaf chlorophyll stability can be used for screening for alkalinity tolerance.
- Molecular analysis of these tolerant accessions gives more information about differences among these accessions for their tolerance (osmotic stress tolerance, ion exclusion, tolerance to accumulation of ions etc.) and also for development of markers.

PIE-3451 : DNA marker aided analysis of mulberry gene bank towards a core assembly for sustainable conservation and enhanced utilization in crop improvement (DBT sponsored collaborative project with CSRTI, Mysore)

CSGRC, Hosur *– Coordinator: Director, CSGRC, Hosur; Dr. S. R. Ramesh (PI) and Dr. K. Jhansi Lakshmi (CI)*

CSRTI, Mysore *- Coordinator: Director, CSRTI, Mysore; Dr. V. Girish Naik, (PI) and Dr. M. K. P. Urs (CI)*

Duration: 3 years (September 2010 to December 2013)

Introduction

Mulberry field gene bank maintained at CSGRC, Hosur comprising of 1269 accessions, apart from many breeders collections maintained at different institutes like CSR&TI, Mysore. Large size of germlpasm holding and redundant accessions has become a limiting factor for utilization and conservation. Identification of core-subset / panel of germplasm is an important requirement for effective utilization of mulberry genetic resources in breeding programmes and conservation. Accordingly, attempt is made to develop a core set of mulberry germplasm using phenotypic and SSR & AFLP molecular markers so as to get maximum diversity representation.

Objectives

- Identification of a panel of diverse mulberry germplasm amenable to association mapping by marker (by genomic and EST SSR) aided analysis.
- Evaluation of panel of diverse mulberry germplasm for important traits *viz*., sprouting, senescence, rooting, leaf quality, yield contributing traits and key morphological characters.
- Construction of a core sub-set of mulberry germplasm by molecular marker (SSRs and AFLPs) and phenotypic analysis.

Methodology

For identification of core collections, 1065 mulberry germplasm collections were considered which are conserved in the field gene bank of CSGRC, Hosur based on the data available for 29 important key parameters which include morphological, growth, yield and quality. Cluster analysis was carried out using UPGMA method and 520 unique mulberry accessions were short listed. For verification of data on growth and yield parameters, the unique mulberry accessions along with the check varieties V1, Kosen and MR2 were evaluated in an experimental plantation under ARBD over a period of two years and also confirmative data on morphological parameters were generated. Additionally data on sprouting and senescence was also generated at CSGRC, Hosur. Simultaneously, molecular markers data (SSR &AFLP) on unique set of mulberry germplasm was carried out at CSRTI, Mysore. Using the phenotypic and molecular marker data, the core set of mulberry germplasm was identified.

Observation / Results

The identified set of 520 unique mulberry accessions comprising of 389 indigenous and 131 exotic accessions were evaluated over a period of two years. Analysis of data revealed that the whole collection consisting of 1065 mulberry accessions were analyzed to sample unique collections (UC) using 29 key phenotypic markers through cluster analysis (Ward's minimum variance method) based on phenotypic markers. The short-listed accessions including 36 mandatory breeders interest genotypes.

The frequency of accessions for different growth parameters viz., no. of branches/plant, average shoot length, weight of leaves, internodal distance, leaf yield/plant and harvest index were presented in Fig.1. The variability of mulberry accessions and top performing accessions on growth parameters are presented in Table – 5 and Table – 6. Highest coefficient of variability (59.27%) was observed for stem yield followed by leaf yield/plant (51.12%) and weight of 100 leaves (50.29%). The no. of branches ranged from 1 to 25 with mean of 10 branches. Higher number of accessions are in the range of 7-13. Leaf yield ranged from 30 – 1938 g/plant with mean yield of 492.8g. Most of the accessions were in the range of 205 - 805 g/plant. Though harvest index ranged from 28.34 – 89.92%, most of the accessions were in the range of 50 -60%. Days to sprouting in exotic accessions ranged from 9 to 32 days with mean 23 days and coefficient of variation 22% while in indigenous accessions, days to sprouting varied from 7 -35 with mean of 19 days and coefficient of variation 19.86%. The normal distribution curve is Fig. 2a is skewed toward late sprouting in exotic accessions and skewed towards early sprouting in indigenous accessions. No. of accessions in different categories for leaf senescence, sex expression and leaf lobation were presented in Fig. 2b, 2c and 2d respectively.

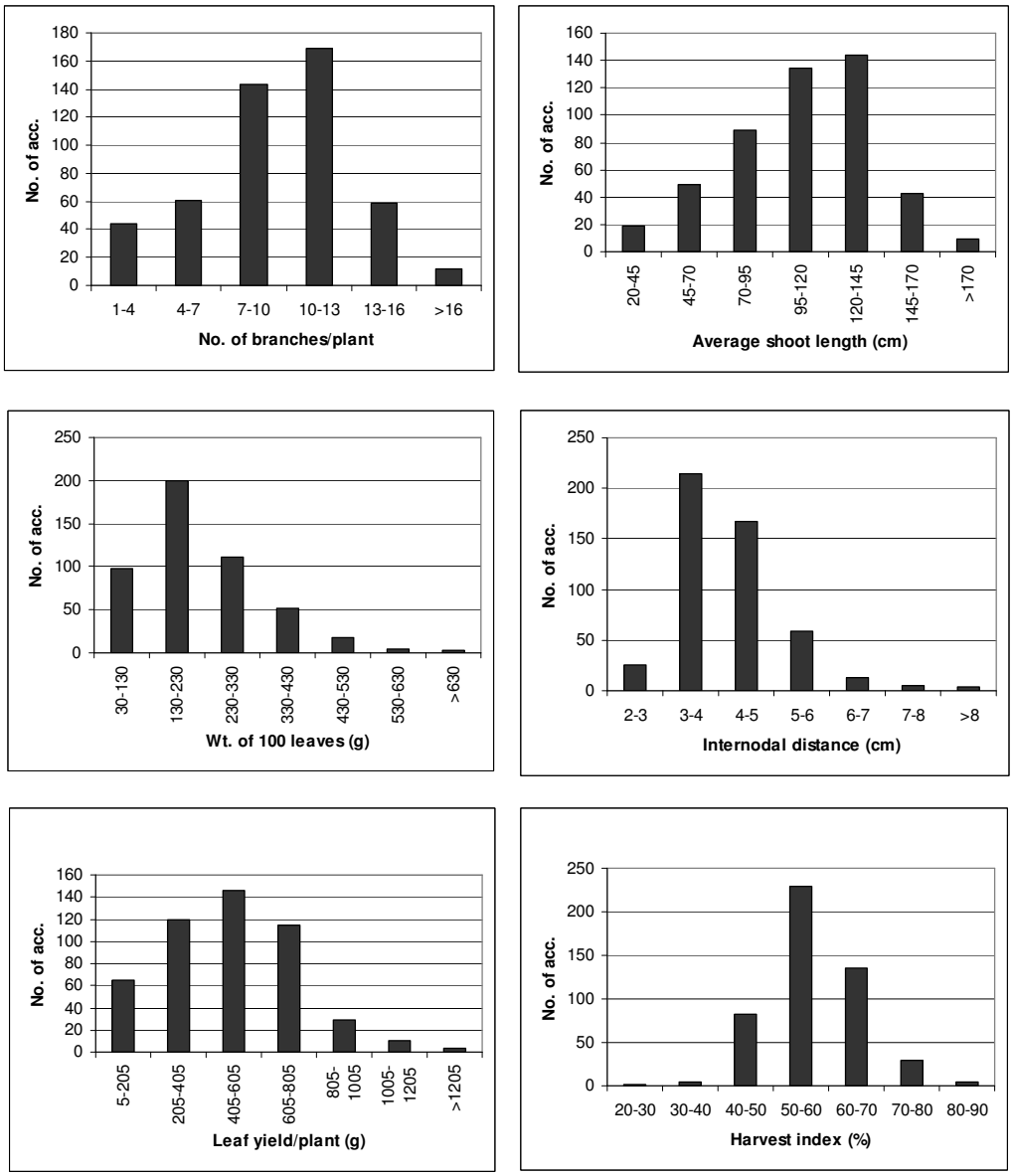
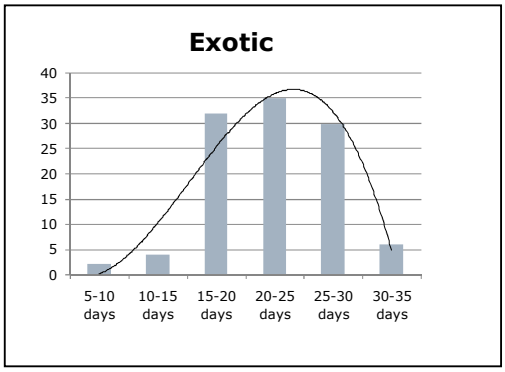
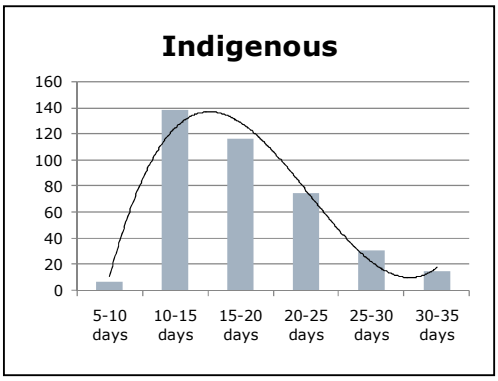


Fig. 1: Variability in Growth parameters in unique mulberry accessions



Mean : 23 days Range : 9-32 CV % : 22.01



Mean : 19 days Range : 9-35 CV % : 19.86

Fig. 2a: Variability in days to sprouting in unique mulberry accessions

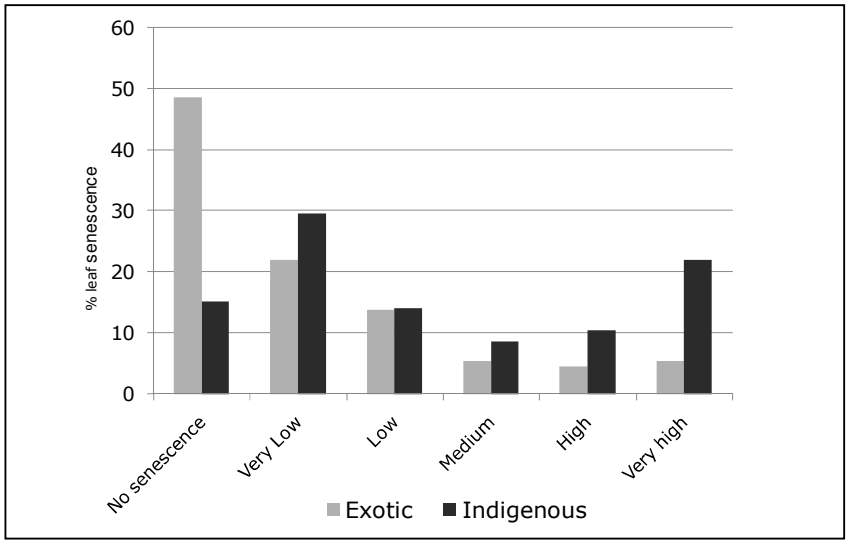


Fig. 2b : Variability in leaf senescence in unique mulberry accessions

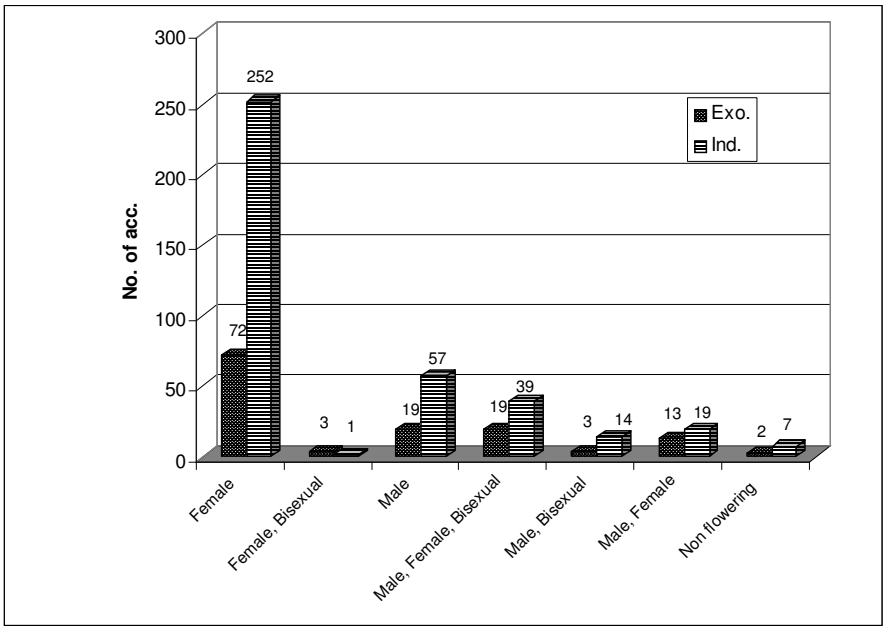


Fig. 2c : Sex expression in unique mulberry accessions

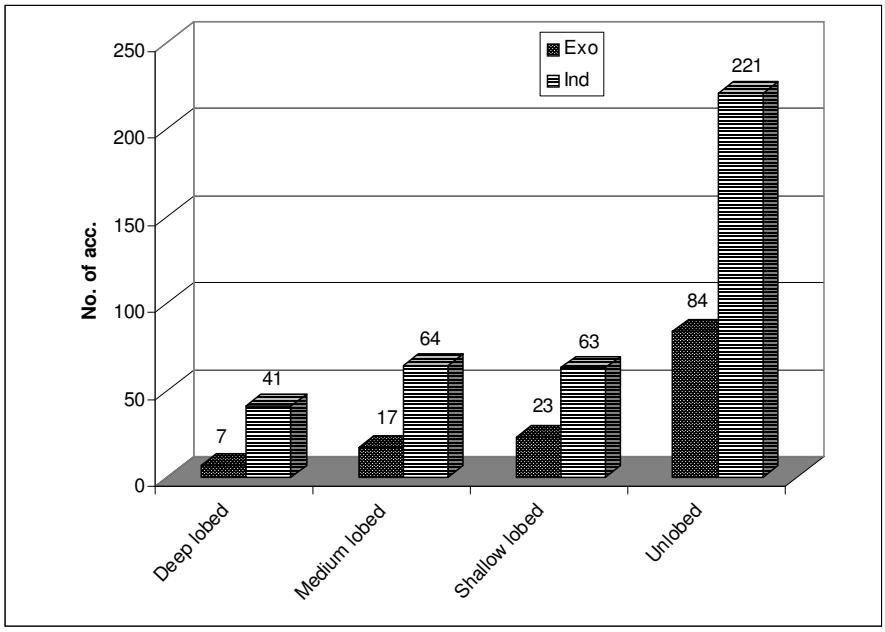


Fig. 2d : Leaf lobation in unique mulberry accessions

Table – 5 : Variability in growth and yield parameters

Parameters	Mean ± SE	Range	CV%
No. of branches (no.)	9.67 ± 0.16	1.00 - 24.50	36.25
Length of the longest shoot (cm)	123.74 ± 1.57	10.00 - 225.83	27.92
Average shoot length (cm)	108.21 ± 1.49	20.00 - 201.49	30.29
Weight of 100 leaves(g)	222.0 ±.5.10	33.2 - 665.6	50.29
Internodal distance (cm)	4.20 ± 0.04	2.52 - 10.00	22.88
Leaf yield /plant (g)	492.80 ± 11.42	30.00 - 1938.33	51.12
Stem yield (g)	414.65 ± 11.12	7.50 - 1366.00	59.27
Harvest Index (%)	57.38 ± 0.39	28.34 - 89.92	14.92

Table- 6 : Top performers - Indigenous/Exotic mulberry accessions

Parameter	Acc-type (range)	Accession number
No. of branches	Ind (16 - 25)	MI-0695, MI-0686, MI-0318, MI-0352, MI-0631, MI-0464, MI-0029, MI-0527, MI-0529, MI-0538
	Exo (13 - 17)	ME-0044, ME-0145, ME-0083, ME-0027, ME-0008, ME-0007, ME-0104, ME-0226, ME-0239, ME-0220
Length of the longest shoot (cm)	Ind. (178 - 203)	MI-0618, MI-0033, MI-0633, MI-0226, MI-0827, MI-0111, MI-0026, MI-0030, MI-0002, MI-0015
	Exo.(173 - 226)	ME-0051, ME-0160, ME-0008, ME-0018, ME-0007, ME-0071, ME-0001, ME-0020, ME-0096, ME-0056
Average shoot length (cm)	Ind. (160 - 190)	MI-0029, MI-0633, MI-0026, MI-0330, MI-0226, MI-0083, MI-0033, MI-0111, MI-0015, MI-0002
	Exo.(153 - 202)	ME-0099, ME-0160, ME-0001, ME-0007, ME-0008, ME-0130, ME-0071, ME-0096, ME-0020, ME-0056
Wt. of 100 leaves (g)	Ind.(490 - 670)	MI-0655, MI-0758, MI-0773, MI-0539, MI-0330, MI-0572, MI-0633, MI-0387, MI-0164, MI-0845
	Exo.(380 - 550)	ME-0060, ME-0131, ME-0169, ME-0146, ME-0096, ME-0006, ME-0100, ME-0141, ME-0036, ME-0011
Internodal distance (cm)	Ind. (2.5 - 2.8)	MI-0470, MI-0444, MI-0318, MI-0448, MI-0396, MI-0446,MI-0791, MI-0443, MI-0384, MI-0445
	Exo.(2.9 - 3.5)	ME-0008, ME-0219, ME-0070, ME-0063, ME-0254, ME-0169, ME-0110, ME-0073, ME-0207, ME-0134
Leaf yield/plant (g)	Ind. (971 - 1268)	MI-0686, MI-0303, MI-0135, MI-0464, MI-0191, MI-0052, MI-0246, MI-0523, MI-0241, MI-0529
	Exo.(933 – 1938)	ME-0020, ME-0052, ME-0169, ME-0179, ME-0096, ME-0007, ME-0071, ME-0006, ME-0027, ME-0056

Discussion

The development of core subset/panel of diverse germplasm is an important requirement for effective utilization of mulberry genetic resources in crop improvement programmes by conventional as well as by modern biotechnological approaches. A diverse, multipurpose core collection representing the maximum diversity available in entire germplasm collection with a small number of entries will be the first logical step for

intensive screening of desirable alleles. The small size make it possible to increase the number of traits that can be evaluated and also promote the possibility of using advanced techniques for screening. Besides, linkage disequilibrium (LD) based association mapping can be adopted using a panel of diverse germplasm for identification of QTLs for complex traits of economic importance.

Until recently, most of the efforts in mulberry improvement in India were towards increasing leaf yield and many of the important traits were often neglected (Tikader and Kamble, 2008). In addition, mulberry breeder preferred to use same set of gene pool for achieving the objectives of crop improvement programme resulting in narrow genetic base of mulberry. By assessment of total diversity available in mulberry germplasm and construction of a core subset helps for effective utilization of natural gene pool in crop improvement.

Inference/Recommendations

A panel of diverse germplasm (300 entries) and core sub set (150 entries) with maximum genetic and phenotypic diversity were sampled for use in linkage disequilibrium mapping and mulberry crop improvement programme. A total of 36 mandatory accessions were included in the core collection, which have been the integral part of Indian mulberry breeding programme over last four to five decades.

List of mulberry core collections (underlined are kernel accessions)

Exotic : ME-0001, 0004, 0006, 0011, 0018, 0020, 0036, 0046, 0052, 0056, 0060, 0062, 0063, 0065, 0066, 0071, 0073, 0079, 0081, 0085, 0090, 0091, 0093, 0100, 0101, 0102, 0104, 0108, 0118, 0120, 0123, 0134, 0136, 0140, 0141, 0143, 0144, 0150, 0152, 0165, 0173, 0179, 0198, 207, 0208, 0223, 0232, 0239, 0254, 0255.

