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वार्षिक प्रतिवेदन
ANNUAL REPORT
2024

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झाँसी 284003, उत्तर प्रदेश, भारत

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Contents

Preface

Agroforestry fosters environmentally sustainable production while delivering essential ecosystem services that support livelihoods and safeguard the environment. With a strong emphasis on conservation agriculture, it plays a crucial role in preserving natural resources across diverse agro-climatic regions. Additionally, agroforestry is the only viable approach to increasing the nation's forest cover. Amid challenges such as shrinking arable land, soil and water degradation, rising pollution, and the threats of global warming and climate change, agroforestry interventions offer sustainable solutions to meet the growing demand for food, fodder, fiber, firewood, and timber. Addressing these challenges requires innovative farming techniques. Since its establishment, CAFRI has been dedicated to tackling these issues through coordinated research efforts. The Institute had the country's largest germplasm collection of neem and other key agroforestry tree species, including Indian rosewood, cactus, Malabar neem, teak, karanj, leucena, chironji, ber, citrus, mango, aonla, bael, guava, pomegranate, and fig. This extensive collection provides valuable opportunities for exploratory research on superior germplasms.

The ICAR-Central Agroforestry Research Institute (CAFRI), Jhansi, has been designated as the National Nodal Agency for Agroforestry under the Rashtriya Krishi Vikas Yojana (RKVY), as per the Ministry of Agriculture & Farmers' Welfare's notification. This prestigious designation underscores CAFRI's pivotal role in advancing the agroforestry sector by providing technical support, capacity building related to Quality Planting Material (QPM) activities. The institute has developed the Agroforestry Accreditation Protocol for Agroforestry Nurseries to ensure quality and standardization in agroforestry nurseries. This framework aims to promote transparency, reliability, and quality in the production of planting material. The protocol is a cornerstone for strengthening India's agroforestry adoption and practice by ensuring the availability of QPM for various agroforestry species.

ICAR-CAFRI has conducted Trainer of Trainers (ToT) programs in collaboration with state nodal agencies. These programs have been implemented in 12 states and over 300 individuals have been trained. The National Nursery Assessment and Accreditation Committee (NNAAC), established under the provisions of the Agroforestry Accreditation Protocol, was notified by the Ministry of Agriculture & Farmers' Welfare. Till now 197 agroforestry nurseries have been accredited, ensuring their compliance with the stringent quality standards laid down in the accreditation protocol.

The institute is increasingly prioritizing the strengthening of community resilience by diversifying cropping systems through agroforestry interventions in Central India. To increase the tree cover, the Institute has established Rashi Vatika, Nakshatra Vatika, and Navgarh Vatika. Besides these the institute has launched different programs like One Month One District (OM-OD), One Month One Lab (OM-OL), One Tree One Citizen (OT-OC), AMMA (Agroforestry for Mitigating Malnutrition and Adaptation), and PAPA (Promoting Agroforestry for Plantation in Agricultural-Lands) for promotion the promoting the religious, multipurpose, medicinally and economically important tree crops which will be a solution for futuristic agriculture benefitting farmers and other stakeholders. The institute is implementing various externally funded projects with financial support from agencies such as the National Afforestation & Eco-Development Board (NAEB), TOFI, NMSHE, ICRISAT, ICAR-ICRAF, RKVY-MOAFW, ICAR-NCIPM, and NABARD. These projects primarily aim to enhance community resilience by diversifying cropping systems through agroforestry interventions in Central India.

The institute successfully signed a MoU in the year 2024 with different institutes like TEO Ventures Private Limited, The Genomics Foundation, New Delhi, Walnut and Other Nut Fruit Growers Association of India (WANGAI), World Resources Institute India (WRI), and Kalasalingam Academy for Research and Education (KARE) for research and development works related to agroforestry.

The Annual Report provides a comprehensive overview of the Institute's activities, including executive summaries, key research achievements, significant meetings and observances, awards received by scientists and staff, research publications, and participation in training programs, workshops, webinars, meetings, and symposia. It also details the progress of externally funded projects, inter-institutional collaborations, and SCSP schemes. To promote agroforestry innovations and facilitate their rapid adoption, the Institute organized various farmer-centric events, including seminars, training programs, field days, and exhibitions.

I extend my sincere gratitude to Dr. Himanshu Pathak, Hon'ble Secretary, DARE, and Director General, ICAR, New Delhi, for his unwavering support and encouragement. I am also deeply appreciative of Dr. S. K. Chaudhari, Deputy Director General (NRM), ICAR, New Delhi, for his continuous guidance and motivation. My heartfelt thanks go to Dr. Rabir Singh, ADG (A, AF&CC), and the entire NRM Division team for their invaluable assistance. Additionally, I acknowledge my predecessors for their contributions in advancing institutional activities. Lastly, I commend the PME Cell and the editorial team for their dedication and effort in ensuring the timely preparation and release of this report.

(A. Arunachalam)
Director, ICAR-CAFRI &
Project Coordinator, AICRP (Agroforestry)

कार्यकारी सारांश

भा.कृ.अनु.प.–केन्द्रीय कृषिवानिकी अनुसंधान संस्थान को भारतीय कृषि अनुसंधान परिषद की इकाई के रूप में वर्ष 1988 के दौरान झाँसी में स्थापित किया गया। संस्थान द्वारा पिछले 36 वर्षों में विभिन्न कार्यक्रम के अन्तर्गत अनुसंधान कार्य किये जा रहे है। संस्थान में किये जा रहे अनुसंधान का कार्यकारी सारांश निम्नलिखित हैः

सरंक्षित कृषिवानिकी का मूल्यांकन करने वाली परियोजना, जो 2021 में शुरू की गई थीए का उद्देश्य तीन कृषि वानिकी प्रणालियों सागौन–आधारित, बेल–आधारित और सागौऩ बेल–आधारित में संरक्षण कृषि प्रथाओं के प्रदर्शन का मूल्यांकन करना था। पारंपरिक और न्यूनतम जुताई के तहत फसल उपज लगभग समान रही। फसल अवशेष से अलसी और चने की उपज में उल्लेखनीय वृद्धि हुई। फसल अवशेष मृदा सतह पर रखने के कारण मिट्टी में जैविक कार्बन में बिना फसल अवशेष की तुलना में 20–37% की वृद्धि हुई। न्यूनतम जुताई और फसल अवशेष के साथ पोषक तत्वों (नाइट्रोजन, फास्फोरस, पोटेशियम, सल्फर, जिंक, आयरन, मैंगनीज, कॉपर) की उपलब्धता में सुधार हुआ। PCA बाइप्लॉट विश्लेषण ने भी पुष्टि की कि न्यूनतम जुताई के साथ फसल अवशेष ने मिट्टी के जैविक कार्बन और पोषक तत्वों की उपलब्धता में सुधार किया।