Indigenous : MI-0002, 0006, 0007, 0012, 0013, 0014, 0017, 0024, 0026, 0029, 0037, 0043, 0046, 0048, 0052, 0063, 0065, 0066, 0079, 0082, 0099, 0105, 0122, 0124, 0137, 0158, 0160, 0164, 0173, 0182, 0231, 0247, 0285, 0290, 0308, 0310, 0340, 0347, 0352, 0354, 0360, 0364, 0365, 0379, 0383, 0384, 0410, 0417, 0424, 0454, 0457, 0465, 0473, 0491, 0524, 0540, 0551, 0569, 0571, 0572, 0575, 0587, 0589, 0592, 0606, 0621, 0625, 0628, 0629, 0633, 0659, 0661, 0665, 0667, 0673, 0686, 0688, 0697, 0699, 0736, 0737, 0739, 0743, 0745, 0747, 0751, 0772, 0774, 0775, 0782, 0787, 0791, 0803, 0805, 0808, 0809, 0818, 0828, G-2, G-4,RC-1, RC-2.

AIT - 3450: Long-term conservation of eggs/embryos of silkworm genetic resources (*Bombyx mori L.*) through Cryopreservation (DBT, New Delhi sponsored research projects)

Anuradha H. Jingade, A. Ananda Rao, Srinivasa Babu (upto 30.09.2012)

Introduction

The project was undertaken with an objective for long term conservation of mulberry silkworm (*Bombyx mori*) eggs/embryos through cryopreservation. Cryopreservation would provide a comprehensive long term conservation strategy for diverse silkworm genetic resources.

Objectives

- To develop suitable protocol for dechorionation of silkworm eggs, extraction of embryos, *in vitro* culture of silkworm embryo and assessment of survival rates.
- To develop suitable protocols for cryopreservation of egg/embryos of silkworm genetic resources.
- To establish cryo gene bank of embryos of silkworm genetic resources for commercial exploitation.

Materials and methods

Multivoltine silkworm breed, Pure Mysore (PM) was used for the development of egg cryopreservation technology. The technology was validated using ten multivoltine genetic stocks (Sarupat, Tamil Nadu white, Cnichi, Hosa Mysore, Mysore Princess, Kolar Gold, Kollegal Jawan and MY1).

Results

Dechorionation of eggs : PM silkworm eggs were treated with various inorganic compounds to determine the suitable treatment that can successfully permeabilize the eggs with minimal detrimental effect on survival. Potassium hydroxide (KOH), Sodium hydroxide (NaOH), Sodium thiosulphate ($Na_2S_2O_3$), Calcium chloride ($CaCl_2$), Acetic acid ($C_2H_4O_2$), and Sodium hypochlorite (NaOCl) were used in different concentrations for different durations. The treated eggs were incubated at optimum temperature and relative humidity (25±1°C and 80±5%) and a photoperiod of 16:8h (light and dark).

Identification of embryonic stages : The whole eggs treated for dechorionation were observed by light microscopy for determining the embryonic stages. Simultaneously untreated eggs were dissected and embryos were isolated for comparison following standard embryo isolation technique. Intact eggs were subjected to standardized chemical treatment of 2% NaOH for 2 minutes in combination with 5% NaOCl for 10 minutes at regular intervals and were observed under the stereo zoom microscope (Fig. 3). At embryonic age of 20h, germ band is formed; serosa extends completely to form a flattened cell layer and germ band becomes independent from the egg surface. At 24 h, germ band had elongated to form a

spoon shaped embryo with an enlarged head and tail region (stage 5). At 30 h, formation of ectoderm and mesoderm takes place (stage 6) followed by appearance of 18 mesodermal projections takes place (stage 7). Metamerism of the mesoderm is completed at 36 h and embryo covers 3/4th circumference of the egg and is called the longest embryonic stage (stage 15). Neural groove is formed at 40h (stage 16). Embryo increases in width at 42h (stage18). Thoracic and abdominal appendages develop at 60h (stage 19). Blastokinesis occurs at 4.5 days of development wherein 'S' shaped embryo is observed (stage 21 A, B & C). Inversion is completed and the embryo moves towards dorsal side from ventral side, lateral walls complete the dorsal closure (stage 23). At about 6.5 days setae are formed around the body (stage 24). Spiracles are clearly visible at 7 days (stage 25). On the 8th day of development, embryos are in head pigmentation stage (stage 26/27). On the 9th day entire body becomes sclerotised (stage 28/29) (Fig. 4).

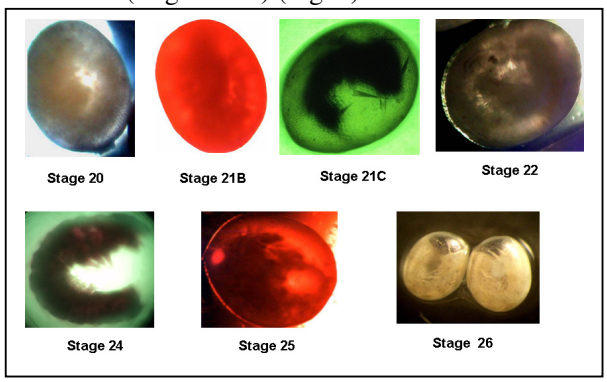


Fig. 3 : Permeabilised eggs with developing embryos

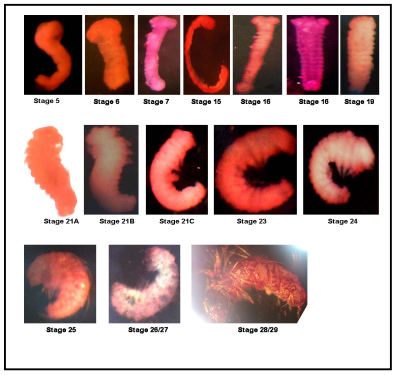


Fig. 4 : Embryonic stages of silkworm eggs

In vitro culture of silkworm embryos

Silkworm eggs of early stages (20 to 36 h), yolk was sucked out from the micropylar region using microsyringe. Embryos along with yolk were incubated in insect media (TNM-FH) for development. The embryos survived for one day and further development of the embryo was not observed. To assess the survival of the isolated embryos of different ages, embryos were incubated in different concentrations of Glycerol (0.2 to 30%), Ringer solution and water at room temperature(RT), 5°C , 0°C and -5°C. Silkworm eggs survived in 30% glycerol at RT, 5°C , 0°C, and -5°C for 24h and in Ringer solution for one hour at RT. Live embryos isolated at different days of development is shown in Fig. 5.

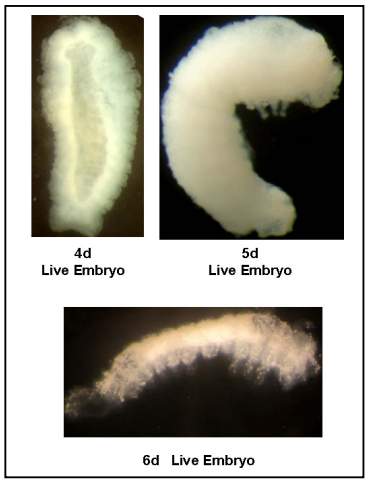


Fig. 5 : Live silkworm embryos at different days of development

Evaluation of CPAs with eggs subjected to chilling

Non dechorionated and dechorionated PM eggs were treated with CPA mixture comprising of 15%Ethylene Glycol (EG) + 15% DMSO + 30% Glycerol + 30% Sucrose for a duration of 10 minutes. The CPA treated eggs were subjected to chilling at -5°C, -10°C, -15°C, -20°C, -25°C and -30°C for duration of 10 minutes. CPA was unloaded by using higher concentration of sugar, washed with distilled water and incubated at standard conditions for hatching studies. In the non dechorionated eggs, hatching of 90% was obtained in treatments with CPA and without CPA. In the dechorioned eggs, hatching of 45 and 40% was obtained in the CPA treated and CPA untreated eggs, respectively (Fig. 6).

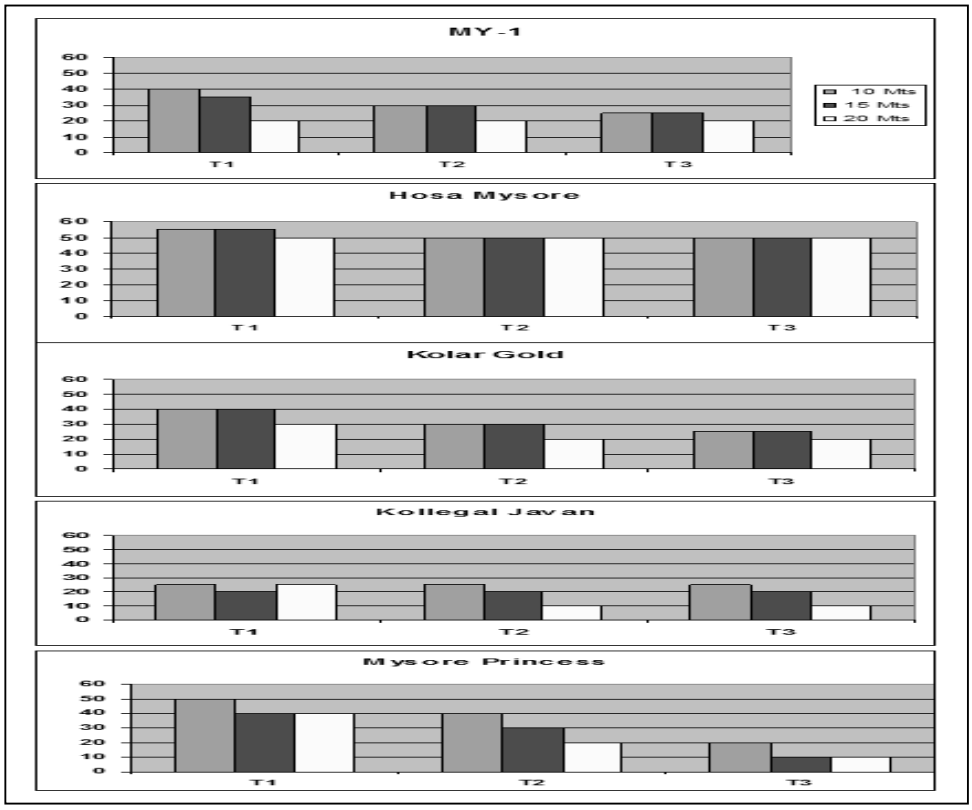


Fig. 6 : Equilibration time of CPA combination (DMSO, EG, Glycerol) on dechorionated eggs of different multivoltine races

Standardization of equilibration time for CPA tolerance using Electroporator

Studies were conducted with Electroporator for the electro-permeabilization of CPA into the eggs through electric conductivity caused by externally applied electric field. Non dechorionated and dechorionated eggs of ten races were electroporated at 400V, 500V and 600 V. It is observed that dechorionated eggs with CPA mixture, desiccated after 24hrs of treatment and non dechorionated eggs were washed and kept for incubation. At 400V, hatching ranged from 57.2% (BMI-0008) to 74.6% (BMI-0017); at 500V, from 55.0% (BMI-0008) to 72.4% (BMI- 0001) and at 600V, from 39.9% (BMI-0009) to 57.5% (BMI-0006).

Discussion

Cryopreservation studies in *B. mori* are very much limited. Gaining permeability into the silkworm eggs require series of chemical treatments as the chorion is very thick. The eggs upon treatment with different chemicals *viz*., Potassium hydroxide, Sodium hypochlorite, Acetic acid, Sodium thiosulphate and Calcium chloride at known concentrations have shown varied responses, which was observed and photographed under the microscope. It is found in the present study that silkworm of embryonic age upto 36 h were cold tolerant and embryo of 48 h was cold sensitive.

Cryopreservation of embryos involves a series of complex and dynamic physio-chemical processes of temperature and water transport between embryo and the surrounding medium. At this stage there is no conspicuous evidence to explain the exact chill tolerant embryonic age. Taking all the clues for the present study, further in-depth studies are required for developing successful cryopreservation techniques for silkworm egg/embryos.

Inference

- Multivoltine silkworm eggs can be successfully dechorionated by treating with 2% NaOH for 2 min + 5% NaOCl for 10 min
- Embryos of 36h age are chill tolerant and 48h embryos are chill sensitive
- Silkworm eggs can tolerate cryoprotectants with 60% survival
- Electroporation of CPA successful at 400V and 500V with 50 - 70% survival
- *In-vitro* culture of silkworm embryos and cryopreservation of silkworm eggs were not successful and requires further investigation taking leads from the observation obtained in the present study.

Technology developed

- Technique for dechorionating silkworm eggs was developed. Treating silkworm eggs with 2% NaOH for two minutes followed by 5 % NaOCl for 10 minutes showed complete dechorionation of eggs.
- Technique for isolation of live silkworm embryos from 4th day of development onwards was developed.
- Equilibration time for the CPA tolerance of different cryoprotectants on silkworm eggs after dechorionation, for 10 multivoltine races, was determined for use in cryopreservation of egg/embryos at room temperature. However, CPA tolerance is required to be standardized with respect to cryo temperature of LN at -196° C.

- Electroporation of eggs using the Electroporator was standardised. 400V and 500V found suitable for effective electroporation of silkworm eggs.

Recommendation

- Survival of eggs at cryo temperature could not be established as *in vitro* culture of silkworm embryos was not successful and requires further investigation taking leads from the observation obtained in the present study.

6. ALL INDIA CO-ORDINATED RESEARCH PROJECTS HIGHLIGHTS

AIE-3454: Evaluation of elite bivoltine silkworm germplasm under different agro climatic conditions: All India Silkworm Germplasm Evaluation Programme Phase-II

CSGRC,Hosur : P.I N.Balachandran, C.I. M.Muthulakshmi and S.Nivedita; CSRTI,Mysore : P.I S.Manthira Moorthy, C.I.Malreddy and A.Naseema begum; CSRTI,Berhampore : P.I M.K.Singh C.I. T. Datta; CSRTI,Pampore : P.I S.Guruswami , C.I. Nazeer Ahmed Saheb and Mir Nissar Ahmad; RSRS,Jorhat : P.I Yumnam Debraj C.I. Ranuma Das; RSRS, Kalimpong : Regina Bhutia C.I. U.K Bandyopadya; RSRS, Jammu : P.I S.K.Raina C.I. M.K.Tayal; RSRS, Sahaspur : P.I P.M.Tripathi C.I. P.K.Tewary

The evaluation data collected updated in the Silkworm Germplasm Information System (SGIS) over the years on the 350 bivoltine silkworm germplasm accessions conserved and maintained at CSGRC, Hosur for 12 rearing and 16 post-cocoon traits were used for identifying the elite bivoltine accessions with multiple traits. These data on the important evaluation parameters were pooled and promising accessions were identified and included in the project for evaluation at all India level under the project AIE-3454 Evaluation of elite bivoltine silkworm germplasm under different agro climatic conditions: All India Silkworm Germplasm Evaluation Programme Phase-II. During the present phase 2011-2014, the network centres selected includes CSRTI, Pampore, CSRTI, Mysore, CSRTI, Berhampore, RSRS, Jammu, RSRS, Sahaspur, RSRS, Kalimpong and RSRS, Jorhat. The following are the accessions included for the study (Table - 7). The brushing programme for the two crops in an year for the networking centres in given in Table - 8.

Table - 7 : List of bivoltine germplasm accessions selected for evaluation

Sl.No	Accession No.	Name of the Accession
1	BBE-0164	Shongetsu Hoshu
2	BBE-0329	MIR-4
3	BBE-0268	J 1 M
4	BBE-0202	C124 (SL)
5	BBE-0266	J 2 P
6	BBE-0225	JZH (PO)

7	BBI-0338	D-1
8	BBE-0263	101-D
9	BBE-0216	HO (SL)
10	BBI-348	NP-2
11	Local Control	Popular local Breed
12	National Control	CSR-2

Table - 8 : Brushing programme of the centres for spring and autumn crop

Sl. No.	Name of the Centre	Spring crop	Autumn crop
1	CSGRC-Hosur	15/02/2012	01/09/2012
2	CSRTI-Berhampore	01/02/2012	01/11/2012
3	RSRS-Sahaspur	01/03/2012	01/09/2012
4	RSRS-Kalimpong	22/04/2012	22/08/2012
5	RSRS-Jorhat	03/03/2012	10/10/2012
6	CSRTI-Mysore	01/02/2012	01/11/2012
7	CSRTI-Pampore	02/05/2012	20/08/2012
8	RSRS-Jammu	07/03/2012	10/09/2012

The project was approved in August 2011 but as the crop seasons of many of the network centres have crossed in August and the dfls of the elite accessions have to be prepared for supply to different network centres, the first crop was initiated from spring 2012 followed by autumn crop in August 2012. The data on the two crop seasons from all the eight network centres were compiled at CSGRC, Hosur. So far four crops have been completed which includes two spring seasons (Table - 9) and two autumn seasons (Table - 10). During the year two crops have been completed with all the eight network centres as per the brushing programme and the data on the important evaluation traits were analysed individually for the spring and autumn crop and the better performing accessions were presented centre wise in Table - 9.

Table-9 : Ranking of accessions based on the Spring crop 2013

Rank	CSRTI Berhampore	CSRTI Pampore	CSRTI Mysore	RSRS, Jammu	RSRS, Jorhat	RSRS, Sahaspur	RSRS, Kalimpong	CSGRC, Hosur
I	BBI-0348	BBI-0045	BBE-0329	BBI-0348	BBI-0338	BBI-0045	BBI-0371	BBE-0266
II	BBE-0263	BBE-0266	BBE-0263	BBI-0290	BBI-0371	BBE-0225	BBE-0266	BBI-0348
III	BBI-0045	BBI-0290	BBI-0348	BBE-0216	BBI-0348	BBE-0216	BBE-0329	BBE-0263
IV	BBE-0329	BBI-0348	BBI-0338	BBI-0338	BBI-0290	BBI-0348	BBE-0216	BBE-0216
V	BBE-0268	BBI-0338	BBE-0266	BBI-0045	BBE-0329	BBI-0290	BBI-0338	BBE-0329

The spring crop results showed accession BBI-0348 performed better in 7 centres, BBE-0329 and BBI-0338 in 5 centres, BBE-0266 and BBI-0290 in 4 centres, BBE-0263 in 3 centres.

Table - 10: Ranking of accessions based on the Autumn crop 2013

Rank	CSRTI Berhampore	CSRTI Pampore	CSRTI Mysore	RSRS, Jammu	RSRS, Jorhat	RSRS, Sahaspur	RSRS, Kalimpong	CSGRC, Hosur
I	BBI-0290	BBE-0216	BBI-0348	BBI-0045	BBE-0225	BBE-0329	BBE-0268	BBI-0338
II	BBE-0216	BBI-0338	BBI-0290	BBI-0348	BBE-0216	BBE-0263	BBE-0202	BBE-0263
III	BBI-0371	BBI-0290	BBE-0266	BBE-0329	BBE-0268	BBE-0225	BBE-0266	BBI-0348
IV	BBE-0268	BBE-0263	BBI-0338	BBE-0263	BBE-0202	BBI-0348	BBI-0348	BBE-0266
V	BBE-0329	BBI-0348	BBE-0202	BBI-0290	BBI-0290	BBE-0216	BBI-0371	BBI-0290

The autumn crop results revealed accession BBI-0348, BBI-0290 performed better in 6 centres, BBE-0263, BBE-0216 in 4 centres, BBE-0329, BBI-0338, BBE-0266 and BBE-0268 in 3 centres. Further two more crops have to be completed with the all eight network centres during 2014-15 and the cocoon samples of the entire eleven test accessions from all the network centres will be received for analyzing the post cocoon traits before concluding the better and promising accessions out of the project.