प्रायोगिक कृषि वानिकी प्रणालियों (सागौन + फसल, मेलिया + फसल, बेर + फसल, आंवला + फसल) के साथ–साथ कृषि (एकल) फसल प्रणाली पर 'प्रमुख कृषि वानिकी आधारित भूमि उपयोग प्रणालियों में मिट्टी के जैविक और जैव रासायनिक लक्षणों का आंकलन' परियोजना में, मिट्टी के विश्लेषण से पता चला है कि ऊष्मायन के बढ़ते दिन (0–60 दिन) के साथ कार्बनिक नाइट्रोजन का खनिजकरण बढ़ा है। इसके विपरीत, खनिज होने से पहले एक शुद्ध फास्फोरस स्थिरीकरण था, जो ऊष्मायन के 30 से 60 दिनों के बीच शुरू हुआ। कार्बनिक नाइट्रोजन और फास्फोरस का खनिजकरण सतह पर उपसतह मिट्टी की तुलना में और राइजोस्फीयर मिट्टी में अंतर–फसल वाली मिट्टी की तुलना में अधिक था। संचयी नाइट्रोजन खनिजकरण राइजोस्फीयर मिट्टी की तुलना में अंतर–फसल वाली मिट्टी में अधिक था और कृषि (एकल) फसल प्रणाली में अधिक था। आंवला और सागौन आधारित कृषि वानिकी ने अंतरफसल और वृक्ष प्रकंद तथा क्षेत्र दोनों में फास्फोरस खनिजीकरण क्षमता अधिक दिखाईए जबकि कृषि (एकल) फसल प्रणाली में यह क्षमता सबसे कम रही।

मध्य प्रदेश और उत्तर प्रदेश के विभिन्न बुंदेलखंड जिलों से विभिन्न रूपत्मक वि ैषताओं वाले तीस सहजन (*मोरिंगा ओलीफेरा*) जर्मप्लाज्म एकत्र किए गए हैं और उन्हें संस्थान के अनुसंधान फार्म में फील्ड जीन बैंक के रूप में संरक्षित किया गया है और आईसीएआर–एनबीपीजीआरए नई दिल्ली के साथ आईसी नंबरों के लिए पंजीकृत किया जा रहा है। लंबे समय तक या साल भर फूलने और फलने के व्यवहार सहित बेहतर गुणों के लिए उपयुक्त जर्मप्लाज्म की पहचान की गई है। आणविक स्तर पर वास्तविक भिन्नता को समझने के लिए भौतिक–रासायनिक और आणविक लक्षण वर्णन की प्रक्रिया चल रही है। पलाश (*ब्यूटिया मोनोस्पर्मा*) एक आध्यात्मिक और औषधीय रूप से महत्वपूर्ण बारहमासी वृक्ष प्रजाति है, लेकिन बढ़ती मांग को पूरा करने के लिए रोग मुक्त और आनुवंशिक रूप से समरूप गुणवत्ता वाले रोपण सामग्री को विकसित करने के लिए प्रभावी इन–विट्रो पुनर्जनन प्रोटोकॉल का अभाव है। इस संबंध में, मुराशिगे और स्कोग (एमएस) और वुडी प्लांट मीडिया (डब्ल्यूपीएम) मीडिया का उपयोग करके एक प्रभावी और तेज प्रत्यक्ष इन–विट्रो ऑर्गेनोजेनेसिस प्रोटोकॉल विकसित किया जा रहा हैए जिसमें प्लांट ग्रोथ रेगुलेटर (पीजीआर) की विभिन्न सांद्रता शामिल है। छाया–तनाव कृषि वानिकी प्रणाली का एक पूरक उपहार हैए हालांकि यह वृद्धि और विकास में बाधा उत्पन्न करके अंतर्निहित फसलों को प्रभावित करता है और काफी उपज हानि का कार.ा बनता है। उम्मीदवार अ.ुओंए जीन और आणविक तंत्रों को समझने और बेहतर कृषि वानिकी प्रणाली के लिए छाया–तनाव सहनशील प्रजनन के लिए एक प्रभावी रणनीति विकसित करने के लिए विभिन्न छाया–तनाव व्यवस्थाओं के तहत मूंग की फसल में संपूर्ण ट्रांसक्रिप्टोमिक्स और मेटाबोलोमिक अध्ययन किए जा रहे हैं।

कृषिवानिकी प्रणालियों में मृदा गुणों पर पौधो की रूपत्मक विशेषताओं का प्रभाव परियोजना के अन्तर्गत, अध्ययन किये गये सभी कृषिवानिकी प्रणालियों की मृदा प्रोफाइल (0–100 सेमी) में, शुद्ध कृषि क्षेत्र की तुलना में अधिक मृदा जैविक कार्बन (एस.ओ.सी.) पाया गयाए जिसमें *एच. बिनाटा* (113.6 मेगा ग्राम प्रति हेक्टेयर) में अधिकतम और शुद्ध कृषि क्षेत्र में न्यूनतम (37.1 मेगा ग्राम प्रति हेक्टेयर) रहा। मृदा की ऊपरी परत (0–15 सेमी) में *एजाडिरेक्टा इंडिका* ने अधिकतम और *एच. बिनाटा* ने सबसे कम मृदा जैविक कार्बन एकत्रित किया। सामान्य तौर पर, मृदा प्रोफाइल के कुल मृदा जैविक कार्बन का 40.1%, ऊपरी दो परतों (0–15 और 16–30 सेमी) में जबकि सबसे निचली परत (90–100 सेमी) में केवल 6.3% हिस्सा पाया गया। मिट्टी की गहराई और पेड़ की प्रजातियों के साथ, मृदा में मृदा जैविक कार्बन अंश, अर्थात बहुत अस्थिर, अस्थिर, कम अस्थिर और गैर–अस्थिर भिन्न–भिन्न पाये जाते हैं। सामान्य तौर पर, शुद्ध कृषि क्षेत्र सहित सभी अध्ययन किए गए कृषिवानिकी प्रणालियों में मृदा जैविक कार्बन का गैर–अस्थिर अंश अधिकतम प्राप्त हुआ। कुछ अपवादों को छोड़कर सभी कार्बन अंश मिट्टी की गहराई के साथ कम होते गए।

सिल्वीपास्टोरल परियोजना में पारिस्थितिकी तंत्र सेवाओं के मूल्यांकन में, प्रमुख पारिस्थितिकी तंत्र सेवाओं जैसे प्रावधानी और विनियमित सेवाओं का मूल्यांकन किया गया। सागौन ने मजबूत सहनशीलता और अनुकूल वृद्धि दिखाई, जबकि महोगनी को कीट संक्रमण और नीलगाय से नुकसान हुआ। विभिन्न उपचारों के बीच सागौन + महोगनी + चरागाह के साथ–साथ समोच्च खाइयों के संयोजन ने उच्चतम बायोमास उत्पादकता और मिट्टी की नमी की मात्रा प्रदर्शित की। समवर्ती रूप से इस कॉन्फ़िगरेशन ने अपवाह मिट्टी के कटाव और पोषक तत्वों की हानि को काफी हद तक कम कर दिया जिससे उच्चतम तलछट फंसाने की दक्षता बढ़ गई। इसके विपरीत केवल महोगनी ने उच्च अपवाह और मिट्टी के कटाव का प्रदर्शन किया। पेड़ों, घासों और संरक्षण उपायों के संयोजन वाले उपचारों में मिट्टी के जैविक गुणों में सुधार देखा गया।

बुन्देलखण्ड के चिन्हित गाँवों से डेटा संग्रह किया गया। प्रारंभिक केंद्रित समूह चर्चा से यह पता चला है कि कृषि वानिकी को अपनाने में प्रमुख बाधा आवारा जानवर (21.75%) हैं। अन्य चिन्हित ग्रामों से डेटा सारणीकरण एवं प्रविष्टि का कार्य प्रगति पर है।

भारतीय कृषि अनुसंधान एवं ि[ा परिषद द्वारा पोषित प्राकृतिक गोंद एवं रॉल (एन.आर.जी.) के संग्रहण, प्रसंस्करण और मूल्य संवर्धन पर नेटवर्क परियोजना के अन्तर्गत केन्द्रीय कृषिवानिकी अनुसंधान संस्थान (सी.ए.एफ.आर.आई.) झाँसी केंद्र को दो उप–परियोजनाओं को मंजूरी दी गई है, अर्थात 1) भारत में एन.आर.जी. की कटाई, प्रसंस्करण और मूल्य संवर्धन पर स्वदेशी तकनीकी ज्ञान (आई.टी.के.) का दस्तावेजीकरण और 2) एन.आर.जी. पौधों को आर्थिक रूप से व्यवहार्य कृषिवानिकी मॉडल में शामिल करने की व्यवहार्यता। वर्ष 2024 के दौरान, मध्य प्रदेश के निवाड़ी जिले में स्वदेशी तकनीकी ज्ञान के लिए सर्वेक्षण किया गया। निवाड़ी जिले में आदिवासियों द्वारा एकत्र किए जाने वाले मुख्य गोंद और रॉल *अकेषिया कैटेचू* (खैर गोंद), *ब्यूटिया मोनोस्पर्मा* (पलास गोंद), *स्टर्कुलिया यूरेन्स* (कराया गोंद) हैं। आदिवासियों द्वारा एकत्रित गोंद को स्थानीय बाजार में सफाई के अलावा बिना किसी कटाई पश्चात प्रसंस्करण के बेंच दिया जाता है। ऊँचे और कांटेदार पेड़ों से गोंद निकालने के लिए सी.ए.एफ. आर.आई., झाँसी द्वारा विकसित एक गोंद टैपिंग टूल– सी.ए.एफ. आर.आई.–थॉर्नी ट्री गम एमेसर का परीक्षण गर्मियों के मौसम में *ए. निलोटिका* (बबूल) पर किया गया। इसके उपयोग द्वारा एक मजदूर ने 10 मिनट में 15 गम टियर (65–0 ग्राम) गोंद एकत्र किए। इससे मजदूर की कार्यकुशलता बढ़ी और साथ ही पेड़ पर चढ़कर गोंद को हाथ से निकालने की तुलना में एकत्र किए गए कुल गम की मात्रा भी बढ़ गई। गोंद देने वाले पेड़ों पर आधारित कृषिवानिकी मॉडल अर्थात कुमट आधारित बहुघटकीय कृषि–बागवानी–वानिकी, *ए. निलोटिका* (बबूल) और *ए. सेनेगल* (कुमट) के साथ वर्षा आधारित कृषि–वानिकी, वन–हर्बल, कुमट आधारित जैव–बाड़ एवं गोंद के बगीचे की देख–रेख की गई और आर्थिक व्यवहार्यता के लिए पेड़ों की वृद्धि, गोंद की उपज और अंतः–फसल उत्पादन के आंकड़ें एकत्र किए गए। कृषिवानिकी मॉडल की निगरानी करने और कृषिवानिकी में गोंद उपज देने वाले पेड़ों को अपनाने के लिए किसानों को प्रेरित करने के लिए गांवों का भ्रमण भी किया गया तथा नर्सरी में उगाए गए कुमट के लगभग 500 पौधे किसानों को वितरित किये गये।

बुन्देलखंड में गम टेपिंग के लिए कृषिवानिकी पेड़ों पर आई.आई.एन. आर.जी.– गम टैपिंग ब्लेजर–75 और ब्लेजर– 150 के उपयोग की व्यवहार्यता का आंकलन के लिये एक परीक्षण किया गया। प्रारम्भिक परिणामों से पता चला कि ब्लेजर–75 द्वारा किये गये चीरे/कट से केवल *बी. मोनोस्पर्मा* (पलाश) (2–0 ग्राम/कट) और *ए. लैटिफोलिया* (1–0 ग्राम/कटा) में बहुत कम गोंद का रिसाव हुआ तथा अन्य प्रजातियों जैसे *ए. पेंडुला, ए. निलोटिका* और *ए. सेनेगल* में गोंद का रिसाव नहीं देखा गया। आई.आई.एन.आर.जी.– गम टैपिंग ब्लेजर–150 का परीक्षण *ए. लैटिफोलिया* (गम–धावरा) पर किया गया और परिणाम उत्साहजनक नहीं रहा क्योंकि ब्लेजर–150 से किये गये चीरे/कट से गोंद का रिसाव नहीं देखा गया। पलाश में गोंद स्राव के माहवार और मौसमी विभिन्नता का आंकलन करने के लिए किए गए परीक्षण के परिणामों से पता चला कि गोंद का स्राव और उसकी उपज वर्ष के विभिन्न महीनों और मौसमों में महत्वपूर्ण रूप से काफी भिन्न–भिन्न होती है। दिसंबर से जून तक गोंद की उपज में क्रमशः गिरावट आती है और जुलाई, अगस्त और सितंबर के महीने में यह न्यूनतम स्तर पर पहुंच जाती है। अधिकतम संभावित कुल गोंद उपज (613–5 ग्राम/पेड़) सर्दियों के मौसम (नवंबर से फरवरी) में दर्ज की गई, उसके बाद गर्मियों (मार्च से जून) (223–4 ग्राम/पेड़) और न्यूनतम (38–9 ग्राम/पेड़) बरसात या मानसून के मौसम (जुलाई से अक्टूबर) में दर्ज की गई। बारिश में वृद्धि के साथ गोंद की उपज में तेजी से गिरावट (R^2 0–851) दर्ज की गई। निष्कर्ष रूप से, ब्यूटिया के पेड़ों से अधिकतम गोंद उपज प्राप्त करने के लिए सर्दियों के मौसम में दिसंबर और जनवरी का महीना सबसे अच्छा समय है।