7. INTER - INSTITUTIONAL COLLABORATIVE PROJECTS

PIB - 3505: Development of drought tolerant mulberry variety for rain fed sericulture (*collaborative project with CSRTI, Berhampore*)

Duration: February 2014- December, 2019

CSRTI, Berhampore: *Dr. M.K. Ghosh, Dr. P.K. Ghosh, Dr. S. K. Dutta and Dr. M.V. Santhakumar*

CSGRC, Hosur : *Dr. K. Jhansilakshmi and Sri M.M. Borpuzari*

Drought is the most serious production constraint and projected to worsen with anticipated climate change. Tolerance to drought is complex quantitative trait controlled by several genes with small effects. Hence, strategic trait based crossing which helps to accumulate complimentary drought adaptive physiological traits in the progeny was choosen for development of drought tolerant variety. Towards this direction, parents (Female - 10 and male - 7) were identified based on specific traits, initiated staggered pruning for synchronization of flowering and a total of 12 cross combinations were planned and out of which hybridization work of 10 crosses (MI-0437 x ME-0125, MI-0437 x MI-0256, ME-0065 x MI-0670, MI-0685 x MI-0314, MI-0685 x MI-3008, MI-0827 x MI-0012, MI-0828 x ME-0125, MI-0762 x ME-0065, MI-0763 x MI-0012, MI-0214 x MI-0670, MI-0836 x MI-0308) was completed.

8. OTHER PROGRAMMES OF CONTINUOUS/ROUTINE NATURE

MULBERRY DIVISION

Five research projects were implemented in the mulberry division during the year and out of this three mulberry projects have been concluded. Towards the enrichment of mulberry field gene bank with diverse collections, 15 mulberry accessions collected from survey and exploration were added to the *ex situ* collections. The VII phase (2012 - 2015) of on going research programme on collection, characterization, evaluation, conservation, and supply of mulberry genetic resources was continued during the year. The characterization and evaluation data of 22 mulberry accessions was analysed and documented in the Mulberry Germplasm Information System (MGIS), which facilitated for identification of promising accessions and for the development of trait specific core collections for faster utilization of resources. New mulberry germplasm catalogue (volume - 5) for 150 accessions was published containing the data on morphology, reproductive, leaf anatomy, growth and yield, propagation, biochemical, disease incidence and passport information. Sixty mulberry accessions were evaluated under ARBD and promising accessions were identified. Forty mulberry accessions were cryo-preserved using dehydration and slow freezing protocol.

The DBT sponsored collaborative research project with CSRTI, Mysore on development of core collections of mulberry using molecular markers was concluded with short-listing 150 diverse core set for utilization of mulberry genetic resources. In order to identify promising mulberry accessions for high water use efficiency, 120 shortlisted mulberry germplasm have been screened for high water use efficiency and 34 promising accessions identified for utilization in the breeding programmes for low input conditions. Utilizing these promising accessions for WUE and NUE, a collaborative research project with CSRTI, Berhampore was initiated on development of drought resistant mulberry variety and strategic trait based crossing programme was planed utilizing 10 female and 7 male parents. Screening for alkaline and saline tolerance yielded 17 alkaline (at pH) and 20 saline tolerant (at 6 dS/m) promising accessions were identified. During the year a total of 333 mulberry accessions have been supplied to different indenters for utilization of the resources.

PIG - 3482: Collection, introduction, characterization, evaluation, conservation and supply of mulberry genetic resources

S-01: Survey, exploration and collection of mulberry genetic resources

Preliminary screening was made for thirty four mulberry germplasm collections of survey (KSSRDI, Thalaghattapura - 19, Goa - 10 and Pondicherry - 05) based on morphological characterization and 15 mulberry accessions were finally selected and added to *ex situ* field gene bank thus raising the total collections in the *ex situ* field collection to 1269.

S-02: Characterization of mulberry genetic resources

Plant genetic diversity plays a key role in the development of new cultivars. Characterisation mainly deals with the heritable characters enable an easy and quick discrimination between phenotypes and allows a simple grouping of accessions facilitating breeder and users for utilization. Besides, the genetic identity and its documentation is utmost important with the increased impact of globalisation and patenting regime. The mulberry germplasm held at the field gene bank remain largely unknown and unutilised if they are not properly characterised, evaluated and documented.

E-01: Morphological characterization of mulberry genetic resources

A.Ananda Rao and P.Saraswati

The variability and the frequency distribution of 22 mulberry accessions for different morphological characters are given in Table - 11. The growth nature is mostly spreading type (81.82 %). The branches are slightly curved in most of the accessions (77.27 %). The leaves are with 1/2 phyllotaxy (59.09 %), shape ovate (54.54 %) and wide ovate (36.36 %). The leaf nature is mostly homophyllous (77.27 %). The leaf lobation is mostly unlobed entire (68.18 %). The texture of leaves is mostly coriaceous (thick) nature (81.82 %) with dense trichome (50 %). Highest leaf thickness was recorded for the accessions *viz.* MI-0895, MI-0896, MI-0898, MI-0891 and MI-0901. Erect morpho types *viz*., MI-0890, MI-0908, MI-0910, MI-0911 and leaf length more than 21 cm *viz*., MI-0899, MI-0898, MI-0902, MI-0909 and MI-0010 are found promising for utilization.

Table - 11: Morphological characterization of mulberry genetic resources

Sl.No	Acc. No.	Accessions Name	Phyllotaxy	Branching nature	Straightness of the branch	Colour of young shoot	Colour of matured shoot
1	MI-0890	Chuchumialang	1/2	Erect	Straight	Purple green	Purple brown
2	MI-0891	IC538735	1/2	Spreading	Slightly curved	Green	Purple brown
3	MI-0892	Sungeri-1	1/3, 1/2	Spreading	Straight	Green	Purple brown
4	MI-0893	Sungari-2	1/2	Spreading	Slightly curved	Green	Purple green
5	MI-0894	IC538734	1/2	Spreading	Slightly curved	Green	Grey
6	MI-0895	Khanouli	1/2	Spreading	Slightly curved	Green	Grey green
7	MI-0896	Matiana	1/2	Spreading	Slightly curved	Green	Grey green
8	MI-0897	Seema-1	1/2	Spreading	Slightly curved	Green	Grey green
9	MI-0898	Theog-1	1/2	Spreading	Slightly curved	Green	Grey green
10	MI-0899	Chirgao-3	1/2	Spreading	Slightly curved	Green	Grey green
11	MI-0900	Changhar -1	1/2	Spreading	Slightly curved	Green	Grey green
12	MI-0901	Chirgao	1/2	Spreading	Slightly curved	Green	Purple brown
13	MI-0902	Vishala	1/2	Spreading	Slightly curved	Green	Green
14	MI-0903	Acc.126	1/2,2/5	Spreading	Slightly curved	Green	Purple brown

15	MI-0904	Rati	2/5	Spreading	Slightly curved	Green	Grey green
16	MI-0905	Saundatti	1/3, 1/2	Spreading	Slightly curved	Green	Green
17	MI-0906	Acc.117	1/2, 2/5	Spreading	Slightly curved	Green	Green
18	MI-0907	AB x Philip	1/2,1/3	Spreading	Slightly curved	Green	Purple green
19	MI-0908	Bogatee	1/2,1/3	Semi erect	Straight	Green	Grey green
20	MI-0909	Acc.199	1/2, 1/3	Spreading	Slightly curved	Green	Grey green
21	MI-0910	Burian	1/3	Semi erect	Straight	Purple green	Purple green
22	MI-0911	Jodhpur-3	1/2	Semi erect	Straight	Purple green	Grey green

Table contd….

Sl.No.	Acc.No.	Stipule duration	Stipule nature	Lobation type	Leaf Nature	Leaf colour	Leaf texture
1	MI-0890	Caducous	Foliacious	Unlobed	Homophyllous	Green	Coriaceous
2	MI-0891	Caducous	Foliacious	Medium lobed	Homophyllous	Deep green	Coriaceous
3	MI-0892	Caducous	Free - lateral	Unlobed	Homophyllous	Green	Chartaceous
4	MI-0893	Caducous	Free - lateral	Unlobed	Homophyllous	Deep green	Coriaceous
5	MI-0894	Caducous	Free - lateral	Medium lobed	Homophyllous	Deep green	Coriaceous
6	MI-0895	Caducous	Free - lateral	Medium lobed	Heterophyllous	Deep green	Coriaceous
7	MI-0896	Caducous	Free - lateral	Medium lobed	Heterophyllous	Deep green	Coriaceous
8	MI-0897	Caducous	Free - lateral	Medium lobed	Heterophyllous	Green	Coriaceous
9	MI-0898	Caducous	Free - lateral	Unlobed	Homophyllous	Deep green	Coriaceous
10	MI-0899	Caducous	Foliacious	Medium lobed	Heterophyllous	Deep green	Coriaceous
11	MI-0900	Caducous	Free - lateral	Unlobed	Homophyllous	Deep green	Coriaceous
12	MI-0901	Caducous	Free - lateral	Unlobed	Homophyllous	Deep green	Coriaceous
13	MI-0902	Caducous	Free - lateral	Unlobed	Homophyllous	Deep green	Coriaceous
14	MI-0903	Caducous	Free - lateral	Unlobed	Homophyllous	Deep green	Coriaceous
15	MI-0904	Caducous	Free - lateral	Unlobed	Homophyllous	Deep green	Coriaceous
16	MI-0905	Caducous	Free - lateral	Unlobed	Homophyllous	Deep green	Chartaceous
17	MI-0906	Caducous	Free - lateral	Unlobed	Homophyllous	Green	Chartaceous
18	MI-0907	Caducous	Free - lateral	Unlobed	Homophyllous	Deep green	Coriaceous
19	MI-0908	Caducous	Free - lateral	Unlobed	Homophyllous	Deep green	Coriaceous
20	MI-0909	Caducous	Free - lateral	Unlobed	Homophyllous	Deep green	Coriaceous
21	MI-0910	Caducous	Free - lateral	Unlobed	Homophyllous	Green	Coriaceous
22	MI-0911	Caducous	Free - lateral	Medium lobed	Heterophyllous	Green	Chartaceous

Table contd….

Sl.No	Acc. No.	Leaf apex	Leaf base	Leaf margin	Leaf length (cm)	Leaf width (cm)	Leaf shape	Petiole Length (cm)	Petiole width (cm)	Trichome density	Lenticel Density
1	MI-0890	Caudate	Cordate	Serrate	19.50	16.00	Ovate	4.20	0.30	Sparse	7.0
2	MI-0891	Acuminate	Cordate	Serrate	16.70	16.00	Wide ovate	5.00	0.30	Dense	3.0
3	MI-0892	Acuminate	Truncate	Serrate	14.00	9.50	Ovate	3.50	0.20	Dense	5.0

4	MI-0893	Acuminate	Lobate	Serrate	12.50	10.00	Ovate	3.00	0.20	Sparse	3.0
5	MI-0894	Acuminate	Cordate	Serrate	17.50	15.00	Wide ovate	3.30	0.40	Dense	5.0
6	MI-0895	Acuminate	Lobate	Dentate	16.00	14.50	Wide ovate	4.40	0.30	Dense	2.0
7	MI-0896	Acuminate	Cordate	Serrate	19.70	13.50	Ovate	4.80	0.40	Dense	3.0
8	MI-0897	Acuminate	Cordate	Serrate	17.80	14.00	Ovate	3.50	0.30	Sparse	2.0
9	MI-0898	Acute	Cordate	Dentate	21.50	18.00	Wide ovate	4.50	0.40	Dense	3.0
10	MI-0899	Acuminate	Truncate	Serrate	23.20	19.80	Wide ovate	8.80	0.50	Dense	5.0
11	MI-0900	Acuminate	Truncate	Serrate	14.00	10.80	Ovate	3.50	0.20	Dense	3.0
12	MI-0901	Acuminate	Cordate	Dentate	13.30	10.00	Ovate	3.50	0.30	Dense	2.0
13	MI-0902	Acuminate	Acute	Serrate	21.30	14.40	Ovate	4.00	0.30	Medium	2.0
14	MI-0903	Acuminate	Cordate	Serrate	13.50	11.50	Wide ovate	3.70	0.40	Medium	3.0
15	MI-0904	Acuminate	Truncate	Serrate	16.20	13.50	Wide ovate	4.00	0.30	Dense	3.0
16	MI-0905	Acuminate	Truncate	Serrate	11.20	7.50	Ovate	2.00	0.20	Sparse	6.0
17	MI-0906	Acuminate	Acute	Serrate	8.40	5.50	Narrow ovate	2.30	0.20	Medium	3.0
18	MI-0907	Acuminate	Truncate	Serrate	16.30	11.60	Ovate	5.00	0.20	Medium	5.0
19	MI-0908	Acuminate	Cordate	Serrate	18.40	11.30	Narrow ovate	4.20	0.20	Sparse	6.0
20	MI-0909	Acuminate	Truncate	Serrate	23.00	20.00	Wide ovate	4.40	0.50	Medium	2.0
21	MI-0910	Acuminate	Cordate	Serrate	21.60	16.50	Ovate	5.00	0.40	Medium	4.0
22	MI-0911	Acuminate	Cordate	Serrate	13.50	11.50	Wide ovate	4.20	0.30	Dense	3.0

E-02: Leaf anatomical characterization of mulberry genetic resources

A.Ananda Rao and P.Saraswati

The variability of 22 mulberry accessions on different leaf histological characters is given in Table - 12 . The stomatal size ranged from 202.47 to 510.53 sq.µm with mean value of 324.31 sq.µm, stomatal frequency raged from 262.06 to 883.92/ sq.mm with mean value of 543.46/sq.mm and chloroplast/stomata ranged from 8 to 20 with mean value of 13. Palisade thickness ranged form 46.90 to 105.52 µm with mean value of 76.83 µm and the spongy thickness ranged from 48.28 to 103.45 µm with mean value of 64.93 µm. The leaf thickness ranged from 123.96 to 246.72 µm with mean value of 189.58 µm. Highest coefficient of variation was recorded for idioblast projection length (87.63 %) followed by lower epidermal thickness (46.65 %). Leaf histological characters are important for selection of accessions for drought tolerance. Hence, ranking of accessions was carried out to select and shortlist the varieties for both biotic and abiotic stress tolerance (Table - 13). Ten indigenous namely MI-0896, MI-0898, MI-0891, MI-0901, MI-0895, MI-0903, MI-0902, MI-0911, MI-0907 and MI-0906 which possesses more than 4 desirable characters are qualified for further evaluation in the hot spots.

Table - 12: Variability of 22 mulberry accessions on leaf anatomical parameters

Sl. No.	Characters	Mean	Min	Max	SD	SE	CV%
1	Stomatal size (sq.µm)	324.31	202.47	510.53	89.07	20.43	27.46
2	Stomatal freqency/sq.mm	543.46	262.06	883.92	174.14	39.95	32.04
3	No of chloroplast/ stomata	123.99	8.00	20.40	3.87	0.89	29.78
4	Idioblast length (µm)	22.25	6.21	74.48	19.5	4.47	87.63
5	Idioblast width (µm)	25.62	10.35	42.76	10.56	2.42	41.23
6	Idioblast freqency/sq.mm	21.20	7.48	40.44	7.88	1.81	37.16
7	Upper cuticular thickness (µm)	6.40	3.45	7.59	1.51	0.35	23.50
8	Lower cuticular thickness (µm)	4.34	3.28	6.90	1.44	0.33	33.25
9	Upper epidermal thickness (µm)	27.90	11.03	41.38	7.68	1.76	27.53
10	Lower epidermal thickness (µm)	9.19	3.45	20.00	4.29	0.98	46.65
11	Palisade thickness (µm)	76.83	46.90	105.52	16.22	3.72	21.11
12	Spongy thickness (µm)	64.93	48.28	103.45	12.67	2.91	19.52
13	Total leaf thickness (µm)	189.58	123.96	246.72	28.57	6.55	15.07
14	Palisade : Spongy ratio	1.24	0.88	2.03	0.32	0.07	25.56

Table - 13 : Top performing and ranking of mulberry genetic resources based on leaf anatomical parameters

Traits	Range	Accession no.
Stomatal size (sq.µm)	202.47 -260.31	MI-0904, MI-0903, MI-0911, MI-0908, MI-0906
Stomatal frequency/sq.mm	262.06 - 415.96	MI-0898, MI-0901, MI-0897, MI-0896, MI-0907
No of chloroplast/stomata	20.40 -16.00	MI-0896, MI-0898, MI-0891, MI-0901, MI-0897
Idioblast length (µm)	6.21 - 9.66	MI-0905, MI-0893, MI-0906, MI-0911, MI-0902
Idioblast width (µm)	10.35 - 15.17	MI-0907, MI-0908, MI-0893, MI-0911, MI-0910
Idioblast frequency /sq.mm	7.48 - 13.10	MI-0905, MI-0890, MI-0908, MI-0900, MI-0906
Upper cuticular thickness (µm)	7.59 - 7.59	MI-0898, MI-0891, MI-0892, MI-0907, MI-0894
Lower cuticular thickness (µm)	6.90 -6.21	MI-0901, MI-0904, MI-0902, MI-0907, MI-0903
Upper epidermal thickness (µm)	41.38 -33.10	MI-0896, MI-0902, MI-0910, MI-0903, MI-0900
Lower epidermal thickness (µm)	20.00 - 10.35	MI-0895, MI-0897, MI-0890, MI-0901, MI-0902
Palisade thickness (µm)	105.52 - 91.03	MI-0896, MI-0892, MI-0898, MI-0891, MI-0895
Spongy thickness (µm)	103.45 - 72.41	MI-0895, MI-0898, MI-0906, MI-0890, MI-0896
Total leaf thickness (µm)	246.72 - 205.51	MI-0895, MI-0896, MI-0898, MI-0891, MI-0901
Palisade : Spongy ratio	2.03 - 1.46	MI-0892, MI-0911, MI-0903, MI-0891, MI-0896

table -13 contd…

Ranking of mulberry genetic resources on leaf anatomical parameters		
Acc. No.	No. of parameters	No. of parameter with value
MI-0896	7	2(322.371), 3(20.4), 9(41.378), 11(105.515), 12(72.412), 13(236.547), 14(1.46)
MI-0898	6	2(262.056), 3(19.6), 7(7.586), 11(97.239), 12(79.309), 13(224.133)
MI-0891	5	3(18.8), 7(7.586), 11(94.481), 13(211.03), 14(1.463)
MI-0901	5	2(274.535), 3(18.8), 8(6.896), 10(12.414), 13(205.513)
MI-0895	4	10(20), 11(91.032), 12(103.446), 13(246.719)
MI-0903	4	1(219.452), 8(6.207), 9(33.792), 14(1.546)
MI-0902	4	4(9.655), 8(6.896), 9(38.62), 10(10.345)
MI-0911	4	1(256.64), 4(8.965), 5(13.793), 14(1.849)
MI-0907	4	2(415.963), 5(10.345), 7(7.586), 8(6.207)
MI-0906	4	1(260.313), 4(7.241), 6(13.096), 12(74.481)

E-03: Reproductive characterisation of mulberry genetic resources

A.Ananda Rao and P.Saraswati

Seventeen indigenous accessions have flowered in the main flowering season (Sep-Oct and Feb-Mar) during the period. The sex expression of the studied accessions indicated preponderance of unisexuality with dioecious nature. Out of 17 accessions studied 15 (88.24 %) are dioecious and 2 (11.76%) are monoecious in nature. Under dioecious conditions femaleness (53.33%) was more predominant. Significant variation was recorded for all the reproductive characters in indigenous accessions studied (Table - 14). Highest number of flowers/inflorescence was recorded in the accession no. MI-0915 (♀), MI-0902 (♀) and MI-0903 (♂).

Table - 14: Reproductive characterization of mulberry genetic resources (22 accessions)

Acc. No.	**Sex**	**Inflorescence length (cm)**			**Inflorescence width (cm)**			**No. of flowers/catkin**			**Style length (mm)**	**Stigma length-shorter (mm)**	**Stigma length-longer (mm)**
		♂	♀	Bisex	♂	♀	Bisex	♂	♀	Bisex			
MI-0890	BISEX	--	--	2.23	--	--	0.57	--	--	36.33	--	--	--
MI-0894	FEML	--	1.70	--	--	0.65	--	--	53.00	--	0.50	2.10	2.15
MI-0897	MALE	1.60	--	--	1.00	--	--	32.00	--	--	--	--	--
MI-0900	FEML	--	1.68	--	--	0.56	--	--	57.00	--	1.20	2.00	2.30
MI-0902	FEML	--	2.58	--	--	0.68	--	--	76.60	--	0.74	1.80	2.12
MI-0903	MALE	2.16	--	--	0.80	--	--	54.60	--	--	--	--	--
MI-0904	FEML	--	1.63	--	--	0.45	--	--	45.50	--	1.03	1.28	1.48
MI-0905	FEML	--	1.40	--	--	0.82	--	--	53.20	--	1.22	2.24	2.56
MI-0906	FEML	--	1.20	--		0.66	--	--	23.00	--	1.00	1.92	2.10
MI-0907	MLFL	2.40	1.24	--	0.40	0.46	--	25.00	21.60	--	0.78	1.42	1.76
MI-0908	MALE	2.30	--	--	0.50	--	--	69.00	--	--	--	--	--

MI-0909	FEML	--	1.50	--	--	0.60	--	--	38.00	--	0.50	0.90	0.90
MI-0910	FEML	--	2.00	--	--	0.80	--	--	36.50	--	0.75	2.10	2.70
MI-0911	FEML	--	1.00	--	--	0.40	--	--	17.00	--	0.27	1.43	1.53
MI-0912	MALE	1.45	--	--	0.45	--	--	24.00	--	--	--	--	--
MI-0913	FEML	--	0.80	--	--	0.60	--	--	49.00	--	0.50	1.80	1.90
MI-0914	FEML	--	1.20	--	--	0.67	--	--	42.00	--	0.25	1.85	2.10

Table contd…

Acc. No.	Stamen length (mm)	Anther length (mm)	Pollen diameter (µm)	Pollen viability (%)	Fruit parameters		
					Length (cm)	Width (cm)	Weight (g)
MI-0890	--	--	--	--	--	--	--
MI-0894	--	1.15	--	--	--	--	--
MI-0897	3.62	1.06	--	--	--	--	--
MI-0900	--	--	--	--	2.46	1.32	1.16
MI-0902	--	--	--	--	3.43	1.23	0.99
MI-0903	4.12	1.10	19.99	14.50	--	--	--
MI-0904	--	--	--	--	2.73	1.01	1.24
MI-0905	2.50	--	--	--	2.35	1.25	1.05
MI-0906	--	--	--	--	1.46	0.64	0.41
MI-0907	2.02	0.88	17.92	93.45	1.00	0.60	0.29
MI-0908	3.06	0.92	19.31	60.83	3.80	0.74	1.10
MI-0909	--	--	--	--	--	--	--
MI-0910	--	--	--	--	--	--	--
MI-0911	--	--	--	--	--	--	--
MI-0912	3.04	0.96	22.06	30.33	--	--	--
MI-0913	--	--	--	--	1.34	0.66	0.47
MI-0914	--	--	--	--	1.60	0.90	0.36

S-03: Evaluation of mulberry genetic resources

E-01: Evaluation of mulberry genetic resources for propagation traits

D. Mohan Ram Rao and P. Saraswati

Fifty indigenous mulberry accessions along with 2 check varieties (V1 and K2) were evaluated for seventeen propagation parameters using the set descriptors. The experiment was conducted in RBD with three replications by planting 20 cuttings per accession in each replication along with check varieties. The sprouting data was recorded after one month of plantation and survival percentage and other growth parameters were recorded after 90 days of plantation. Maximum survival percentage was recorded in MI-0939 (91.67 %) while the check V-1 variety exhibited rooting (90 %) and K2 with 67 %.

Table - 15: Survival (%) of mulberry germplasm after 90 days of plantation

Frequency	No. of Accs (% of frequency)	Accessions
> 90	1 (2%)	MI-0939(91.67 %)
80-90	5 (10%)	MI-0906, MI-0932, MI-0934, MI-0935, MI-0938
50-79	6 (12 %)	MI-0905, MI-0904, MI-0912, MI-0913, MI-0933, MI-0936
<50	17 (34%)	MI-0931, MI-0928, MI-0927, MI-0925 MI-0922, MI-0913, MI-0918, MI-0917, MI-0916, MI-0914, MI-0902 MI-0901, MI-0937, MI-0673, MI-0622, MI-0616, MI-0455
0 %	21 (42 %)	MI-0378, MI-0408, MI-0411, MI-0414 MI-0417, MI-0418, MI-0419, MI-0420, MI-0427, MI-0428, MI-0429 MI-0452, MI-0618, MI-0628, MI-0629, MI-0636, MI-0659, MI-0676, MI-0787, MI-0837, MI-0838

The percentage frequency of survival of different mulberry accessions was given in the Table - 15 which indicated that 21 accessions (42%) mainly belong to *Morus laevigata* and *M.serrata* did not survive and 17 (34%) accessions showed < 50 % survival. The variability of mulberry accessions on different propagation parameters was given in Table-16.

Table - 16: Variability of Mulberry accessions for propagation parameters

Acc. No.	Mean	Min.	Max.	SD	SE	CV%
Survival (%)	59.015	10	91.67	24.13	5.27	40.89
Shoot length(cm)	61.72	36.55	81.89	11.73	2.56	19.00
No. of roots/sapling	4.94	3.11	7.00	1.14	0.25	23.15
Longest root length (cm)	23.41	15.11	33.00	4.06	0.89	17.34
Root weight -fresh (g)	4.94	2.11	8.67	1.96	0.43	39.78
Root weight -dry (g)	1.70	0.40	3.28	0.74	0.16	43.49
Root volume (ml)	4.70	1.98	8.33	1.88	0.41	39.97

The 21 mulberry accessions which showed 0 % survival were excluded from the analyses. The survival % percentage ranged from 10 to 91. 67 % and mean 59.05 %. The length of longest root length ranged from 15.11 to 33.30 cm with mean value of 23.41 cm. The high CV(%) was observed in dry root weight (43.49 %) followed by survival % (40.89%). The 5 best promising accessions was presented in the Table - 17.

Table -17: Promising Mulberry accessions for propagation traits 2013-14

Parameters	Range	Accession no.
Survival %	91.67 - 80.00	MI-0939, MI-0308, MI-0935, MI-0938, MI-0934
Shoot length (cm)	81.89 - 71.22	MI-0906, MI-0913, MI-0916, MI-0933, MI-0938
No. of roots	7.0 - 6.22	MI-0308, MI-0935, MI-0916, MI-0938, MI-0913
Longest Root Length (cm)	33.0 - 25.17	MI-0934, MI-0922, MI-0913, MI-0906, MI-0932
Root weight – fresh (g)	8.67 - 6.94	MI-0938, MI-0913, MI-0937, MI-0933, MI-0939
Root weight – dry (g)	3.28 - 2.33	MI-0913, MI-0938, MI-0935, MI-0939, MI-0933
Root volume (ml)	8.33 - 6.56	MI-0913, MI-0938, MI-0937, MI-0933, MI-0935

Among 50 accessions evaluated for propagation traits, MI-0938 and MI-0913 has shown top ranking with 6 traits followed by MI-0935 and MI-0933 with 4 traits and MI-0939 with 3 traits (Table - 18).

Table - 18 : Ranking of mulberry accessions based on multiple parameters

Accession No.	No. of traits	Parameter no. (value)
MI-0938	6	1(80), 2(71.22), 3(6.22), 5(8.67), 6(2.94), 7(8.00)
MI-0913	6	2(75.00), 3(6.22), 4(28.67), 5(8.61), 6(3.29), 7(8.33)
MI-0935	4	1(88.33), 3(6.33), 6(2.44), 7(6.56)
MI-0933	4	2(71.78), 5(6.94), 6(2.33), 7(6.78)
MI-0939	3	1(91.67), 5(6.94), 6(2.44)

1. Survival (%), 2. Shoot length (cm), 3. No. of roots, 4. Longest root length(cm), 5. Root weight-fresh(g), 6. Root weight-dry(g), 7. Root volume (ml)

E-02: Evaluation of mulberry genetic resources for growth and yield parameters under ARBD

S.R.Ramesh and K.Jhanshilakshmi

Sixty mulberry accessions were evaluated for growth and yield parameters in ARBD for 4 seasons. The variability of mulberry accessions on various growth and yield parameters was presented in Table - 19. Significant variation was observed in all the parameters studied. Highest CV % was observed in case of stem wt/plant (50.02 %) followed by hundred leaf wt. (45.96 %). The top performing accessions are presented in Table - 20. Among 60 accessions evaluated under ARBD, 10 mulberry accessions *viz.*, MI-0633, MI-0529, MI-0539, MI-0622, MI-0788, MI-0747, MI-0773, MI-0673, MI-0581 and MI-0827 recorded with higher leaf yield with more than 0.5 kg/plant. Seven mulberry accessions viz. MI-0633, MI-0529, MI-0622, MI-0247, MI-0827, MI-0805, MI-0695 performed better with more than 4 multiple desired traits which may be utilized in cross breeding programmes as parents (Table - 21).

Table - 19: Variability of mulberry accessions for growth and yield parameters under ARBD

Parameters	Mean	Min.	Max.	SE	CV%	KOSEN	S-13	V-1
Number of branches/plant	9.09	3.75	15.67	0.31	26.29	6.73	12.09	9.85
Length of longest shoot (cm)	119.72	55.67	183.67	3.29	21.12	117.29	138.17	158.81
Average shoot length (cm)	81.52	42.44	124.10	2.52	23.72	86.17	96.51	109.08
Hundred leaves wt. (g)	342.82	103.70	726.43	20.51	45.96	275.98	150.97	248.66
Internodal distance (cm)	4.47	2.58	7.89	0.11	19.67	4.20	3.56	3.97
Leaf yield / plant (g)	441.22	125.00	1073.67	23.61	41.11	547.71	686.56	746.75
Stem wt./ plant (g)	314.90	65.92	829.17	20.51	50.02	302.77	549.62	561.71
Harvest index (%)	60.11	45.37	73.50	0.93	11.90	65.29	56.63	57.51

Table - 20: Top ten accessions for growth and yield parameters (2013-14) under ARBD

Parameter	Range	Promising accessions
Number of branches/plant	15.67 - 11.58	MI-0529, MI-0695, MI-0686, MI-0664, MI-0709, MI-0247, MI-0633, MI-0622, MI-0747, MI-0844
Length of longest shoot (cm)	183.67 - 143.33	MI-0633, MI-0827, MI-0622, MI-0621, MI-0247, MI-0755, MI-0529, MI-0822, MI-0766, MI-0788
Average shoot length (cm)	124.1 - 101.48	MI-0695, MI-0622, MI-0805, MI-0633, MI-0529, MI-0827, MI-0247, MI-0429, MI-0755, MI-0844
Hundred leaf wt. (g)	726.43 - 530.45	MI-0164, MI-0673, MI-0572, MI-0773, MI-0845, MI-0633, MI-0581, MI-0383, MI-0628, MI-0805
Internodal distance (cm)	2.58 - 3.78	MI-0832, MI-0685, MI-0709, MI-0543, MI-0695, MI-0827, MI-0589, MI-0673, MI-0529, MI-0663
Leaf yield / plant (g)	1073.67 - 610.08	MI-0529, MI-0633, MI-0622, MI-0686, MI-0539, MI-0845, MI-0747, MI-0532, MI-0676, MI-0805
Stem wt. (g)	829.17 - 467.13	MI-0529, MI-0686, MI-0633, MI-0827, MI-0622, MI-0247, MI-0845, MI-0695, MI-0621, MI-0673
Harvest index (%)	73.5 - 68.01	MI-0750, MI-0629, MI-0581, MI-0787, MI-0805, MI-0592, MI-0164, MI-0758, MI-0705, MI-0655

Table - 21: Top Performing accessions for multiple traits

Acc. No.	No. of parameters	Parameter no. (value)
MI-0633	6	1(12.33), 2(183.67), 3(113.92), 4(575.18), 6(860.75), 7(614.75)
MI-0529	6	1(15.67), 2(145.42), 3(110.98), 5(3.78), 6(1073.67), 7(829.17)
MI-0622	5	1(12.17), 2(161.25), 3(115.89), 6(737.58), 7(530.5)
MI-0247	4	1(12.33), 2(157.08), 3(109.84), 7(487.75)
MI-0827	4	2(166.67), 3(110.59), 5(3.67), 7(567.83)
MI-0805	4	3(114.6), 4(530.45), 6(610.08), 8(70.22)
MI-0695	4	1(15.5), 3(124.1), 5(3.53), 7(476.58)

1.No. of branches, 2. Length of the longest shoot (cm), 3.Average shoot length (cm), 4. Wt. of 100 leaves (g), 5. Internodal distance (cm), 6. Leaf yield/plant (g), 7. Stem yield/plant (g), 8. Harvest Index(%)

E-03: Evaluation of mulberry accessions for biochemical parameters

K.Jhanshilakshmi

Twenty five mulberry accessions in the field gene bank were evaluated for biochemical parameters. Among the accessions tested, protein content (dry wt.) ranged from 3.70 to 10.77 % with mean value 7.02 %. Carbohydrate content (dry wt.) ranged from 6.05 to 12.14 % with mean value of 8.42 %. Among different parameters recorded, coefficient of variation was highest (33.39 %) for protein content (fr. wt) and lowest for total chlorophyll content(13.40 %). The variability in respect of different biochemical parameters estimated for 25 accessions during the project period is presented in the Table - 22**.** Promising mulberry accessions on biochemical parameters was given in Table - 23 revealed that three accessions i.e. MI-0927, MI-0922 and MI-0925 performed better for more than three parameter.

Table - 22: Variability of mulberry accessions for biochemical parameters

Parameter	Mean	Min	Max	SD	SE	CV%
Chlorophyll a (mg/g fr. wt)	1.84	1.07	2.19	0.25	0.05	13.54
Chlorophyll b (mg/g fr. wt)	0.21	0.10	0.32	0.05	0.01	26.29
Total chlorophyll (mg/g fr. wt)	2.04	1.18	2.44	0.27	0.06	13.40
a/b ratio	9.26	5.01	12.48	2.06	0.42	22.23
Protein (% fr.wt.)	1.90	1.03	2.98	0.52	0.11	27.33
Protein (% dr.wt.)	7.02	3.70	10.77	1.63	0.33	23.18
Soluble carbohydrates (% fr.wt.)	2.35	1.22	4.14	0.79	0.16	33.39
Soluble carbohydrates (% dr.wt.)	8.42	6.05	12.14	1.51	0.31	17.96

Table - 23: Top performing accessions and ranking of mulberry accessions based on biochemical parameters

Parameter	Range	Better performing accessions
Chlorophyll a (mg/g fr. wt)	2.19 - 2.08	MI-0932, MI-0922, MI-0921, MI-0925, MI-0944
Chlorophyll b (mg/g fr. wt)	0.32 - 0.27	MI-0942, MI-0944, MI-0925, MI-0939, MI-0933
Total chlorophyll (mg/g fr. wt)	2.43 - 2.31	MI-0932, MI-0925, MI-0944, MI-0922, MI-0921
a/b ratio	12.48 - 11.33	MI-0927, MI-0924, MI-0921, MI-0922, MI-0928
Protein (% fr.wt.)	2.98 - 2.51	MI-0926, MI-0927, MI-0918, MI-0922, MI-0935
Protein (% dr.wt.)	10.77 - 8.57	MI-0926, MI-0936, MI-0935, MI-0940, MI-0927
Soluble carbohydrates (% fr. wt.)	4.14 - 3.08	MI-0928, MI-0918, MI-0929, MI-0932, MI-0927
Soluble carbohydrates (% dr. wt.)	12.14 - 9.67	MI-0929, MI-0928, MI-0927, MI-0918, MI-0925
Better performing accessions based on multiple traits		
Acc. No.	No. of parameters	Parameters
MI-0927	5	4(12.4), 5(2.68), 6(8.56), 7(3.07), 8(9.80),
MI-0922	4	1(2.18), 3(2.36), 4(12.08), 5(2.55),
MI-0925	4	1(2.10), 2(0.27), 3(2.38), 8(9.67),

1. Chlorophyll a (mg/g fr.wt); 2. Chlorophyll b (mg/g fr.wt); 3. Total chlorophyll (mg/g frwt); 4. Chl. a/b ratio; 5. Protein (% fr.wt.); 6. Protein (% dr.wt.); 7. Soluble carbohydrates (% fr.wt.); 8. Soluble carbohydrates (% dr.wt.)

E-04: Growth behaviour of mulberry germplasm in the field gene bank

A.Ananda Rao and P. Saraswati

Mulberry is a perennial tree and expresses its full potentiality and manifestation of its genetic characters under tree form. The field gene bank at CSGRC, Hosur is maintained as a dwarf tree with spacing of 2.4 x 2.4 m with the crown height of 1.5 m following the recommended cultural practices suitable for tree plantation. Preliminary evaluation of growth characters in the field gene bank is the initial step and utmost important to short-list the accessions for further evaluation with limited accessions. During the project period of three years a total of 22 mulberry accessions which have subsequently attained 2 years of establishment in the field gene bank, have considered for record of data on different growth parameters considering two pruning. The data on different growth parameters have been taken after 75-90 days of pruning and analysed statistically.

Variability of growth parameters in the field gene bank

Twenty two indigenous mulberry accessions in the field gene bank maintained as dwarf trees for two years after their initial establishment and at 70th day after pruning were evaluated for growth and yield parameters. The variability of mulberry accessions for different growth and yield parameters is given in Table - 24.

Table - 24: Variability of mulberry accessions on growth and yield parameters (22 acc.)

Parameters	Mean	Min	Max	SD	SE	CV%
No of branches	16.35	4.00	39.00	8.53	1.82	52.19
Longest shoot length (cm)	220.83	95.00	285.00	54.46	11.61	24.66
Total shoot length (cm)	2714.76	565.00	6625.00	1600.94	341.32	58.97
Leaf yield/plant (kg)	2.24	0.52	4.62	1.25	0.27	55.81
Internodal distance (cm)	5.45	3.07	8.80	1.42	0.3	25.96
Hundred leaf wt. (g)	548.98	59.00	1213.00	295.04	62.9	53.74
Leaf petiole ratio by wt (g)	9.14	3.60	19.38	3.15	0.67	34.53
Total moisture content (%)	72.58	60.59	86.32	6.71	1.43	9.24
Moisture retention capacity (%)	68.03	18.42	84.15	13.32	2.84	19.59
Total biomass/ plant (kg)	4.86	0.89	10.92	2.91	0.62	59.86
Leaf shoot ratio	0.99	0.56	1.69	0.31	0.07	31.60
Laminar index (%)	87.8	72.19	94.84	4.47	0.95	5.09
Harvest index	0.49	0.36	0.61	0.07	0.02	14.94

Leaf yield/plant ranged from 0.52 to 4.62 kg (mean 2.24 kg/plant) where as the total biomass ranged from 0.89 to 10.92 kg (mean 4.86 kg/plant). The moisture retention capacity ranged from 18.42 to 84.15 % (mean 68.03 %). However, the maximum CV% was recorded for total biomass/plant (59.86 %) followed by total shoot length/plant (58.97 %). Trait

specific promising accessions were identified *viz.* leaf yield more than 3 kg/plant- MI-0943, MI-0939, MI-0940, MI-0928, MI-0941 and total biomass more than 8kg/plant *viz*., MI-0943, MI-0939, MI-0938, MI-0940, MI-0928 for utilization. In order to select and shortlist of mulberry accessions for further evaluation based on different growth characters, ranking of mulberry accessions was carried out with growth characters and three accessions *viz*., MI-0940, MI-0920, MI-0944 performed better for 5 multiple traits which may be utilized for crop improvement programmes (Table-25).