परियोजना ने कृषि वानिकी में वास्तविक समय में वृक्षों की निगरानी, वृक्ष स्वास्थ्य ट्रैकिंग को बढ़ाने, विकास डेटा अपडेट और एसएएमएस पोर्टल के माध्यम से जोखिम अलर्ट के लिए आरएफआईडी चिप प्रौद्योगिकी को सफलतापूर्वक मान्य किया। प्रणाली लागत बचतए बेहतर डेटा सटीकता प्रदान करती है और संरक्षण प्रयासों का समर्थन करती है। एआईए आईओटी और ड्रोन के साथ भविष्य की खोज वानिकी प्रबंधन पर इसके प्रभाव को और अधिक अनुकूलित कर सकती है।

यह अध्ययन जीनोटाइपिंग–बाय–सीक्वेंसिंग (जीबीएस) का उपयोग करके 16 नीम (*अजादिराक्टा इंडिका*) परिग्रहण में आणविक लक्षण वर्णन और एसएनपी पहचान पर केंद्रित है। दो आबादी – पश्चिम–मध्य (डब्ल्यूसी) और दक्षिण–पूर्वी (एसई) – का विश्लेषण साइटोक्रोम पी450 (सीवाईपी), टेरपीन सिंथेज (टीपीएस21)ए जीजीपीए एफडीपीएसए एसक्यूएलई और एआईजीडी सहित एजाडिरेक्टिन बायोसिंथेसिस मार्ग से जुड़े जीन में भिन्नता के लिए किया गया। मैपिंग प्रतिशत 27.25% से 84.52% तक थाए डब्ल्यूसी आबादी में एसई आबादी की तुलना में एसएनपी और इंडेल्स की अधिक संख्या प्रदर्शित हुई। विश्लेषण में गुणसूत्र– वार एसएनपी वितरण प्रदान किया गया है।

Executive Summary

The executive summary of the research and development activities carried out at ICAR-Central Agroforestry Research Institute during 2024 is presented here:

The project on the assessment of conservation agroforestry, initiated in 2021, aimed to evaluate the performance of conservation agriculture practices in three agroforestry systems-Teak-based, Bael-based, and Teak+Bael-based agroforestry system. Crop yields under conventional and minimum tillage were comparable. Residue retention significantly improved yields of linseed and chickpea. Residue retention increased soil organic carbon by 20–37% compared to no retention. Nutrient availability (N, P, K, S, Zn, Fe, Mn, Cu) improved with minimum tillage and residue retention. PCA biplot analysis confirmed that residue application combined with minimum tillage improved soil organic carbon and nutrient availability, particularly in sorghum-chickpea and maize-linseed systems.

In 'Assessment of soil biological and biochemical characters in predominant agroforestry-based land use systems' project on the experimental agroforestry systems (Teak + cropping, Melia + cropping, Ber + cropping, Amla + cropping) along with an agricultural (sole) cropping system, soil analysis revealed that mineralization of organic nitrogen increased with the increasing day of incubation (0-60 day). In contrast, there was a net phosphorus immobilization before it gets mineralized, which started between 30 and 60 days of incubation. Mineralization of organic nitrogen and phosphorus was higher at surface than subsurface soil and at the rhizosphere soil than at the inter-cropped soil. Cumulative nitrogen mineralization was higher in inter-cropped soil over rhizosphere soil and was higher in agricultural (sole) cropping system. Amla and teak based agroforestry showed higher phosphorus mineralization capacity both in the intercropped and tree rhizosphere and zone, while agricultural (sole) cropping system showed the least.

Thirty *Moringa oleifera* germplasm with varied morphological characteristics have been collected from different Bundelkhand districts of Madhya Pradesh and Uttar Pradesh and are preserved as field gene bank at research farm of the institute and are being registered with ICAR-NBPGR, New Delhi, for IC numbers. Suitable germplasms have been identified for superior qualities including prolonged or year-round flowering and fruiting behaviors. Physio-chemical and molecular characterizations are in the process to understand the actual variation at molecular level. Palash (*Butea monosperma*) being a spiritual and medicinally important perennial tree species lacks effective in-vitro regeneration protocol for developing the disease-free and genetically homogenous quality planting material to meet the growing demand. In this regard, an effective and rapid direct in-vitro organogenesis protocol is being developed using Murashige and Skoog (MS) and woody plant media (WPM) media supplemented with different concentrations of plant growth regulators (PGRs). Shade-stress is a complementary gift of an agroforestry system, though it affects the underlying crops by hampering the growth and development and leading to a considerable yield loss. The whole transcriptomics and metabolomic studies are being carried out in the green gram crop under different shade-stress regimes to understand the candidate molecules, genes and molecular mechanisms and developing an effective strategy for shade-stress tolerance breeding for a better agroforestry system.

In comparison to pure agriculture field all the agroforestry systems recorded more total SOC in soil profile (0-100cm) with maximum in *H. binata* (113.6 Mg ha^{-1}) and the minimum (37.1 Mg ha^{-1}) in pure agri field. In surface layer (0-15cm) *Azadirachta indica* accumulated maximum SOC and *H. binata* the least. In general, upper two layers (0-15 and 16-30cm) shared 40.1% of the total SOC of the profile while lowest layer (90-100cm) only 6.3%. Different SOC fractions *viz.* very labile, labile, less labile and non-labile varied with the soil depths and the tree species. In general, the non-labile fraction of SOC was maximum in all the studied agroforestry systems including pure agriculture field. All the carbon fractions declined with the depth in the soil profile with few exceptions.