Table - 25: Top performing and ranking of mulberry genetic resources based on growth and yield parameters

Parameter	Range	Top performing accessions
No. of branches	39 - 25	MI-0928, MI-0940, MI-0932, MI-0927, MI-0918
Length of longest shoot (cm)	285 - 270	MI-0938, MI-0942, MI-0937, MI-0933, MI-0927
Total shoot length (cm)	6625 - 3703	MI-0928, MI-0940, MI-0927, MI-0937, MI-0942
Leaf yield/plant (kg)	4.62 - 3.51	MI-0943, MI-0939, MI-0940, MI-0928, MI-0941
Internodal distance (cm)	3.07 - 4.50	MI-0926, MI-0932, MI-0929, MI-0933, MI-0927
Hundred leaf wt. (g)	1213.00 - 786.50	MI-0931, MI-0943, MI-0925, MI-0939, MI-0920
Leaf petiole ratio by wt.	19.38 - 10.78	MI-0933, MI-0937, MI-0931, MI-0944, MI-0940
Total Moisture content (%)	86.32 - 79.08	MI-0936, MI-0938, MI-0942, MI-0940, MI-0943
Moisture retention capacity (%)	84.15 - 78.49	MI-0936, MI-0938, MI-0942, MI-0940, MI-0920
Total biomass/plant (kg)	10.92 - 7.63	MI-0943, MI-0939, MI-0938, MI-0940, MI-0928
Leaf shoot ratio	1.69 - 1.30	MI-0944, MI-0920, MI-0941, MI-0923, MI-0926
Laminar index (%)	94.84 - 90.73	MI-0933, MI-0937, MI-0931, MI-0944, MI-0940
Harvest index	0.60 - 0.56	MI-0920, MI-0941, MI-0944, MI-0923, MI-0926

Ranking of mulberry accessions based on growth and yield parameters

Acc-No.	No. of parameters	Parameter no. (value)
MI-0940	8	1(30), 3(5366), 4(3.812), 7(10.784), 8(82.507), 9(78.799), 10(8.2), 12(90.727),
MI-0920	5	6(786.5), 9(78.488), 11(1.556), 13(0.608695652173913), 14(),
MI-0944	5	7(11.965), 11(1.688), 12(91.456), 13(0.589830508474576), 14(),
MI-0933	4	2(275), 5(4.231), 7(19.379), 12(94.84),
MI-0943	4	4(4.62), 6(1133), 8(79.082), 10(10.92),
MI-0942	4	2(280), 3(3703), 8(83.432), 9(80.142),
MI-0941	4	4(3.51), 11(1.481), 13(0.596938775510204), 14(),
MI-0938	4	2(285), 8(83.557), 9(80.321), 10(8.4),
MI-0937	4	2(277.5), 3(4401.5), 7(13.151), 12(92.351),
MI-0926	4	5(3.065), 11(1.304), 13(0.565916398713826), 14(),
MI-0927	4	1(25), 2(270), 3(5007), 5(4.5),
MI-0928	4	1(39), 3(6625), 4(3.55), 10(7.63),

E-05: Natural incidence of Major Foliar Fungal Diseases in Mulberry Germplasm

P. Saraswathi and M.M. Borpuzari

Five hundred and fourty Mulberry accessions were scored visually in Mulberry field gene bank in three different seasons April-June, July-sept and Oct-Jan to ascertain the disease incidence status /susceptibility to major foliar fungal diseases *viz.,* leaf spot, and leaf rust and powdery mildew in different genotypes in different seasons (Table - 26). The infection status or the disease incidence was graded for percent of leaf area infected on a 0-5 scale and the Percent Disease Index (PDI) was calculated.

Table - 26 : Natural incidence of Foliar fungal diseases in different seasons 2013-14

Diseases	I Season (Apr-Jun)	II Season (Jul-Sep)	III Season (Oct-Jan)
Leaf spot	5	26	16
Powdery mildew	-	16	15
Leaf Rust	-	1	5
Tukra	89	38	3
No incidence	446	459	501
Total no. of accessions	**540**	**540**	**540**

- Out of 540 observed no incidence of diseases were noticed in 446 accessions during April-June, 459 in July-September, and 501 during October-January.
- Leaf spot was observed in 5 accessions in I season, 26 accessions in II season and 16 accessions in III season respectively.
- Powdery mildew was noticed during July-September (16 accessions) and October-January (15) accessions.
- Leaf rust was recorded in one accession during July-September and 5 accessions during October-January.
- Tukra incidence was noticed in 89 accessions during April-June, 38 accessions during July-September and 3 accessions October-January 2014.

S04: Conservation and supply of mulberry genetic resources

M.M.Borpuzari, S.R.Ramesh and A.Ananda Rao

A total of 1269 mulberry accessions (Indigenous - 999 and Exotic -270) are conserved in the *ex situ* field gene bank with recommended cultural practices. Dormant buds of 80 mulberry accessions were cryopreserved in the liquid nitrogen using dehydration and slow freezing protocol. Obtained national accession numbers for 31 mulberry accessions and updated in database. 177 mulberry accessions were planted in a separate plot for backup plantation of *ex situ* field gene bank. The fast growing with high biomass was recorded among indigenous and exotic accessions for utilization. During the period 303 (Ind-266 and Exo-37) mulberry accessions were supplied to different institutes/organization (Table - 27) .

Table - 27: Supply of mulberry genetic resources for utilization

Sl.No.	Indentor Name	Date/ No. of acc. Supplied	Accession nos.	Purpose
1	CSRTI, Mysore	14/06/2013 Ind - 90 Exo - 11	Indigenous- MI-0021, MI-0034, MI-0064, MI-0071, MI-0074, MI-0087, MI-0121, MI-0143, MI-0145, MI-0148, MI-0150, MI-0153, MI-0156, MI-0161, MI-0168, MI-0193, MI-0205, MI-0206, MI-0207, MI-0211, MI-0222, MI-0227, MI-0234,MI-0236, MI-0255, MI-0256, MI-0294, MI-0301, MI-0304, MI-0312, MI-0315, MI-0316, MI-0327, MI-0331, MI-0343, MI-0344, MI-0346, MI-0349, MI-0353, MI-0369, MI-0370, MI-0377, MI-0378, MI-0380, MI-0502, MI-0535, MI-0544, MI-0546, MI-0547, MI-0548, MI-0549, MI-0550, MI-0551, MI-0554, MI-0556, MI-0558, MI-0559, MI-0561, MI-0562, MI-0564, MI-0565, MI-0567, MI-0568, MI-0573, MI-0574, MI-0576, MI-0579, MI-0582, MI-0583, MI-0585, MI-0586, MI-0591, MI-0593, MI-0594, MI-0596, MI-0597, MI-0598, MI-0599, MI-0600, MI-0601, MI-0603, MI-0607, MI-0608, MI-0609, MI-0610, MI-0614, MI-0619, MI-0623, MI-0624, MI-0627 Exotic - ME-0029, ME-0031, ME-0048, ME-0058, ME-0107, ME-0151, ME-0163, ME-0181, ME-0182, ME-0200, ME-0253	Molecular biology research work
2	Titan School, Hosur	16/06/2013 Ind - 5	MI-0118, 0189, MI-0266, MI-0171, MI-0508	Biodiversity conservation
3	CSRTI, Mysore	29/06/2013 Ind - 91	MI-0634, MI-0635, MI-0636, MI-0637,MI-0639, MI-0644, MI-0660, MI-0666, MI-0670, MI-0679, MI-0680, MI-0681, MI-0683, MI-0693,MI-0698, MI-0700, MI-0701, MI-0702, MI-0706, MI-0708, MI-0710, MI-0711, MI-0712, MI-0713, MI-0714,MI-0717, MI-0720, MI-0721, MI-0723, MI-0724, MI-0725, MI-0727, MI-0728, MI-0729, MI-0731, MI-0733, MI-0734, MI-0735, MI-0738, MI-0740, MI-0741, MI-0742, MI-0744, MI-0748, MI-0749,MI-0752,MI-0756, MI-0757, MI-0759,MI-0761,MI-0762, MI-0764, MI-0765, MI-0767, MI-0768, MI-0770, MI-0771, MI-0776, MI-0778, MI-0779, MI-0780,MI-0783, MI-0784, MI-0785, MI-0786, MI-0789, MI-0790, MI-0792, MI-0794, MI-0795, MI-0796, MI-0797, MI-0799, MI-0804, MI-0806, MI-0807, MI-0810, MI-0811, MI-0817, MI-0819, MI-0820, MI-0823, MI-0824, MI-0825, MI-0826, MI-0829, MI-0830, MI-0831, MI-0835, MI-0836, MI-0843	Molecular biology research work
4	CSRTI, Mysore	17/08/2013 Ind - 23 Exo - 7	Indigenous - MI-0002, MI-0006, MI-0007, MI-0012, MI-0013, MI-0014, MI-0017, MI-0026, MI-0037, MI-0043, MI-0046, MI-0048, MI-0052, MI-0066, MI-0099, MI-0105, MI-0124, MI-0158, MI-0160, MI-0173, MI-0344, MI-0364, MI-0524 Exotic - ME-0004, ME-0006, ME-0056, ME-0065, ME-0066, ME-0141, ME-0144	Screening root rot resistance
5	RSRS, Jorhat	22/08/2013 Ind - 23	MI-0090, MI-0106, MI-0151, MI-0255, MI-0342, MI-0344, MI-0346, MI-0349, MI-0354, MI-0355, MI-0356, MI-0357, MI-0358, MI-0359, MI-0395, MI-0807, MI-0844, MI-0845, MI-0873, MI-0875, MI-0877, MI-0879, MI-0889	Germplasm Maintenance
6	KVK, Manipur	08/10/2013 Ind - 4 Exo - 2	MI-0012, ME-0065, ME-0066, MI-0025, MI-0037, MI-0049	Biodiversity conservation

7	Shivaji University, Kolhpur	24/10/2013 Ind - 2	MI-0364, MI-0363	Biodiversity conservation
8	College of Sericulture, Cinthamani	27/12/2013 Ind - 4	MI-0020, MI-0056, MI-0118, MI-0308	Biodiversity maintenance
9	SBRL, Kodathi	06/01/2014 Ind - 1 Exo - 6	Indigenous - MI-0012 Exotic - ME-0001, ME-0002, ME-0008, ME-0017, ME-0037, ME-0220	Bio-molecular Research
10	SBRL, Kodathi	30/01/2014 Ind - 20 Exo - 12	Indigenous - MI-0159, MI-0029, MI-0068, MI-0026, MI-0059, MI-0019, MI-0056, MI-0015, MI-0054, MI-0044, MI-0041, MI-0039, MI-0195, MI-0258, MI-0381, MI-0528, MI-0563, MI-0038, MI-0023, MI-0225 Exotic - ME-0036, ME-0001, ME-0008, ME-0006, ME-0004, ME-0056, ME-0071, ME-0093, ME-0069, ME-0080, ME-0099, ME-0180	Bio-molecular Research
11	TNAU, Coimbatore	19/03/2014 Ind - 1	MI-0052	Evaluation
	Total	**302** **(Ind-264** **Exo-38)**		

AIG-3483: Collection, characterisation, preliminary evaluation, conservation and supply of silkworm genetic resources

S-01: Collection of Silkworm Genetic Resources

N.Balachandran, M.M.Borpuzari and V.Sivaprasad

Central Sericultural Germplasm Resources Centre has an important mandate of collection of silkworm (*Bombyx mori*) genetic resources with unique characteristics and new breeds developed by CSRTIs and state sericulture research institutes of the traditional sericulture states and also the breeds authorized by Central Silk Board. The utilization of the seri genetic resources depends on the availability of the wide genetic variability in the silkworm genetic resources conserved. The 458 indigenous and exotic germplasm comprising native and evolved races representing wide variability includes 77 multivoltine, 361 bivoltine and 20 mutant genetic stocks representing 14 countries including India have been collected from 18 donor Institutes. Theses collection of silkworm genetic resources exhibit great variability in terms of origin, nature of breed, qualitative and quantitative traits, with unique characteristics. During the year 2013-14 six silkworm breeds [Mcon-1, Mcon-4 (2 MV breeds) Bcon-1, Bcon-4 from CSRTI, Berhampore and Gen-2 and Gen-3 (4 BV breeds) from CSRTI,Mysore] authorized by central silk board were collected. The passport data obtained from the donor institutes were updated into the SGIS database. On completion of two quarantine rearings and ensuring disease freeness these breeds were accessioned and added to the gene bank. The national accession numbers were allotted by NBAII, Bangalore for all the six silkworm accessions (Table - 28).

Table - 28: New collections made during the year 2013-14

Sl.No	Name of the race	Voltinism	Donor Institute	Institute Accession Number	National Accession Number
1	Mcon-1	Multivoltine	CSRTI, Berhampore	BMI-0079	NBAII-CSG-BBI-0079
2	Mcon-4	Multivoltine	CSRTI, Berhampore	BMI-0080	NBAII-CSG-BBI-0080
3	Bcon-1	Bivoltine	CSRTI, Berhampore	BBI-0382	NBAII-CSG-BBI-0382
4	Bcon-4	Bivoltine	CSRTI, Berhampore	BBI-0383	NBAII-CSG-BBI-0383
5	Gen-2	Bivoltine	CSRTI, Mysore	BBI-0384	NBAII-CSG-BBI-0384
6	Gen-3	Bivoltine	CSRTI, Mysore	BBI-0385	NBAII-CSG-BBI-0385

At present the status of conservation of silkworm genetic resources includes 464 silkworm germplasm consisting 79 multivoltine, 365 bivoltine and 20 mutant genetic stocks representing 14 countries and 18 donor Institutes (Table - 29).

Table - 29 : Phase wise silkworm germplasm collection conserved by CSGRC, Hosur.

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	Continuous	15	6	-	21
Grand Total		**365**	**79**	**20**	**464**

S-02: Characterisation and preliminary evaluation of silkworm genetic resources

In order to identify and typifying a germplasm morphological characterisation of the silkworm genetic resources is very much essential in using the standard descriptor states. The 458 silkworm germplasm accessions were morphologically characterised for 27 morphological descriptors at various growth stages *viz*., egg, larva, cocoon, pupa and moth stages. During the year under report the 458 silkworm genetic resources were characterised and confirmed following the morphological descriptors. The accessions were maintained true to type as per the passport data and the data generated on the characterisation aspects are updated in the database. The CD produced out of the project FSL-3447 includes digital imaging of all the silkworm accessions for the growth stages and included as accession profile database for the sake of the breeders and stake holders which can be easily retrieved for comparison and further use in the selection and short listing the silkworm germplasm with desirable traits or set of traits. Further, the characterisation database is also useful during

registration of new germplasm by ascertaining whether the same genotypes or similar kind of accessions are existing in the gene bank already. The characterisation database will help in identifying the similar accessions, duplicates and also efficient management of the gene bank and to have an authentic passport database for every new collection**.**

E-01: Morphological characterisation of silkworm genetic resources

N.Balachandran, M.Muthulakshmi R.RadhaKrishnan, Veeranna Gowda and M.M.Borpuzari

During the year under report confirmatory morphological characterisation was completed for all the 77 multivoltine, 361 bivoltine and 20 mutant accessions at various growth stages *viz*., egg, larva, cocoon, pupa and moth stages. The variability in the morphological features of the germplasm accessions for each descriptor was found true to type as per the passport data for all the accessions. The data on the important morphological parameters of the 77 multivoltine silkworm genetic resources is presented in Table - 30. The larval pattern showed three types with the maximum of 41 accessions with plain larvae (53.25%) followed by marked larvae in 32 accessions (41.56 %) and mixed larval pattern in 4 accessions (5.19 %). The cocoon colour maximum numbers of accessions (31) are with greenish yellow cocoons (40.26 %) and 22 accessions are with white cocoons (30.14 %) and 19 accessions are with chrome yellow cocoons (28.57 %) and four accessions with yellow cocoons (5.19 %) and one accession with creamy white cocoon (1.30 %). Similarly the distribution of cocoon shape revealed a maximum of 27 nos. in the oval shaped cocoons category (35.06 %) followed by 24 accessions in the elongated with narrow constriction category (31.17 %) and 17 accessions with spindle cocoons (22.08 %), four accessions with spatulate cocoons (5.19 %), three accessions with dumbbell cocoons (3.90%) and two accessions with elongated cocoons (2.60 %).

Table - 30: Characterisation of multivoltine SWGRs for important morphological traits

Parameters	Frequency	Percentage
Larval pattern		
Marked	32	41.56
Mixed	4	5.19
Plain	41	53.25
Cocoon colour		
Chrome yellow	19	24.68
Creamy white	1	1.30
Greenish yellow	31	40.26
White	22	28.57
Yellow	4	5.19
Cocoon shape		
Dumb-bell	3	3.90
Elongated	2	2.60
ENC	24	31.17
Oval	27	35.06
Spatulate	4	5.19
Spindle	17	22.08

E-02: Preliminary evaluation of multivoltine silkworm genetic resources for growth and reproductive traits

N. Balachandran M.M.Borpuzari and V.Sivaprasad

The preliminary evaluation data of the four conservation crops conducted during the year were analysed for the 12 important rearing traits and the variability in the economic traits and the high and the low performing accessions for each of the individual economic traits alongwith the mean and CV % is presented in Table-31.

Table - 31: Range of variability of 77 multivoltine accessions for important economic traits

Trait	Min.	Max.	Mean	SE	CV%
Fecundity (No.)	327 (BMI-0032)	489 (BMI-0074)	402	4.04	8.77
Hatching (%)	91.28 (BMI-0033)	97.22 (BMI-0076)	94	0.16	1.51
Wt. of 10 Larvae g.	15.91 (BMI-0020)	35.11 (BMI-0023)	20	0.32	14.15
Total larval duration (h)	483 (BMI-0058)	633 (BMI-0001)	513	3.39	5.75
Fifth Larval duration (h)	122 (BME-0013)	208 (BMI-0067)	141	1.89	11.70
ERR (By No.)	9474 (BMI-0078)	9798 (BME-0015)	9666	7.55	0.68
ERR (By Wt.) Kg.	7.86 (BMI-0064)	11.78 (BMI-0076)	9.25	0.09	8.55
Pupation rate (%)	82.69 (BMI-0075)	94.53 (BME-0015)	90.04	0.29	2.85
Single Cocoon Weight g.	0.668 (BME-0047)	1.22 (BMI-0076)	0.86	0.01	10.31
Single Shell Weight g.	0.082 (BME-0047)	0.226 (BMI-0076)	0.12	0.00	20.32
Cocoon Shell Percentage (%)	11.536 (BMI-0044)	18.74 (BMI-0077)	13.57	0.16	10.05
Cocoon yield /100dfls (Kg.)	31.453 (BMI-0064)	47.10 (BMI-0076)	37.00	0.36	8.55

The fecundity was maximum of 489 eggs /dfl in accession number BMI-0074 and it was minimum 329 eggs/dfl in accession no. BMI-0032. Weight of 10 larvae was maximum in accession number BMI-0023 (35.11 g.) and it was minimum in accession number BMI-0020 (15.91 g.). The total larval duration was shorter in accession BMI-062 (452 h.) and accession BMI-0001 was having the longer larval duration of 633 hrs. Similarly the fifth age larval duration was shorter 97 hours in accession BMI-004 and it was longer in accession BMI-067 with 208 hrs. ERR by number was high 9798 in accession number BME-0015 and it was low in accession number BMI-0078 with 9474 number of good cocoons per 10000 larvae reared. The Effective rate of rearing by weight was higher in accession BMI-0076 with 11.76 Kg. and it was low in accession number BMI-0064 with 7.86 Kg. Higher pupation rate was recorded

in accession BME-0015 (94.53 %) and it was low 82.69 % in accession BMI-0075. Single cocoon weight was higher in accession BMI-0076 with 1.22 g. and low single cocoon weight 0.668 g was recorded in accession BMI-0047. The single shell weight was high 0.226 g in accession BMI-0076 whereas it was low in accession BMI-0047 (0.082g.). Higher cocoon shell percentage of 18.74 % was recorded in accession BMI-0077 and it was low (11.536 %) in accession BMI-0044. Accession BMI-0076 recorded the highest cocoon yield per 100 dfls of 47.09 Kg. whereas it was low in BMI-0064 with 31.453 Kg. The top performing accessions for individual traits are presented in Table - 32 for all the 12 rearing parameters alongwith the range values.

Table - 32 : Top performing multivoltine accessions for rearing traits

Trait	Range	Accession No.
Fecundity (No.)	489 - 443	BMI-0074, BMI-0059, BMI-0078, BMI-0077, BMI-0069, BME-0052, BMI-0024, BME-0005, BMI-0076, BMI-0071
Hatching (%)	97.22 - 95.72	BMI-0076, BMI-0077, BMI-0017, BMI-0078, BMI-0071, BMI-0075, BMI-0019, BMI-0074, BMI-0043, BMI-0044
Wt.of 10 Larvae (g.)	35.11 - 21.73	BMI-0023, BMI-0078, BMI-0076, BMI-0077, BMI-0074, BMI-0067, BME-0048, BMI-0025, BMI-0061, BMI-0041
Total larval duration (h)	483 - 491	BMI-0058, BME-0015, BMI-0063, BMI-0064, BME-0030, BME-0013, BMI-0002, BMI-0003, BMI-0008, BMI-0060
Fifth Larval duration (h)	122 - 126	BME-0013, BMI-0008, BMI-0058, BMI-0046, BMI-0003, BMI-0002, BMI-0004, BME-0047, BMI-0064, BMI-0063
ERR (by no.)	9798 - 9744	BME-0015, BMI-0008, BMI-0001, BMI-0018, BMI-0009, BME-0047, BME-0030, BMI-0071, BMI-0061, BMI-0059
ERR (by wt.) Kg.	11.76 - 10.14	BMI-0076, BMI-0078, BMI-0074, BMI-0025, BMI-0024, BMI-0038, BME-0048, BMI-0039, BME-0012, BMI-0040
Pupation rate (%)	94.53 - 92.71	BME-0015, BMI-0071, BMI-0070, BMI-0008, BMI-0019, BME-0005, BMI-0039, BMI-0021, BMI-0009, BMI-0017
Single cocoon weight g.	1.22 - 0.957	BMI-0076, BMI-0078, BMI-0074, BMI-0077, BMI-0067, BME-0012, BMI-0024, BMI-0026, BME-0048, BMI-0065
Single shell weight (g)	0.226 - 0.134	BMI-0076, BMI-0077, BMI-0078, BMI-0074, BMI-0075, BMI-0073, BMI-0065, BMI-0067, BME-0048, BMI-0023
Cocoon shell percentage (%)	18.74 - 14.62	BMI-0077, BMI-0076, BMI-0074, BMI-0078, BMI-0073, BMI-0075, BMI-0065, BMI-0007, BMI-0057, BMI-0001
Cocoon yield /100dfls (Kg.)	47.09 - 40.60	BMI-0076, BMI-0078, BMI-0074, BMI-0025, BMI-0024, BMI-0038, BME-0048, BMI-0039, BMI-0008, BME-0012

The multiple trait evaluation for rearing (12 traits) revealed (Table - 33) the accession BMI-0076, BMI-0074 and BMI-0078 ranked first with 8 parameters followed by accession BMI-0077 for 6 parameters. Whereas, accession BMI-0048 and BMI-008 qualified for 5 parameters and accession BMI-024 and BMI-0071 for 4 parameters.

Table - 33 : Multivoltine accessions for multiple traits

Accession No.	No. of traits	Trait No. and Values
BMI-0076	8	1(444), 2(97.22), 3(26.40), 7(11.78), 9(1.22), 10(0.226), 11(18.49), 12(47.09)
BMI-0074	8	1(488.63), 2(95.97), 3(26.08), 7(10.61), 9(1.04), 10(0.18), 11(17.12), 12(42.38)
BMI-0078	8	1(464.13), 2(96.29), 3(26.85), 7(11.04), 9(1.15), 10(0.19), 11(16.74), 12(44.12)
BMI-0077	6	1(459.13), 2(97), 3(26.27), 9(1.03), 10(0.19), 11(18.74)
BME-0048	5	3(23.14), 7(10.31), 9(0.96), 10(0.13), 12(41.26)
BMI-0008	5	4(488), 5(122), 6(9777), 8(93.27), 12(40.61)
BMI-0024	4	1(450), 7(10.51), 9(0.97), 12(42.05)
BMI-0071	4	1(443), 2(96.28), 6(9753), 8(93.93)

E-03: Preliminary evaluation and conservation of bivoltine silkworm genetic resources (First batch)

M. Muthulakshmi, R.Radhakrishnan, Veeranna Gowda, Borpuzari and V.Sivaprasad

A total of 361 bivoltine silkworm germplasm accessions were evaluated for growth and reproductive traits during the year 2013-14 in three batches in the period between June,2013 to March,2014 (I batch June-August, 2013, II batch September-November, 2013, III batch January, 2014 - March, 2014) and the variability statistics studied for important quantitative traits is presented. Morphological characters were confirmed at three stages *viz.,* larva, pupa and adult. All the silkworm accessions were maintained true to type as per passport data without any selection pressure. On comparison of data it was found that the quantitative traits were in accordance with the passport data, thus indicating uniform performance of the germplasm over the period. Evaluation data were analysed statistically and variability in 12 important economic traits of the first batch of bivoltine crop with 114 accessions are presented in Table - 34. The number of eggs per dfl ranged from 312 (BBI-0052) to 631 (BBI-0326), hatching percentage was minimum of 81.5 % (BBI-0063) and maximum of 98.2 % (BBI-0046). The larval weight for 10 larvae was maximum (42.6 g) in accession no. BBE-0285 and minimum of 26.7 g was recorded in (BBE-0025). Accession no. BBI-0290 had the maximum total larval duration (552 h) and BBI-0356 had the maximum fifth age (148h) larval duration, whereas BBE-0025 had the minimum total larval duration (496 h) as well as fifth age (92 h) larval duration. The Yield/10000 larvae per number was high in accession no. BBI-0057 (9945) and it was low in accession no. BBE-0028 (9363). The Cocoon yield/ 10000 larvae (wt) was higher in accession BBE-0028 with 17.5kg, whereas it was low in accession number BBI-0083 with 9.5 kg. Pupation rate was high (98.1) in accession no. BBE-0033 and it was low (70.5 %) in BBE-0031.

Table - 34: Variability in selected economic characters of bivoltine silkworm genetic resources (first batch with 114 accessions)

Traits	Mean	Min.	Max.	SD	SE	CV%
Fecundity (No.)	448	312(BBI-0052)	631(BBI-0326)	73.9	6.9	16.5
Hatching (%)	92.6	81.5(BBI-0063)	98.2(BBI-0046)	3.6	0.3	3.9
Wt. of grown larvae (g)	37.5	26.7(BBE-0025)	42.6(BBI-0285)	2.5	0.2	6.8
Total larval duration (h)	523	496(BBE-0025)	552(BBI-0290)	10.7	1.0	2.0
Vth age larval duration (h)	119	92(BBE-0025)	148(BBI-0356)	10.3	1.0	8.6
Yield/10000 larvae (by no.)	9727	9363(BBE-0028)	9945(BBI-0057)	134.0	12.6	1.4
Yield/10000 larvae by wt. (kg)	12.8	9.5(BBI-0083)	17.5(BBE-0028)	1.6	0.1	12.1
Pupation rate (%)	89.6	70.5(BBE-0031)	98.1(BBE-0033)	5.0	0.5	5.6
Single cocoon weight (g)	1.28	0.99(BBE-0025)	1.60(BBE-0004)	0.1	0.0	8.0
Single shell weight (g)	0.20	0.12(BBE-0025)	0.31(BBI-0328)	0.0	0.0	15.7
Shell ratio (%)	16.2	12.08(BBI-0305)	21.6(BBI-0328)	1.7	0.2	10.3
Cocoon / 100 dfls (kg)	51.3	37.9(BBI-0083)	69.9(BBE-0028)	6.2	0.6	12.1

figures in parentheses indicates respective accession number

Table-35: Top ranking bivoltine germplasm accessions identified in first batch with 114 accessions for individual traits

Traits	Range	Accession numbers
Fecundity (No.)	631 - 558	BBI-0326, BBE-0040, BBE-0019, BBE-0043, BBE-0036, BBE-0004, BBI-0082, BBE-0010, BBE-0015, BBI-0054
Hatching (%)	98.2 - 96.6	BBI-0046, BBI-0283, BBE-0013, BBE-0016, BBI-0062, BBI-0070, BBI-0080, BBI-0286, BBE-0031, BBI-0065
Wt. of grown larvae (g)	42.6 - 40.3	BBI-0285, BBI-0326, BBI-0084, BBI-0359, BBE-0035, BBE-0034, BBI-0079, BBE-0003, BBI-0284, BBI-0057
Total larval duration (h)	496 - 509	BBE-0025, BBE-0037, BBE-0051, BBI-0052, BBI-0053, BBI-0059, BBE-0042, BBI-0070, BBI-0073, BBE-0041
Fifth age larval duration (h)	92 - 105	BBE-0025, BBE-0037, BBE-0051, BBE-0015, BBI-0073, BBI-0070, BBE-0032, BBE-0041, BBE-0033, BBE-0042
Yield/10000 larvae (by no.)	9945 - 9889	BBI-0057, BBI-0052, BBE-0033, BBI-0279, BBE-0030, BBI-0294, BBI-0063, BBI-0285, BBE-0037, BBI-0358
Yield/10000larvae by wt. (Kg)	17.5 - 15.2	BBE-0028, BBE-0035, BBE-0004, BBI-0046, BBI-0328, BBI-0075, BBI-0068, BBI-0293, BBE-0034, BBE-0003
Pupation rate (%)	98.1 - 95.2	BBE-0033, BBE-0005, BBI-0279, BBE-0002, BBI-0057, BBE-0001, BBE-0006, BBE-0030, BBI-0285, BBE-0042
Single cocoon weight (g)	1.56 - 1.43	BBE-0004, BBI-0293, BBE-0035, BBI-0359, BBI-0056, BBE-0003, BBI-0328, BBI-0279, BBE-0034, BBE-0002
Single shell weight (g)	0.32 - 0.25	BBI-0328, BBI-0359, BBI-0324, BBI-0326, BBI-0293, BBI-0284, BBI-0355, BBI-0325, BBE-0004, BBI-0279
Shell ratio (%)	21.7 - 18.7	BBI-0328, BBI-0324, BBI-0359, BBI-0326, BBI-0290, BBI-0325, BBI-0358, BBI-0355, BBI-0354, BBI-0284
Cocoon / 100 dfls (Kg)	69.9 - 60.8	BBE-0028, BBE-0035, BBE-0004, BBI-0328, BBI-0046, BBI-0075, BBI-0293, BBI-0068, BBE-0034, BBE-0003

Accession BBE-0004 showed high single cocoon weight 1.60 g. and it was low in accession BBE-0025 with 0.99 g. The single shell weight was high in accession BBI-0328 (0.31 g.) and it was low in accession no. BBE-0026 (0.12 g.). Maximum Shell ratio (%) was recorded in accession BBI-0328 with 21.6 and minimum in BBI-0305 with 12.08. Higher cocoon yield /100 dfls of 69.9 Kg was recorded. in accession BBE-0028 and in accession BBI-0083 it was 37.9 Kg. Further the coefficient of variation was high in Fecundity (No.) with 16.5 % and Single shell weight (g) (15.7 %) followed by cocoon yield / 100 dfls and cocoon yield / 10,000 larvae by weight (12.1 %) and shell ratio (10.3 %) which indicates the range of variability. Similarly the CV % was very low in the trait of Cocoon Yield per 10,000 larvae with a CV of 1.5 % and 2.0 % for total larval duration. Top ten accessions were identified individually for the 12 important economic characters and the range values were also given. (Table - 35). Superior accessions with multiple traits were identified based on multiple trait evaluation index and are presented in Table - 36. Accession BBI-0328, BBE-0004 were found to be better with higher values for five economic traits followed by BBE-0034, BBE-0035, BBI-0326, BBI-0359 and BBE-0003 for four traits.

Table - 36 : Top ranking bivoltine accessions identified with multiple traits (Bivoltine first batch)

Acc. No.	No. of Traits	Trait No. (values)
BBI-0328	5	7(15.6), 9(1.46), 10(0.32), 11(21.6), 12(62.6)
BBE-0004	5	1(569), 7(16.4), 9(1.55), 10(0.25), 12(65.8)
BBE-0034	4	3(41.1), 7(15.3), 9(1.43), 12(61.2)
BBE-0035	4	3(41.5), 7(17.1), 9(1.50), 12(68.4)
BBI-0326	4	1(631), 3(42.0), 10(0.28), 11(20.5)
BBI-0359	4	3(41.5), 9(1.48), 10(0.30), 11(20.8)
BBE-0003	4	3(40.5), 7(15.2), 9(1.47), 12(60.8)

Figures in parantheses indicates the actual value of the traits
1.Fecundity (No.), 2. Hatching(%), 3. Weight of 10 larvae(g),4. Total Larval Duration (h),5. Fifth age larval duration (h), 6. ERR/10000 (No.), 7. ERR/10000(wt.),8. Pupation rate (%), 9. Single cocoon weight (g.),10. Single shell weight (g.),11. Cocoon shell ratio (%), 12. Cocoon yield /100dfls (Kg..)

Preliminary evaluation and conservation of bivoltine silkworm genetic resources (II batch)

R.Radhakrishnan M.Muthulakshmi,Veeranna Gowda ,V.Sivaprasad and A.Manjula

A total of 134 bivoltine silkworm germplasm accessions were conserved under second batch by conducting rearing during September-October 2013 and eggs were preserved under 10 months cold preservation schedule with 12 months schedule as back up. Morphological characters were confirmed at three stages *viz*., larva, pupa and adult. All the silkworm accessions were maintained true to type as per passport data without any selection pressure. Data were analyzed statistically and variability statistics is presented in Table - 37. Top ten superior bivoltine germplasm of the II bivoltine batch were identified for 12 important economic rearing parameters and presented in Table - 38. High fecundity of 650 eggs per dfl was observed in accession BBI-0357. Accession number BBI-0123 exhibited maximum hatching of 97.7 %. Accession BBI-0373 was recorded with lesser larval duration

of 543 h. Accession BBE-0159 was identified for maximum larval weight (45.89 g). Accession BBI-0334 was recorded with high pupation rate of 97.6% and high single cocoon weight of 1.69 g was recorded in accession BBI-0344. Maximum single shell weight (0.33 g) recorded in accession BBI-0344. Shell ratio of 23.17 g was found higher in accession BBI-0366. Higher cocoon yield/100 dfls of 77.06 kg was recorded in accession BBI-0370 and low in accession BBI-0374 with 32.73 Kg. Coefficient of variation was high for fecundity (16.57) followed by single shell weight (15.89), cocoon yield/100 dfls (13.51) and Yield/10000 larvae by weight (13.50). Minimum variability was noticed in the case of total larval duration (1.13) and Yield/10000 larvae (No.) with CV of 1.8 %.

Table - 37 : Variability statistics of 134-bivoltine-silkworm germplasm reared under second batch

Particulars	Mean	Min.	Max.	SD	SE	CV%
Fecundity (No.)	475	276(BBI-0141)	650(BBI-0357)	78.64	6.84	16.57
Hatching (%)	91.7	71.8(BBI-0093)	97.7(BBI-0123)	3.59	0.31	3.91
Wt.of 10 larvae (g)	35.2	19.55(BBI-0093)	45.89(BBE-0159)	4.13	0.36	11.74
Total larval duration (h.)	558	543(BBI-0373)	577(BBI-0381)	6.33	0.55	1.13
V age larval duration (h.)	147	111 (BBI-0373)	168(BBI-0344)	8.58	0.75	5.82
Yield/10000 larvae (No.)	9730	8982(BBI-0193)	9971(BBI-0092)	175.06	15.24	1.80
Yield/10000 larvae wt. (Kg.)	13.86	8.20(BBI-0374)	19.25(BBI-0370)	1.87	0.16	13.50
Pupation rate (%)	87.9	67.0(BBI-0103)	97.6(BBI-0334)	5.82	0.51	6.62
Single cocoon wt. (g)	1.38	0.91(BBI-0141)	1.69(BBI-0344)	0.13	0.01	9.38
Single shell wt. (g)	0.24	0.09(BBI-0092)	0.33(BBI-0344)	0.04	0.00	15.89
Shell ratio (%)	17.64	9.44BBI-0093)	23.17(BBI-0366)	1.86	0.16	10.56
Cocoon yield/100 dfl (Kg.)	55.43	32.73(BBI-0374)	77.06(BBI-0370)	7.49	0.65	13.51

The evaluation data collected was analyzed for superior accessions with multiple traits and presented in Table - 39. Accession BBI-0339 was found to be better with higher values for six economic traits. Four accessions (BBI-0344, BBI-0343, BBI-0370 and BBI-0378) were found to be better with higher values for five economic traits. Accession BBE-0148 was found to be better with higher values for four economic traits.

Table - 38 List of top ten bivoltine germplasm accessions identified for individual trait

Traits	Range	Accession Numbers
Fecundity (No.)	650 - 593	BBI-0357, BBE-0150, BBI-0367, BBI-0343, BBI-0350, BBI-0123, BBE-0148, BBI-0090, BBE-0159, BBI-0126
Hatching (%)	97.7 - 95.8	BBI-0123, BBE-0164, BBE-0162, BBI-0357, BBI-0131, BBE-0146, BBE-0148, BBI-0119, BBI-0346, BBI-0360
Weight of 10 grown larvae (g)	45.89 - 39.9	BBE-0159, BBI-0344, BBE-0160, BBI-0089, BBI-0339, BBI-0342, BBI-0330, BBI-0086, BBI-0095, BBI-0100

Total larval duration (h)	543-552	BBI-0373, BBI-0120, BBI-0111, BBI-0112, BBI-0341, BBI-0108, BBI-0121, BBI-0295 BBI-0375, BBE-0168
Fifth larval duration (h)	111-132	BBI-0373, BBI-0379, BBI-0377, BBI-0376, BBI-0375, BBI-0366, BBI-0367, BBI-0369, BBI-0368, BBI-0378
Yield/10000 larvae (by no.)	9971 - 9911	BBI-0092, BBE-0148, BBE-0158, BBI-0334, BBI-0292, BBI-0347, BBI-0140, BBI-0378, BBI-0122, BBI-0124
Yield /10000 larvae wt.(Kg)	19.25 - 17.05	BBI-0370, BBI-0344, BBI-0101, BBE-0153, BBI-0343, BBE-0165, BBI-0336, BBI-0342, BBI-0301, BBI-0339
Pupation rate (%)	97.6 - 94.7	BBI-0334, BBE-0158, BBE-0159, BBE-0155, BBI-0372, BBI-0292, BBE-0157, BBI-0347, BBE-0146, BBE-0148
Single cocoon weight (g)	1.69 - 1.53	BBI-0344, BBI-0339, BBI-0343, BBI-0374, BBI-0345, BBI-0086, BBI-0375, BBI-0338, BBI-0370, BBI-0378
Single shell weight (g)	0.33 - 0.29	BBI-0344 BBI-0339, BBI-0378, BBI-0370, BBI-0330, BBI-0343, BBI-0345, BBI-0366, BBE-0149, BBI-0086
Shell ratio (%)	23.17 - 19.72	BBI-0336, BBE-0149, BBI-0378, BBE-0332, BBI-0370, BBI-0129, BBI-0364, BBI-0102, BBI-0339, BBI-0349
Cocoon yield /100dfls (Kg)	77.06 - 68.26	BBI-0370, BBI-0344, BBI-0101, BBE-0153, BBI-0343, BBE-0165, BBI-0336, BBI-0342, BBI-0301, BBI-0339

Table - 39 Top ranking bivoltine accessions identified with multiple traits

Acc. No.	No. of Traits	Trait number (values)
BBI-0339	6	3(40.95), 7(17.05), 9(1.62), 10(0.32), 11(19.77), 12(68.26)
BBI-0344	5	3(41.35), 7(18.35), 9(1.69), 10(0.33), 12(73.47)
BBI-0343	5	1(616), 7(17.75), 9(1.6), 10(0.3), 12(70.92)
BBI-0370	5	7(19.25), 9(1.55), 10(0.31),11(20.28), 12(77.06)
BBI-0378	5	5(132), 6(9918), 9(1.53), 10(0.32),11(20.85)
BBE-0148	4	1(604), 2(96.03), 6(9946), 8(94.7)

**figures in parentheses indicates the actual value of the traits*

1.Fecundity (Nos.), 2. Hatching(%), 3. Weight of 10 larvae(g),4. Total Larval Duration (h),5. Fifth age larval duration (h), 6. ERR/10000 (No.), 7. ERR/10000(wt.),8. Pupation rate (%),9. Single cocoon weight (g.),10. Single shell weight (g.), 11. Cocoon shell ratio (%), 12. Cocoon yield /100dfls (Kg.)