Dynamics of ecophysiological responses with respect to potentials of CO_2 assimilation and chlorophyll content index (CCI) of *Pongamia pinnata* tree populations have been observed. Distinct differential responses in the contrasting tree populations have been noted in relation to various physio-biochemical attributes.

A pioneering project initiated in 2021 aimed to assess ecosystem services in silvipastoral systems. Teak exhibited strong resilience and favorable growth. Mahogany faced challenges with lower survival due to insect infestations and damage from blue cows. The highest biomass production was recorded in treatment T7 (Teak + Mahogany + Pasture + CST), followed by T5 (Teak + Mahogany + Pasture + HMB). The lowest biomass production occurred in T2 (Sole Teak). Soil moisture content was highest in treatments with conservation measures, particularly T7, and lowest in sole mahogany plots. Runoff analysis revealed the lowest runoff in T7 and highest in sole mahogany plots. T7 showed superior soil and nutrient retention, with CST demonstrating the highest sediment trapping efficiency. Sole teak and mahogany plots

exhibited higher soil and nutrient losses. Treatments combining trees, grasses, and conservation measures exhibited enhanced soil biological properties.

Data collection were made from Bundelkhand villages. From preliminary focused group discussion, it is revealed that the major constraint in adoption of agroforestry is stray animals (21.75%). The data tabulation and entry is under the progress from other identified villages.

The research experiment conducted using two tillage practices and five nitrogen management options showed nitrogen management significantly influenced wheat crop performance, but tillage practices remained statistically at par. The application of 100% RDN resulted in higher plant height, tiller number, spike length, grain per spike, thousand-grain weight and grain, straw, and biological yields. Among treatment combinations, 100% RDN and conventional tillage resulted in higher growth, yield attributes, and yields of wheat.

For the ICAR-CAFRI Jhansi centre of the NP-HPVANRG, two sub projects are approved *viz.* i) Documentation of Indigenous technical knowledge (ITKs) on harvesting, processing and value addition of NRG"s in India and ii) Feasibility for inclusion of NRG plants into economically viable agroforestry models. During the year, Niwari district of M.P. was surveyed for ITK. The main gums and resins collected by tribal in Niwari include *Acacia catechu* (khair gum) *Butea monosperma* (palas gum) *Sterculia urens* (karaya gum). During interactions gum tappers informed that they do not adopt any post-harvest value addition processes except cleaning of the gums tears. A gum tapping tool- *CAFRI-Thorny Tree Gum Amasser,* developed to tap gum from thorny trees, was tested on *A. nilotica* during summer season. It is easy to use and a laborer collected 15 gum tears (65.0 g) in 10 minute. It increased efficiency of laborer and also increased quantity of total gum collected in comparison to tapping gum manually by climbing on the tree. The agroforestry models *viz. Acacia senegal* based multi-component agri-hort-silviculture, *A. nilotica* and *A. senegal* based rainfed agri-silviculture & silvi-herbal, and *A. senegal* based bio-fence & gum gardens were monitored for tree-growth, gum yield and yield from intercrops. Also the visits were conducted to villages to monitors agroforestry models on farmland and motivate farmers for adopting gum-yielding trees in agroforestry. About 500 seedlings of *A. senegal* raised in nursery were supplied to farmers.

Trials were conducted to assess feasibility of using IINRG-gum tapping Blazer-75 and Blazer- 150 on agroforestry trees. The findings revealed that use of Blazer-75 yielded negligible gum only in *B. monosperma* (2.0 g/cut) and *A. latifolia* (1.0 g/ cut) and in other species such as *A. pendula, A. nilotica* and *A. senegal* no gummosis was noticed. The BLAZER-150 was tested on *A. latifolia* (Gum-dhawara) and the results are not encouraging as cut made with blazer-150 did not exude/yield gum. The trial for assessing month-wise and seasonal variability in gum exudation in Palash (*Butea monosperma)* was concluded. The results revealed that gum exudation and its yield varies significantly in different months and seasons of the year. From December to June the gum yield declines reaching to the minimal in the month of July, August and September. The maximum potential total gum yield (613.5g/tree) was recorded in winter season (November to February) followed by summer (March to June) (223.4g/tree) and minimum (38.9g/tree) in rainy or monsoon season (July to October). The gum yield exponentially declined (R^2 0.851) with the increase in rainfall. Conclusively, the months of December and January of winter season are the best time to tap butea trees for maximum gum yield.

The project successfully validated RFID chip technology for real-time tree monitoring in agroforestry, enhancing tree health tracking, growth data updates, and risk alerts via the SAMS portal. The system offers cost savings, improved data accuracy, and supports conservation efforts. Future exploration with AI, IoT, and drones could further optimize its impact on forestry management.

This study focused on the molecular characterization and SNP identification in 16 neem (*Azadirachta indica*) accessions using genotyping-by-sequencing (GBS). Two populations-west-central (WC) and south-eastern (SE)-were analyzed for variations in genes associated with the azadirachtin biosynthesis pathway, including cytochrome P450 (CYP), terpene synthase (TPS21), GGPs, FDPS, SQLE, and AiGDs. The mapping percentage ranged from 27.25% to 84.52%, with the WC population exhibiting a higher number of SNPs and indels than the SE population. Chromosome-wise SNP distribution is provided in the analysis.

The National Agricultural Science Fund (NASF) funded project entitled "Comparative study on carbon dynamics and functional rhizosphere microbial biomass of agroforestry systems in dry- and wet-tropical climatic situations" has been implemented at ICAR-Central Agroforestry Research Institute, Jhansi being a Lead Institute located in dry-tropical location with the following three objectives - 1) To study the carbon dynamics of selected agroforestry systems in the dry- and wet-tropical climatic locations 2) To characterize the soil microbial population and biomass contributing to carbon dynamics 3) To study the comparative carbon sequestration potential of the selected agroforestry systems in relation to the microbial components. Baseline data and soil samples have been analysed from the experimental fields before initiating the experiments in *kharif* season for baseline information from selected agroforestry systems (teak and aonla based) and sole crop. Experiments have been conducted taking blackgram (*Vigna mungo*) as understory crop. Sample collection from post-*kharif* (after harvest) phase has been done and various analysis are progressing. The project has also been implemented by the Co-operating Centre *i.e.* School of Environment and Natural Resources, Doon University, Dehradun, Uttarakhand.