Preliminary evaluation and conservation of bivoltine silkworm genetic resources (III batch)

Veeranna Gowda, M. Muthulakshmi, R. Radhakrishnan, M.M. Borpuzari and V. Sivaprasad

Evaluation of quantitative and reproductive traits in respect of 113 bivoltine silkworm germplasm accessions was conducted in the III batch conservation rearing during January to March 2014. Variability analysis of important economic traits was also evaluated statistically. The evaluation results of the III batch bivoltine germplasm accessions are as in Table - 40. Comparison of the rearing data of III batch, it is clear that the quantitative traits of the bivoltine silkworm germplasm accessions studied are in accordance with the passport data exhibiting consistent performance over the years / rearings. Statistical analysis of the data revealed higher CV % for ERR/10000 larvae by weight and yield / 100 dfls (16.91 %),

fecundity (15.73 %), shell weight (13.61 %), weight of 10 grown larvae (11.12%), single cocoon weight (9.77 %), shell ratio (7.26 %) and fifth age larval duration (6.37 %). Whereas, in some of the quantitative traits variability was meager as observed in ERR/10000 larvae by number (1.82 %) and total larval duration (1.60 %).

Table - 40 : Variability in rearing performance of 113 bivoltine silkworm germplasm accessions III batch.

Traits	Mean	Min.		Max.		SD	SE	CV %
Fecundity (No.)	500	287	(BBE-0219)	686	(BBI-0215)	78.69	7.44	15.73
Hatching (%)	88.70	78.62	(BBI-0208)	96.86	(BBE-0199)	4.18	0.40	4.72
Weight of 10 larvae (g)	25.24	15.03	(BBE-0209)	30.88	(BBI-0172)	2.81	0.27	11.12
Total larval duration (h)	609	588	(BBI-0259)	632	(BBE-0228)	9.75	0.93	1.60
Vth age larval duration (h)	153	132	(BBI-0259)	176	(BBE-0228)	9.73	0.92	6.37
Yield/10000 larvae (by No.)	9796	8381	(BBE-0170)	9950	(BBE-0266)	177.86	16.81	1.82
Yield/10000 larvae by Wt.(kg)	10.98	5.85	(BBI-0248)	17.35	(BBE-0187)	1.86	0.18	16.91
Pupation rate (%)	92.53	64.17	(BBE-0170)	98.49	(BBE-0222)	4.54	0.43	4.91
Single cocoon weight (g)	1.06	0.69	(BBE-0209)	1.26	(BBE-0197)	0.10	0.01	9.77
Single shell weight (g)	0.18	0.11	(BBE-0209)	0.24	(BBE-0244)	0.02	0.00	13.61
Cocoon shell ratio (%)	17.32	14.52	(BBE-0191)	20.12	(BBI-0304)	1.26	0.12	7.26
Cocoon yield / 100 dfls (kg)	43.92	23.34	(BBI-0248)	69.41	(BBE-0187)	7.43	0.70	16.91

113 bivoltine silkworm germplasm accession conservation rearing (III batch) was done and multiple traits evaluation for all the quantitative traits was assessed and the top ranking performance accessions were identified. Bivoltine accession BBI-0215 exhibited maximum fecundity of 686 and BBI-0219 minimum of 287 eggs per laying. The hatching percentage ranged from the least of 78.60 % (BBI-0208) to highest of 96.86 % (BBE-0181). In respect of larval (10) weight, BBI-0172 recorded maximum of 30.88 g and BBE-209 minimum of 15.03 g. Larval duration ranged from a minimum of 588 h (BBI-0259) to maximum of 632 h (BBE-0228). In case of fifth age, BBE-0228 has taken longer duration of 176 h when compared to BBI-0259 with shorter duration of 132 h. Yield/10000 larvae by number trait ranged from a maximum of 9949 (BBE-0266) to minimum of 8381 (BBE-0170). BBE-0187 recorded highest of 17.35 kg when compared to the lowest of 5.85 kg scored by BBE-0248 in the trait yield / 10000 larvae by weight. In respect of pupation rate, BBE-0170 scored less (64.17 %) and highest of 98.49 % was recorded by BBE-0222. BBE-0197 accession showed highest single cocoon weight of 1.26 g whereas BBE-0209 showed lowest of 0.69 g. The single shell weight was more in accession BBE-0244 (0.24g) and less in BBE-0209 (0.11g). Highest cocoon shell ratio of 20.12 % was recorded in BBI-0304 and lowest in BBE-0191 (14.52 %). In cocoon yield / 100 dfls quantitative trait, a maximum of 69.41 kg was recorded by BBE-0187 accession and minimum in BBI-0248 (23.34kg). List of top ranking bivoltine germplasm accessions in performance for different economic traits are as enlisted in Table - 41.

Table - 41: Top ranking bivoltine silkworm germplasm accessions identified for individual traits

Traits	Range	Accession numbers
Fecundity (No.)	686 - 604	BBI-0215, BBE-0214, BBI-0205, BBI-0276, BBI-0235, BBE-0193, BBI-0239, BBE-0206, BBE-0246, BBE-0272.
Hatching (%)	96.86 - 93.95	BBE-0181, BBE-0199, BBE-0252, BBE-0272, BBE-0210, BBE-0188, BBE-0206, BBE-0201, BBE-0201, BBE-0218.
Weight of 10 grown larvae (g)	30.88 - 28.76	BBI-0172, BBI-0254, BBE-0272, BBE-0269, BBE-0177, BBI-0274, BBE-0186, BBE-0215, BBE-0267, BBI-0235.
Total larval duration (h)	624 - 632	BBE-0228, BBE-0232, BBE-0199, BBE-0268, BBE-0224, BBE-0267, BBE-0198, BBE, 195, BBE-0193, BBE-0188.
Fifth age larval duration (h)	168 - 176	BBE-0228, BBE-0232, BBE-0199, BBE-0268, BBE-0224, BBE-0267, BBE-0185, BBE-0188, BBE-0193, BBE-0195.
Yield/10000 larvae (by No.)	9950 - 9823	BBE-0266, BBI-0271, BBE-0262, BBE-0242, BBE-0263, BBI-0239, BBI-0289, BBI-0257, BBE-0222, BBE-228.
Yield/10000 larvae by wt.(kg)	17.35 - 11.50	BBE-0187, BBE-0179, BBI-0207, BBE-0193, BBE-0175, BBI-0204, BBE-0194, BBE-0199, BBE-0197, BBI-0235.
Pupation rate (%)	98.49 - 96.70	BBE-0222, BBE-0262, BBE-0261, BBE-0233, BBE-0233, BBI-0257, BBI-0208, BBE-0228, BBE-0178, BBE-0180.
Single cocoon weight (g)	1.26 - 1.19	BBE-0197, BBE-0222, BBE-0244, BBE-0272, BBE-0187, BBE-0230, BBE-0186, BBI-0215, BBI-0298, BBI-0235.
Single shell weight (g)	0.24 - 0.22	BBE-0244, BBI-0304, BBE-0186, BBE-0222, BBE-0181, BBE-0187, BBE-0197, BBE-0216, BBE-0225, BBE-0272.
Cocoon shell ratio (%)	20.12 - 19.18	BBI-0304, BBI-0239, BBE-0181, BBE-0192, BBE-0242, BBE-0177, BBE-0225, BBE-0262, BBE-0186, BBE-0244
Cocoon yield / 100 dfls (kg)	69.41 - 52.49	BBE-0187, BBE-0179, BBI-0207, BBE-0193, BBE-0175, BBI-0204, BBE-0194, BBE-0199, BBE-0197, BBI-0235.

Table-42 Top ranking bivoltine accessions identified with multiple traits

Acc. No.	No. of traits	Trait No. and Value
BBE-0272	5	1(603.5), 2(95.2), 3(30.13), 9(1.22), 10(0.22),
BBE-0197	4	7(13.25), 9(1.26), 10(0.22), 12(52.92),
BBE-0222	4	6(9924.5), 8(98.49), 9(1.24), 10(0.23),
BBE-0187	4	7(17.35), 9(1.22), 10(0.22), 12(69.412),
BBE-0186	4	3(28.92), 9(1.2), 10(0.23), 11(19.184),
BBI-0235	4	1(652.5), 3(28.76), 9(1.19), 12(52.488),

Figures in the parantheses indicate actual value of the traits.

Fecundity (No.), 2. Hatching (%), 3. Weight of 10 larvae (g), 4. Total larval duration (h), 5. Fifth age larval duration (h), 6. ERR / 10000 larvae (No.), 7.ERR / 10000 larvae wt. (Kg), 8.Pupation rate (%) 9. Single cocoon wt. (g), 10. Single shell wt. (g), 11.Cocoon shell ratio (%), 12. Cocoon yield/100 dfls (Kg).

Bivoltine germplasm accessions superior in many traits were identified based on multiple traits evaluation index (Table - 42). Out of 6 bivoltine accessions evaluated, BBE-0272 qualified for 5 economic characters whereas the remaining 5 accessions were found performing better higher values for 4 economic traits.

E-04: Preliminary evaluation for growth and reproductive traits of mutant silkworm genetic resources

M. Muthulakshmi, R.Radhakrishnan, Veeranna Gowda, M.M. Borpuzari and V.Sivaprasad

Evaluation of 20 mutant genetic stocks were completed in two crop cycles (First crop during July-September, 2013 and the second crop during January 2013 to March 2014) and the evaluation data on the important evaluation parameters were recorded and updated in the SGIS database. Variability statistics on twelve important economical character of 20 mutant genetic stocks are presented in Table - 43.

Table - 43: Variability in economical character of 20 mutant genetic stocks. (pooled data of two crops)

Traits	Mean	Min.	Max.	SD	SE	CV%
Fecundity (No.)	347	270 (BBE-0316)	485 BBE-0306)	58.13	13.34	16.76
Hatching (%)	85.7	75.3 (BBE-0308)	95.2 (BBE-0320)	5.89	1.35	6.88
Wt. of 10 of grown larvae (g)	19.6	14.2 (BBE-0318)	25.0 (BBE-0306)	3.25	0.74	16.57
Total larval duration (h)	501	496 (BBE-0309)	510 (BBE-0314)	3.99	0.92	0.80
Fifth age larval duration (h)	112	103 (BBE-0331)	118 (BBE-0333)	4.53	1.04	4.06
Yield/10000 larvae (by no.)	9772	9545 (BBE-0323)	9920 (BBE-0333)	97.36	22.34	1.00
Yield/10000 larvae by wt. (Kg)	8.6	6.85 (BBE-03080	11.6 (BBE-0319)	1.35	0.31	15.75
Pupation rate (%)	90.1	80.3 (BBE-0321)	97.5 (BBE-0333)	3.88	0.89	4.31
Cocoon weight (g)	0.8	0.63 (BBE-0318)	1.12 (BBE-0306)	0.12	0.03	14.68
Shell weight (g)	0.1	0.06 (BBE-0319)	0.14 (BBE-0306)	0.02	0.00	22.37
Shell ratio (%)	11.6	8.96 (BBE-0316)	13.50 (BBE-0333)	1.23	0.28	10.57
Cocoon yield / 100 dfls (Kg)	34.3	27.4 (BBE-0308)	46.5 (BBE-0319)	5.40	1.24	15.75

Figures in parentheses indicates respective accession number

The data analysed statistically revealed higher co-efficient of variation for single shell weight (23.4 %), fecundity (16.76 %) followed by weight of 10 grown larvae (16.57 %) cocoon per 100 dfls (15.75 %) and yield/10000 larvae by wt. (15.75%) where as, it was less in the case of traits like total larval duration (0.8%) and yield/10000 larvae (1.0 %).

S-03: A- 01: Conservation of multivoltine silkworm genetic resources
N. Balachandran, P.Somasundaram, K.Ashokkumar M.M.Borpuzari and V.Sivaprasad

All the 77 multivoltine accessions were conserved by conducting rearing in 5 crops *viz*., 87th to 91st generation followed by preservation of eggs at a low temperature of 5º C for 35 days. So far 91 generations completed. The accessions were maintained true to type on par with the passport data with out any loss and ensuring complete disease freeness.

S-04: A- 01: Conservation of bivoltine silkworm genetic resources
M. Muthulakshmi, R.Radhakrishnan, Veeranna Gowda, P.Somasundaram, K.Ashokkumar, Borpuzari and V.Sivaprasad

All the 361 bivoltine accessions were conserved by conducting rearing in 3 batches and by preserving the eggs in 10 months hibernation schedule in two cold storages with 12 months cold preservation as back up. The accessions were maintained true to type on par with the passport data without loss and ensuring disease freeness. So far, first phase accessions have completed 20 generations, the second phase accessions completed 17 generations and the remaining accessions completed 11 generations during the year 2013-2014.

S-05: A-01: Conservation of mutant silkworm genetic resources.
M. Muthulakshmi, M.M.Borpuzari and V.Sivaprasad

Conservation rearing of all the 20 bivoltine mutant genetic stocks were conducted two times in a year (I crop June-August, 2013, II crop-January, 2014–March, 2014 and dfls conserved following six months hibernation schedule in two cold storages with 8 months hibernation schedule as back up. The accessions were maintained true to type on par with the passport data without loss and ensuring disease freeness. So far, mutant accessions have completed 25 generations.

S-03: S-04, S-05 A- 02: Supply of silkworm genetic resources:
N.Balachandran, M.Muthulakshmi R.RadhaKrishnan, Veeranna Gowda and M.M.Borpuzari

During the year under report 243 BV accessions were supplied to 12 indenters in 24 spells and 22 MV accessions were supplied to 3 indenters in 6 spells for PG research, evaluation and as breeding resource materials. The details are shown in Table - 44 & 45.

Table -44 : Bivoltine silkworm germplasm supplied during the year 2013-2014

SL. No.	Indenter Name	No. of times supplied	No. of accessions supplied	Purpose
1	SBRL, Bangalore	2	49	Research
2	CSRTI, Berhampore	2	22	AISGEP evaluation
3	RSRS, Sahaspur	2	22	AISGEP evaluation
4	RSRS, Kalimpong	3	27	AISGEP evaluation

5	RSRS, Jorhat	2	22	AISGEP evaluation
6	RSRS, Jammu	2	22	AISGEP evaluation
7	CSRTI, Pampore	2	22	AISGEP evaluation
8	CSRTI, Mysore	3	33	AISGEP evaluation
9	Marathwada Agrl. University, Parbhani, Maharashtra	1	6	PG Research
10	TNAU, Coimbatore	3	11	PG Research
11	SKUAST, Jammu and Kashmir	1	6	PG Research
12	North Eastern Hill University, Shillong	1	1	PG Research
Total		**24**	**243**	

Table - 45: Multivoltine silkworm germplasm supplied during the year 2013-2014

SL. No.	Indenter Name	No. of times supplied	No. of accessions supplied	Purpose
1	TNAU, Coimbatore	4	13	PG Research
2	CSRTI, Mysore	1	1	Breeding resource materials
3	SBRL, Bangalore	1	8	PG Research
Total		**6**	**22**	

CYR - 3484 : **Evaluation of silkworm genetic resources for post cocoon traits**
Nivedita S, N. Balachandran and M.Muthulakshmi

Silk cocoons form the raw material for the reeling industry. Therefore it is important to evaluate the cocoon quality and fibre characteristics of all accessions in the gene bank. This would enable the breeders in selection of such parents, which would ensure a good harvest of robust cocoons that can be reeled conveniently into gradable raw silk. During the year, five multivoltine and three bivoltine newly introduced accessions were evaluated for all 16 post cocoon parameters, including 8 reeling parameters and 8 raw silk quality parameters. The results are given in Table - 46 and Table - 47 respectively.

Table - 46. Post cocoon traits of 5 multivoltine accessions

Sl. No.	Accession Number	BMI-073	BMI-075	BMI-076	BMI-077	BMI-078
	Accession Name	BL-67	PM (Mutant)	APM-2	APM-3	APDR-15
	Reeling parameters					
1	Reelability (%)	57.37	63.98	84.88	93.0	85.5
2	Waste (%)	60.88	89.29	23.94	30.61	30.3
3	Filament length (m)	279.9	214.2	828.7	524.3	518.79
4	Avg. NBFL (m)	164.9	140.8	722.8	502.2	456.10
5	Denier (d)	2.26	2.33	1.84	1.91	2.07
6	Raw silk (%)	6.94	5.86	14.06	11.58	10.60
7	Raw silk recovery (%)	41.36	36.17	73.85	65.09	64.44
8	Renditta	14.41	17.07	7.11	8.64	9.44
Sl. No.	**Raw silk quality parameters**					
1	Neatness (%)	35	28	79	78	83
2	Low neatness (%)	20	20	73	70	80
3	Cleanness (%)	85	86	88	94	85
4	Evenness variation-I (stripes)	170	170	70	120	115
5	Tenacity (g/den)	3.36	3.25	3.72	4	3.61
6	Elongation (%)	19.2	20.3	20.5	14.4	21.4
7	Cohesion (strokes)	18	34	52	39.5	57
8	Boil - off loss (%)	21.5	25.3	20.8	22.4	22.8

Table - 47. Post cocoon traits of 3 bivoltine accessions

Sl. No.	Accession Number	BBI-371	BBI-372	BBI-379
	Accession Name	SK6	SK7	APDR-105
	Reeling parameters			
1	Reelability (%)	84.6	84.6	93.8
2	Waste (%)	20.92	21.30	23.2
3	Filament length (m)	632.4	675.8	798.7
4	Avg. NBFL (m)	549.9	587.5	771.7
5	Denier (d)	2.34	2.39	2.05
6	Raw silk (%)	12.13	12.68	12.89
7	Raw silk recovery (%)	71.44	74.87	71.35
8	Renditta_	8.24	7.89	7.76

Sl. No.	Raw silk quality parameters			
1	Neatness (%)	98	87	95
2	Low neatness (%)	95	85	90
3	Cleanness (%)	88	90	95
4	Evenness variation-I (stripes)	50	40	80
5	Tenacity (g/den)	3.60	3.85	3.76
6	Elongation (%)	17.9	20.4	13.1
7	Cohesion (strokes)	78	52	65
8	Boil - off loss (%)	27.7	23.3	22.4

Among the new MV accessions tested, BMI-0076 had better reeling traits such as longer filament length (828.7 m), longest NBFL (722.8 m), less waste (23.94%), good raw silk recovery (73.85 %) and a minimum renditta of 7.11. BMI-075 was found to have lowest filament length (214.2m) and lowest NBFL (140.8m) and the maximum renditta (17.07).

Also, BMI-0076 was found to have the maximum neatness (79.0%) and low neatness (73%), higher tenacity (3.72gf/den) and the least evenness variations (70 stripes). On the other hand, BMI-0075 had the lowest neatness (28%) and low neatness (20%), lowest tenacity (3.25 gf/den) and highest evenness variation (170 stripes). The maximum boil-off loss (25.3%) was also recorded for this accession.

Among the bivoltine races tested, BBI-0379 had better traits such as maximum reelability (93.8%), maximum filament length (798.7m) and maximum cleanness (95%). From the pooled data, ten promising multivoltine accessions have been identified statistically and these accessions are being subjected to re-evaluation under further trials, in order to confirm the consistency and estimate the variability in their performance. Under the II trial, four promising MV accessions were reared as per standard protocol and evaluated for post cocoon traits. The results represented in Table - 48.