1. General

Climate change accompanied by land degradation on account of unabated forest destruction worldwide is a serious threat to the very sustenance of mankind. Increasing population pressure and its associated demands limit expansion of forests which is already insufficient for a healthy ecosystem. These warrants land use change on a wider scale. The problem can be addressed through agroforestry which has proven potential of climate moderation, halting land degradation and increasing biomass production per unit area and time without demanding additional land. Agroforestry land use is the only viable option to avert degradation and bring back the agricultural economy in harmony with nature. In India, research and development programmes on promoting agroforestry over the past five decades have been spread over time and regions but, the speedy transition of tree-based farming in the country is still a challenge. This calls for organized efforts in setting priorities and strategies for the promotion of tree-based farming system through agroforestry research and extension services in India.

ICAR-Central Agroforestry Research Institute (ICAR-CAFRI), formerly the National Research Centre on Agroforestry, located at Jhansi, has successfully served the country for 36 years achieving several milestones in integrating trees, crops and livestock on the same farmland.

The institute in its national agroforestry mandate has conducted basic, strategic, adaptive research to systematize the science of agroforestry and has developed robust agroforestry models for different agro-climatic regions across the country, and handholds different states in the country for implementation of the objectives of agroforestry policy through skilling and human resource development programme.

VISION

To improve the quality of life of rural people through integration of perennials crops on agricultural landscape for economic, environmental and social benefits.

MISSION

Integration of woody perennials in the farming systems to improve land productivity through conservation of soils, nutrients and biodiversity to augment natural resource conservation, restoration of ecological balance, alleviation of poverty and to mitigate risks of weather vagaries.

MANDATE

- Develop sustainable agroforestry practices for farms, marginal land and wastelands in different agroclimatic zones of India.
- Coordinate network research for identifying agroforestry technologies for inter-region.
- Training in agroforestry research for ecosystem analysis.
- Transfer of agroforestry technology in various agroclimatic zones.

INFRASTRUCTURE FACILITIES

Laboratories

ICAR-CAFRI has a main office building with eight well equipped laboratories (Agroforestry; Agronomy; Horticulture, Plant Protection; Plant Physiology; Remote Sensing & GIS, Soil Analytical; and Tissue Culture & Biotechnology).

Library

Library is an integral part of the institute. The institute's library is well furnished and equipped with LAN facilities. Library operations are automated using Koha Library Management Software. List of library holdings are as under:

Holding	Total Collection (Numbers)
Books (including Hindi books)	4652
Periodical subscribed (Indian)	12
Bound back volumes of research journals	2487
Dissertation -M.Sc.	125
Thesis-Ph.D.	29
CD- ROM (Forest Science Database, ICAR, ICFRE)	135
Maps	251
News Paper	07

On request references were supplied to the researchers on individual basis as well as through **CERA (Consortium for E-Resources in Agriculture)** servers through e-mail as well as hard copies.

Library Services:

Borrowing Facility

Reference Service

Inter Library Loan

Agriculture Knowledge Management Unit

ICAR-CAFRI has 100 Mbps Leased Line Internet Connectivity from National Knowledge Network, Lucknow. Web server-based Ubuntu LINUX has been installed for hosting the Institute's website (https://www.cafri.icar.gov.in). The entire network administration of computers, internet and website management is looked after by the Agriculture Knowledge Management Unit (AKMU).

Facilities at Research Farm

The Institute Research Farm spreads over 178.029 acres, possessing dug well (06), submersible (07), jet pump (01), and farm Pond (04). General crop cultivation and agroforestry experiments occupy about 85% of it's total area. Crop cultivation at research farm is totally dependent on rainfall and the operation of the canal for the *kharif* and *rabi* seasons, respectively. The details of crop production and revenue generated in 2024-25 are given as follows:

***Kharif*-2024**			
Crop and variety	**Sown area (ha)**		
	Experimental	**General**	**Total**
Sorghum Hybrid	1.65	-	1.65
Maize Hybrid	1.65	-	1.65
Paddy-pusa basmati-1121	0.50	-	0.50
Black gram Azad-2	2.25	-	2.25
Moong	-	2.90	2.90
Dhaincha	3.10	-	3.10
Pearl millet (Bajra)	-	0.80	0.80
Total	9.15	3.70	12.85

Revenue generated from farm produce	
Name of the product	**Revenue (Rs.)**
Aonla	70,000/-
Guava	25,599/-
Bael	25,000/-
Ber	7,000/-
Moringa pods	500/-
Total	**1, 28, 099/-**

During the *Rabi* season 2024-25, about 14.70 ha of area was utilized for the cultivation of different crops. The details are given below:

Crop and variety	**Sown area (ha)**		
	Experimental	**General**	**Total**
Wheat (HD2932)	1.70	-	1.70
Barley (DWRB137/Jai-393)	1.50	1.20	2.70
Gram (Jaki 9218/ IPC 2006-77)	2.35	0.20	2.55
Mustard (Giriraj)	2.75	2.60	5.35
Linseed	1.20	-	1.20
Taramira	1.20	-	1.20
Total	**10.70**	**4.00**	**14.70**

The farm section generated revenue to the tune of Rs. 8.61 lakhs from the sale of grains, fruits, straw, saplings, goatery, fishery, and poultry during the period. The farm section also maintains the most improved farm machinery and implements for mechanized farming operations. Moreover, there is a mini workshop equipped with welding

and drill machines, an air compressor, a grinder, and other tools that are used for repairing and maintaining available farm machinery.

Others

The institute has computer laboratory, committee room, conference hall, canteen, sports complex and agroforestry technology information centre (ATIC) and well-furnished Farmers' Training Hostel.

MIS/FMS

Five management modules *viz.,* financial, project (project and scheme code generation), stores (indent creation), human resource (training information, applying leaves) and payroll (information related to transfer and joining of employees) have been supported through MIS/ FMS.

Research and Academic

The institute conducts M.Sc. and Ph.D. courses as well as research in Agroforestry, Horticulture, Environmental Sciences, Plant Protection, Soil Science, Biotechnology and Soil & Water Conservation from different recognized Universities. During 2024, the institute signed MoUs with following institutions for achieving excellence in teaching & research.

Sr. No.	Name of the party/ Institute entered MoU with ICAR-CAFRI	Date of Signing MoU
Universities		
1.	Chandra Shekhar Azad University of Agriculture & Technology, Kanpur	03-Apr-24
2.	Kalasalingam Academy of Research and Education (Deemed to be University), Krishnankoil, Tamil Nadu	06-Aug-24
3.	Deen Dayal Upadhyaya Gorakhpur University, Uttar Pradesh	12-Nov-24
Others		
1.	The Genomics Foundation (TGF), New Delhi	01-Jan-24
2.	India Resources Trust, New Delhi	20-Feb-24
3.	Teo Ventures Private Limited	08-May-24
4.	Global Green Growth Co, Bengaluru, India	15-Aug-24
5.	Chaturveda Plantech Pvt Ltd, Hyderabad	22-Nov-24

Agricultural Technology Information Centre (ATIC)

The National Agricultural Research System has generated a number of agricultural technologies for the benefit of the farmers. But, the farmers are not able to use these technologies due to lack of access to the information. To bridge this gap of information, Agricultural Technology Information Centers (ATIC) have been established in the country. ATIC of ICAR-CAFRI, Jhansi was established on 24th September, 2017 as a **'single window'** delivery system for the benefit of the farming community. ATIC provides farm advisory services and facilitates information-based decision making among farmers.

Mandate of ATIC:

To empower farmers through direct access to information and knowledge. To create strong linkage between researchers and technology users. To help farmers and other stakeholders in problem solving and decision making.

Objectives:

The objectives for establishing ATIC as a single window system are: (1) To provide a single window delivery system for the products and services to the farmers and other interested groups as a process of innovativeness in technology dissemination. (2) To facilitate direct access of the farmers to the institutional resources available in terms of technology advice, technology products *etc.*, for reducing technology dissemination losses. (3) To provide a mechanism for feedback from the users to the Institute.

Activities:

Conducted different activities like farmers training, capacity building, exposure visits of farmers, students and line departments and other stakeholders. The beneficiaries were about 5365 visitors.

Scheduled Caste Sub Plan (SC-SP) Programme

For training and empowerment of marginalized farming community, ICAR-CAFRI is implementing SC-SP scheme with the main objective to improve the socio-economic conditions of the SC farmers' community. Under this scheme, various training/capacity building programmes were organized for scheduled caste farmer, farm women, widows and handicap people. The scheme includes the enhancement of incomes of the target group for the development of assets such as those related to agricultural sector. During this period forty training programmes related to agroforestry were organized in which different SC-SP welfare materials like equipment/tools were distributed to the farmers/farm women.

In every training programme about 35-50 farmers/ farmwomen have participated from different villages of Bundelkhand region.

Agroforestry Business Incubation Centre (ABiC)

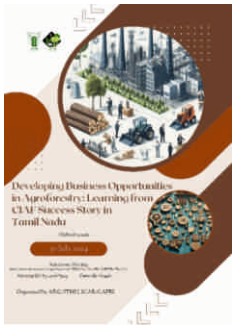
The Agroforestry Business Incubation Centre (ABiC) has been established under the Institute Technology Management of ICAR-CAFRI and it aims to create a vibrant ecosystem for innovation and entrepreneurship in agroforestry, promoting sustainable development and resilience among its stakeholders. Key objectives include fostering Business Incubation by providing a platform for agroforestry ventures to grow and thrive; facilitating Product/Technology Registration to ensure new agroforestry products and technologies meet regulatory standards and gain market acceptance; strengthening Intellectual Property Rights to protect innovations and ensure fair benefits for creators; and driving Human Resource Development to build capacity and enhance skills among stakeholders, thereby contributing to economic and social growth in the sector.

Industrial Agroforestry Complex at ICAR-CAFRI In 2024, the ICAR-Central Agroforestry Research Institute (ICAR-CAFRI), Jhansi, launched a pioneering initiative-the Industrial Agroforestry Complex (IAC)-marking a transformative step in India's agroforestry sector. Designed to bridge research, innovation, and commercialization, the IAC aims to convert agroforestry from a resource-focused activity into a vibrant industrial ecosystem. This flagship initiative seeks to create business opportunities for entrepreneurs, industries, and startups by promoting value addition, market integration, and technology-driven growth across agroforestry value chains.

The IAC is more than a research facility; it is a strategic platform to foster industrial development through agroforestry and the initiative extends beyond tree cultivation to include integrated supply chains, resource optimization, and commercialization of agroforestry technologies. The IAC is envisioned as a center for developing sustainable energy solutions such as biodiesel and biochar, which offer eco-friendly alternatives for fuel and soil enrichment. It also aims to enhance the productivity and market reach of forest-based industries through gum and bamboo processing, thereby improving the utilization of natural resources. It also encourages agroforestry technology dissemination through the promotion of nurseries, mechanization, and digital tools that make modern practices more accessible to farmers and businesses alike.

The IAC works in close synergy with the Agroforestry Business Incubation Centre (ABIC), which has been operational since 2022. The ABIC provides incubation support, mentorship, intellectual property assistance, business development services, and training programs to agroforestry startups and entrepreneurs. Together, the IAC and ABIC form a robust and dynamic ecosystem for promoting agroforestry-based enterprises, creating opportunities for sustainable development and inclusive growth.By establishing the Industrial Agroforestry Complex, ICAR-CAFRI reinforces its commitment to advancing agroforestry as a key contributor to rural livelihoods, industrial growth, and environmental sustainability. The initiative is poised to play a vital role in scaling up agroforestry, driving innovation, and supporting India's climate and development goals through a strong nexus of research, industry, and entrepreneurship.

Strategy adopted



ABiC follows a strategic pathway of Sensitization -Ideation- Acceleration-Competition. Representing ABIC, Dr. Suresh Ramanan S participated in the Multi-stakeholders consultation programme on Indian Wood Certification Scheme (PARMAAN) 30.07.2024 at Jaipur. Also, an Entrepreneurship Development programme on 'Developing Business Opportunities in Agroforestry: Learnings from CIAF Success Story from Tamil Nadu' was organized online by ICAR-CAFRI on 30th July 2024. About fifty participants attended the programme in hybrid mode. Dr. Suresh Ramanan S. (Scientist & Incharge-ITMU, ICAR-CAFRI) welcomed all the participants attending the programme. In the opening remarks, Dr. A. Arunachalam, Director, ICAR-CAFRI, Jhansi highlighted the growing requirements and the need for boosting business opportunities in agroforestry. Dr. A. Arunachalam also appreciated the decades-long success story of Consortium of Industrial Agroforestry (CIAF) congregated by the FCRI-TNAU under the leadership of Prof. K.T. Parthiban and urged on such learnings to be potentially replicated in Bundelkhand region of Uttar Pradesh. Representing the UP-Forest Department, Sh. K.K. Singh IFS, Chief Conservator of Forests, Jhansi Division, Government of Uttar Pradesh emphasized the need for promotion of agroforestry in the Bundelkhand region. He also apprised the efforts of the Government of Uttar Pradesh that is committed to improve the green cover in entire state.