Table - 48. Post cocoon traits of 4 multivoltine accessions (II Trial)

Sl. No.	Accession Number	BMI-007	BMI-009	BMI-021	BMI-027
	Accession Name	Mysore Princess	Kollegal Jawan	CB5	O
	Reeling Parameters				
1	Reelability (%)	86.7	91.3	68.4	93.1
2	Waste (%)	43.88	32.14	55.76	47.27
3	Filament length (m)	388.1	339.6	282.3	260.0
4	Avg. NBFL (m)	347.0	319.2	197.7	249.2
5	Denier (d)	1.68	1.74	1.76	1.90

6	Raw silk (%)	8.97	9.80	6.63	7.37
7	Raw silk recovery (%)	62.03	67.44	54.43	59.05
8	Renditta	11.4	10.2	15.09	13.56
Sl. No.	**Raw silk quality parameters**				
1	Neatness (%)	87	85	65	75
2	Low Neatness (%)	85	83	55	73
3	Cleanness (%)	74	74	88	64
4	Evenness variation-I (stripes)	62	34	60	34
5	Tenacity (g/den)	3.48	3.63	3.68	3.60
6	Elongation (%)	16.2	20.4	18.4	19.4
7	Cohesion (strokes)	62	34	17	72
8	Boil-off loss (%)	24.8	21.3	23.4	24.0

Evaluation of fibroin content in silkworm accessions.

Fibroin and sericin are two proteins in the cocoons of *Bombyx mori* silkworm, which are gaining much attention from researchers due to their remarkable properties like anti-oxidant, UV protection, anti-coagulant, moisture absorption etc. These properties have led to their use as biomaterials in non-conventional applications like cosmetics, medicines, wound healing, drug delivery etc. So far the silkworm accessions have not been evaluated for the contents of these two proteins in their native state. Therefore, the silk protein content in green cocoons of silkworm accessions have to be estimated and so far 102 accessions were evaluated for fibroin content by gravimetric method. Pressurized degumming was followed.

9. TRAINING

Training imparted

- Dr. D. Mohan Ram Rao, Shri. N.Balachandran and Smt M.Muthulakshmi Sci-C handled classes on sericultural topics for the sericultural farmers of Tamil Nadu under CDP programme at TNSTI, Hosur as guest faculty during the year 2013-14.

Training attended

- Smt. Anuradha H. Jingade, Scientist C attended training on **Computational tools for animal genome resource data Analysis at NBAGR, Karnal, Haryana**, from 2nd to 13th December 2013.
- Dr. A. Ananda Rao, Scientist D, Dr. S. Nivedita, Scientist D, Dr. K. Jhansilakshmi, Scientist D, Dr. Veeranna Gowda, Scientist C, Smt. M. Muthulakshmi, Scientist C, Sri. Narayana Bisarahalli, A.D (A&A), Sri. S. Prabhakar, Supdt attended training on Internal Audit at CSGRC, Hosur, on 4.3.2014 conducted by M/s. Margadarshan Management & Measurement Pvt. Ltd, Gurgaon.

Award of Ph.D

- Sri. Veeranna Gowda, Scientist C was awarded Ph.D degree in Sericulture from Mysore university, Mysore, for the thesis entitled **"Studies on the hybrid evaluation of bivoltine breeds of silkworm *Bombyx mori* L. by adopting single, three-way and four-way crossing pattern"**

10. IMPORTANT DELEGATIONS LEAD OR PARTICIAPTED

- Shri. S. Mohan, Honourable Minister for Rural Industries, Govt. of Tamil Nadu visited the centre on 06th September 2013 along with Shri. Harmander Singh IAS, Secretary, Dept. of Industries, Govt. of Tamil Nadu and Shri.S.Prabhakaran IFS, Director of Sericulture, Salem.
- Dr.Yamaguchi, Japanese sericulture expert visited the centre on 19th November 2013 and interacted with the scientists of the centre.
- Dr. Chandish Ballal, Principal Scientist from NBAII, Bangalore visited the centre on 27th December 2013.
- Newly recruited JIS of Dept. of Sericulture, DOS, Govt. of Tamil Nadu visited the centre on 6th March 2014.
- M.M. Borpuzari, Dr. S.R.Ramesh, Dr. A.Ananda Rao, K. Jhansilakshmi and N. Balachandran participated in the scientific discussion held at SBRL, Bangalore on 26th February 2014.

11. PUBLICATIONS

International Journals

1. Veeranna Gowda, Ashwath, S.K. and Kalpana G.V. **(2014)**. Analysis of Stability parameters in the bivoltine breeds of silkworm *Bombyx mori* L. ***Scholars Academic Journal of Biosciences***, 2(1):11-18
2. Veeranna Gowda, Ashwath S.K. and Kalpana G.V. **(2014)**. Selection of potential parental breeds of silkworm *Bombyx mori* L. for tropical climate, ***Int. J. Cur.Res.,*** *6(4):* 6094-6097
3. Veeranna Gowda, Kalpana G.V. and Ashwath S.K. **(2013)**. Identification of promising bivoltine three way cross hybrid of silkworm *Bombyx mori* L. ***Biospectra,*** 8(2):50-60
4. Somasundaram P. and Ashok Kumar K. **(2013).** Key Biochemical markers in silkworms challenged with immuno elicitors and their association in genetic resistance for survival. ***Global Journal of Bioscience and Biotechnology***, 2(3): 290-295.
5. Mohan Ram Rao, Jhansilakshmi K., Saraswati P., Ananda Rao A., Ramesh S.R., Borpuzari, M.M. and Manjula, A. **(2013)**. Scope of Pre-breeding in mulberry crop improvement - A review, ***Science Weekly***, 1(6). Available online at www. weeklyscience.org.
6. Veeranna Gowda, Kalpana, G.V and Ashwath, S.K **(2013)**. Evaluation and identification of potential bivoltine silkworm hybrids of *Bombyx mori* L. ***Journal of Entomology and Zoology Studies***, 1(6): 39-43.
7. Veeranna Gowda, Kalpana, G.V. and Ashwath, S.K. **(2013)**. Differential expression of economic traits in bivoltine breeds of silkworm *Bombyx mori* L. ***Geobios***, 40: 69-81.

8. Ashok Kumar K., Somasundaram P., Rajesh, G.K., Chandrasekar R., Balachandran N. and Sivaprasad V. **(2013)**. Protein markers as a potential tool for biochemical characterization of silkworm genetic resources. http://silkwormmori.blogspot.

National Journals

1. Nivedita S., Ghosh M.K., and Basu A. **(2013).** " Consumers : An important link in the supply chain ", ***Indian Silk*** , 4 (4-5).

12. PAPERS PRESENTED IN CONFERENCES / MEETINGS / SEMINARS

1. Balachandran N., Ramesh S.R., Chandrasekhar M., Kiran B. Malali, Borpuzari, M.M. and Manjula A. (**2013**). Evaluation of elite mulberry genetic resources through bioassay, *In Recent Advances in Modern Biology and Sericulture for Women Empowerment and Rural Development (RAMBSWERD-2013),* 24-26th October, 2013 KSSRDI, Bengaluru.
2. Muthulakshmi M., Balachandran N., Siddiqui A.A., Chauhan T.P.S., Hiremath S.A. and Manjula A. (**2013**). Evaluation of selected bivoltine silkworm germplasm under abiotic stress conditions of northern India. *In Recent Advances in Modern Biology and Sericulture for Women Empowerment and Rural Development (RAMBSWERD-2013)*, 24-26th October, 2013 KSSRDI, Bengaluru.
3. Veeranna Gowda, Kalpana G.V and Ashwath S.K **(2013)**. Identification of promising bivoltine three way cross hybrid of silkworm *Bombyx mori* L for tropical climate**,** *In Recent Advances in Modern Biology and Sericulture for Women Empowerment and Rural Development (RAMBSWERD-2013),* 24-26th October, 2013 KSSRDI, Bengaluru.
4. Jhansilakshmi K., Anandarao A., Borpuzari M.M., Thiyagu T. and Sivaprasad V. **(2013)**. Variability for physiological parameters among the selected mulberry (*Morus* spp.) genetic resources for adaptation to climate change. In *Green India: Strategic knowledge for combating climate change: Prospects and Challenges (GISKCC-2013)*
5. Nivedita S. and Sivaprasad V. (2014). *Technical Applications of Mulberry Silk. In 27th National Convention of Textile Engineers,* 20 - 21 Feb. 2014.
6. Velayudhan K., Balachandran N., RadhaKrishnan S., Singh B.K. and Jayaprakash, P. (2013). Biodiversity in Eri silkworm *Samia ricini* (Donovan) genetic resources and its conservation, In ECOCASD.

13. SERVICES RENDERED

Central Silkworm Seed Act : Shri.N.Balachandran Sci-C as the designated Seed Officer has inspected the Registered Seed Producers (3 Nos.) and Registered Chawki Rearers (1 No.) in Hosur Taluk as per the Central Silkworm Seed Act and submitted reports to the Chairman and Registration Authority/Director, NSSO, CSSC, Bangalore.

Implementation of Official Language : Sheeba, V.S., Junior Hindi Translator assisted Regional Office, Central Silk Board, Chennai in implementation of Official Language in Hindi. Hindi workshops and OLIC meetings were conducted at RO, Chennai.

Implementation of FAS/PRS : S. Sekar, AD (Computer) and T.V. Muralidharan, UDC extended services to SSPC, Dharmapuri and Thirupattur to solve FAS/PRS problems.

14. WORKSHOPS, SEMINARS, FARMERS DAY

Scientists Meet : Dr. V. Sivaprasad, Director, Sri. M.M. Borpuzari, Scientist D, Dr. S. R. Ramesh, Scientist D, Dr. P. Somasundaram, Scientist D, Dr. A. Ananda Rao, Scientist D, Dr. K. Jhansilakshmi, Scientist D, Dr. Nivedita, Scientist D, Sri.R. Radhakrishnan, Scientist C, Smt. Anuradha H. Jingade, Scientist C, Dr Veeranna Gowda, Scientist C, Dr. Mohan Ram Rao**,** Scientist C, Sri N. Balachandran**,** Scientist C, Smt. M. Muthulakshmi, Scientist C, Dr. K. Ashok Kumar, Scientist C attended the 'Scientists Meet' on 21-22 March 2014 at Chancery Pavilion, No.135, Residency Road, Bangalore.

15. DISTINGUISED VISITORS

Sl. No.	Students/Farmers visited	Name of the College/University	No. of Officials/ Students/ Farmers
1	Students & teachers	Various schools from Hosur and surrounding areas	350
2	Students & Professor	TNAU, Coimbatore	31
3	Students & Lecturers	Shivaji University, Kholapur	24
4	Students & Scientists	CSRTI, Berhampore	31
5	Farmers & Officals	V. Pally, Krishnagiri	50
7	Farmers & Officals	Thiruvanamalai	35
7	ISDS Farmers	RSRS, Bangalore	28

16. LIST OF MEMBERS OF RAC/RC/GERMPLASM REGISTRATION/ SUPPLY AND EXCHANGE COMMITTEE

RESEARCH ADVISORY COMMITTEE

Dr.Kailash Chandra Bansal, Director, National Bureau of Plant Genetic Resources (NBPGR), Pusa campus, New Delhi - 110 012	**Chairman**
Dr. B.K.Joshi, Director, National Bureau of Animal Genetic Resources (NBAGR), Makrampur campus, GT. Road Baldi By-pass, Near Basant Vihar, P.B. No 129, Karnal - 132 001, Haryana	Member
Shri Krishna Kumar, IFS, Director, Institute of Forest Genetics & Tree Breeding, P.B. No.1061, R.S. Puram, Coimbatore - 641 002	Member
Dr.T.Subramoniam, Marine Biotechnology group, National Institute of Ocean Technology, Pallikaranai, Chennai-600 100	Member
Prof.G.Subramanya, Chairman, BOS, Sericulture Department, Manasagangotri, University of Mysore, Mysore	Member

Dr.S.Ganesan, Principal Scientist, Divison of Plant Genetic Resources, IIHR, Hesaraghatta, Bangalore-560 089	Member
Director (Tech.), Central Silk Board, CSB Complex, Madivala, Bangalore - 560 068	Member
Director,Central Sericultural Research & Training Institute, Central Silk Board, Srirampura, Mysore-570 008	Member
Director, Central Sericultural Germplasm Resources Centre, P.B.No.44, Thally Road, Hosur - 635 109	**Member - Convener**

RESEARCH COUNCIL

Director, Central Sericultural Germplasm Resources Centre P.B.No.44, Thally Road, Hosur - 635 109	**Chairman**
Scientist-D, Central Sericultural Germplasm Resources Centre P.B.No.44, Thally Road, Hosur - 635 109	**Member – Convener**

GERMPLASM REGISTRATION COMMITTEE

Director (Tech.), Central Silk Board, Bangalore - 560 068	**Chairman**
Director, Central Tasar Research and Training Institute Ranchi -835 303	Member
Director, Central Muga and Eri Research and Training Institute Lahdoigarh -785 700	Member
Need Based Specialist : Invitee Scientist from Plant Breeding or Insect Breeding or Plant Pathology **or** Insect Pathology or Entomology	Member
Director, Central Sericultural Germplasm Resources Centre Hosur - 635 109	**Member – Convener**

GERMPLASM SUPPLY & EXCHANGE COMMITTEE

Director, Central Sericultural Germplasm Resources Centre Hosur - 635 109	**Chairman**
Director (Tech.), Central silk Board, Bangalore – 560 068	Member
Scientist-D, Central Sericultural Germplasm Resources Centre, Hosur – 635 109	Member
Scientist-D, Central Sericultural Germplasm Resources Centre, Hosur – 635 109	**Member – Convener**

17.PERSONNEL

DIVISION / SECTION	NAME	DESIGNATION
	Dr. A. Manjula	**Director** ***(upto 31.08.2013)***
	Dr. V. Sivaprasad V	**Director** ***(05/09/2013 to 28/06/2014)***
	Sri. M.M. Borpuzari	**Director I/C.** ***(from 29/06/2014)***
Mulberry Division	Dr. S. R. Ramesh	Scientist-D
	Dr. A. Ananda Rao	Scientist-D
	Dr. K. Jhansilakshmi	Scientist-D
	Smt. P.Saraswathi	Scientist-C
	Dr. Mohan Ram Rao	Scientist-C
Silkworm Division	Sri.H.V.Vijaya Kumar	Scientist-D ***(upto 30.04.2013)***
	Dr. P. Somasundaram	Scientist-D
	Sri.R. Radhakrishnan	Scientist-C
	Smt. Anuradha H. Jingade	Scientist-C
	Dr. Veeranna Gowda	Scientist-C
	Sri N. Balachandran	Scientist-C
	Smt. M. Muthulakshmi	Scientist-C
	Dr. K. Ashok Kumar	Scientist-C
Post Cocoon Technology	Dr.S.Nivedita	Scientist-D
Informatics Division	S. Sekar	Assistant Director (Computer)
	P. Bharathi Vidya Shankar	Assistant Director (Statistics)
Administration	Narayan Bisarahalli	Assistant Director (Admin. & Accts.)

SUPERANNUATION

- Shri H.V. Vijaya Kumar, Scientist D, superannuated on 30.04.2013
- Dr. A. Manjula**,** Director, superannuated on 31.08.2013

19. MISCELLANEOUS EVENTS/ACTIVITIES

- Anti Terrorism day was observed on 21.05.2013. Dr. Manjula A, Director, administered the pledge in Hindi and English to the staff members.
- 67th Independence Day was celebrated on 15.08.2013 and the National Flag was hoisted in the Office campus.
- Sadhbhavna Diwas was observed at on 20.08.2013 and the Sadbhavana pledge was administered by Dr. A. Manjula, Director to all the employees of the unit.
- Vigilance awareness week was observed from 28.10.2013 to 2.11.2013 and the pledge was administered to the employees on 28.10.2013 by Shri M.M. Borpuzari, Scientist D.
- Communal harmony week was observed from 19.11.2013 to 25.11.2013. On this occasion the National integration pledge was administered to all the employees of this unit on 19.11.2013 by Shri M.M. Borpuzari, Scientist D
- Republic celebrations was held on 26.01.2014 and the National Flag was hoisted in the office campus.
- Silence was observed on 30.01.2014 for 2 minutes in the memory of those who gave their lives in the struggle for India's freedom.
- Hindi pakwada was conducted from 16th September 2013 to 30th September 2013.
- Hindi pakwada 2013 closing functions were organized on the 30th September 2013 and prizes were distributed to the winners/staffs of the CSB centres in Hosur.
- Hindi workshop for I quarter was organized on 15/06/2013. Smt. Sindhu Murali, Hindi teacher, was invited to deliver a lecture in Hindi for the benefit of staff members.
- Hindi workshop for II quarter was organized on 25/09/2013. Smt. V. Radha, Hindi teacher, was invited to deliver a lecture in Hindi for the benefit of staff members.
- Hindi workshop for III quarter was organized on 30/11/2013. Smt. V. Radha, Hindi teacher, was invited to deliver a lecture in Hindi for the benefit of staff members.
- Hindi workshop for IV quarter was organized on 12/03/2014. Smt. V.Radha, Hindi teacher, was invited to deliver a lecture in Hindi for the benefit of staff members.
- OLIC meetings were conducted on 29.6.2013, 18.9.2013, 28.12.2013 and 19.3.2014 under the chairmanship of the Director, CSGRC.
- Hindi documentary films were screened on 15.6.2013, 25.09.2013 &30.11.2013 as a part of Implementation of Hindi as an official language.
- Mr. H.V. Vijaya Kumar, Scientist D was accorded a farewell on his superannuation from CSB services on 30.04.2013
- Dr. A. Manjula**,** Director was accorded a farewell on her superannuation from CSB services on 31.08.2013.

20 .METEOROLOGICAL DATA

Month	Average temperature °C		Average Relative humidity %		Total rainfall (mm)	No.of rainy days	Avg.wind speed (km/hr)	Wind direction
	Min.	Max.	Min.	Max.				
April, 13	20.9	34.6	26.5	85.6	30.5	7	5.2	S
May, 13	21.2	33.2	36.6	86.7	140.0	10	7.3	WSW
June, 13	20.3	28.6	54.5	88.4	21.0	8	11.2	W
July, 13	20.0	28.0	56.1	89.1	28.5	11	11.4	W
August, 13	19.7	28.3	54.4	91.0	109.0	13	8.9	W
September, 13	19.6	28.0	58.5	93.6	117.5	17	7.6	W
October, 13	19.2	28.0	57.2	94.7	99.0	16	6.1	S-W
November, 13	17.0	27.4	49.6	96.7	36.0	8	7.3	ESE
December, 13	13.1	27.0	38.9	94.8	0.00	0	8.2	ESE
January, 14	12.5	27.01	36.3	89.1	0.00	0	6.7	S-E
February, 14	15.4	29.9	28.2	86.8	0.00	0	7.5	S-E
March, 14	16.2	32.0	23.9	83.3	3.0	3	8.8	S-E

Minimum temperature 8.4 °C in December	*Minimum relative humidity 11% in March*
Maximum temperature 37 °C in May	*Maximum relative humidity 99 % in October& November*

21. ADMINISTARTIVE AND FINANCIAL REPORT

a. Staff Position as on 31.03.2014

Category	Sanctioned	Filled	Vacant
Director	1	0	1 (Sci-D, I/C)
Scientific	14	14	0
Technical	8	7	1
Administrative	19	18	1
Supporting (Skilled workers)	39	39	--
Total	81	78	3

b. Abstract of receipts and expenditure statement for the year 2013-14

Fund Head	GIA received (Rs.)	Expenditure (Rs.)	Surrendered (Rs.)
Plan General	1,19,64,553	66,19,153	53,45,000
Plan Capital	53,67,623	39,44,670	14,22,953
Total (PL)	**17332176**	**10564223**	**6767953**
Non Plan (NP)	3,81,54,431	3,81,54,431	NIL
Total (PL+NP)	**5,54,86,607**	**4,87,18,654**	**67,67,953**