Spiritual Vatika

Historically, humans have relied on forests not only for their sustenance but also for cultural and spiritual practices. India's heritage is closely intertwined with trees, which hold symbolic value across its diverse traditions. Forests, representing the wilderness, embody the unpredictable forces and the mysteries of nature. Although the connection between nature and culture is a popular topic in the social sciences, the symbolic role of trees remains underexplored.

Trees have provided shelter, fuel, food, and tools throughout human history, but they have also served as important symbols. For example, trees are often used to express nationalist sentiments and symbolize wisdom, justice, creation, and protection in older texts. The relationship between trees and human life, especially in arts and culture, reflects a deep, symbiotic bond that dates back to ancient times. The different types of thematic plantations, or vatikas, at ICAR-CAFRI, illustrating the cultural and spiritual significance of trees in India.

Vatikas @ ICAR-CAFRI

India's cultural tapestry is rich with traditions that extend beyond festivals, languages, and cuisines to unique gardens, locally known as *vatikas*. These gardens, often designed with a sense of spirituality and ecological harmony, serve more than just aesthetic purposes—they are imbued with deep symbolic meanings tied to religious and cultural narratives. More pertientely, they can be regarded as Tree arboretum.

Rasi Vatika (Zodiac Vatika): This vatika represents the 12 zodiac signs through specific trees, each symbolizing a particular astrological sign. For example, the Indian Gooseberry (*Phyllanthus emblica*) represents Aries, and the Peepal tree (*Ficus religiosa*) represents Cancer.

Navagraha Vatika (Solar Vatika): This vatika is dedicated to the nine celestial bodies (Navagrahas) in Hindu astrology. Each plant in this garden corresponds to one of the celestial entities, such as *Butea monosperma* representing the Moon.

Nakshatra Vatika (Star Vatika): Based on the 27 Nakshatras (constellations) of Indian astrology, this vatika contains specific trees associated with each star. For example, the Indian Gooseberry represents the Ashwini Nakshatra, while the Banyan tree represents the Magha Nakshatra. This vatika connects individuals to a specific tree species and thereby fostering environmental awareness and conservation at individual level.

Harishankari Vatika: This vatika involves the joint planting of three sacred trees: Peepal, Banyan, and Pakad. These trees symbolize the divine presence owing to the longevity of the trees and it is reported to offer environmental benefits such as air purification, biodiversity support, and carbon sequestration.

Panchavati Vatika: A sacred grove of five types of trees-Peepal, Banyan, Bael, Ashok, and Amla-this vatika has profound spiritual and environmental significance. It symbolizes enlightenment, immortality, strength, and ecological balance. Each tree in the Panchavati Vatika has a unique cultural and medicinal value, enriching both spiritual and environmental landscapes.

ICAR-CAFRI, a National Nodal Agency for Agroforestry

The National Nursery Assessment and Accreditation Committee (NNAAC), established under the provisions of the Agroforestry Accreditation Protocol, was notified by the Ministry of Agriculture & Farmers' Welfare (F.No.18-1/2023-NRM-AF (FTS:132982) dated 20 December 2023). Hosted at ICAR-CAFRI, the NNAAC is chaired by the Director, ICAR-CAFRI, and serves as a critical mechanism for evaluating and accrediting agroforestry nurseries across the country.

To date, the NNAAC has convened three meetings, during which proposals received from state agencies were meticulously reviewed. As a result of these assessments, 197 agroforestry nurseries have been accredited, ensuring their compliance with the stringent quality standards laid down in the accreditation protocol.

As part of the outreach and capacity-building initiatives, a dedicated team comprising Dr. A. Arunachalam, Dr. Suresh Ramanan S, and Dr. A.K. Handa has developed promising agroforestry models for twelve states. These models are not only tailored to the agro-climatic and ecological conditions of each state but also incorporate socio-economic factors to ensure their viability. The document provides a detailed state-wise overview, including land use patterns, soil health, climatic resilience, and market linkages, making it a strategic blueprint for sustainable agroforestry expansion.

This initiative is particularly significant as it lays the foundation for district-level agroforestry planning, aligning with national and state priorities for sustainable land management. By offering region-specific models, the document helps policymakers, researchers, and extension agencies in formulating targeted interventions that enhance farm productivity, restore degraded landscapes, and improve rural livelihoods. Additionally, the models emphasize climate resilience by integrating tree species and cropping systems best suited for each region, contributing to carbon sequestration and biodiversity conservation.

These efforts will significantly strengthened the agroforestry sector by ensuring the availability of high-quality planting material, fostering collaboration between stakeholders, and enhancing the capacity of professionals and practitioners. Moving forward, ICAR-CAFRI aims to expand its outreach, accelerate nursery accreditation processes, and promote the adoption of sustainable agroforestry practices nationwide.

Promising Agroforestry Models - State specific

Organizational Setup

DIRECTOR & PROJECT COORDINATOR

Governance & Guidance

Research Programmes

- Agroforestry System Research
- Tree Improvement Research
- Carbon & Climate Change Research
- Agroforestry Extension Research

Service Sections

- PME Cell
- Agriculture Knowledge Management Unit
- Library & Documentation
- Administration & Finance
- Farm cum Workshop
- ITMU & IP&TM (NAIF)
- Public Information Cell

NRM Division, ICAR HQ

- QRT
- RAC
- IMC

Network Research

- AICRP on Agroforestry

State Agricultural University : Solan, Srinagar, Kahikuchi, Palampur, Ludhiana, Pantnagar, Pusa (Bihar), Faizabad, Jhargram, Bhubaneshwar, Ranchi, Sardarkrushinagar, Fatehpur-Shekhawati, Hisar, Rahuri, Nagpur, Hyderabad, Jabalpur, Dharwar, Mettupalaym, Thrissur, Dapoli, Kattuapakkam, Bengaluru, Jammu (J&K), Shimoga

ICAR Institute : Dehradun, Umiam, Imphal, Gangtok, Karnal, Agartala, Ranchi, Jodhpur, Hyderabad, Jhansi

ICFRE Institute : IFGTB, Coimbatore

- HPVA of NRG
- CLIGR

Budget (2024-25)

(₹ in Lakhs)

Sr. No.	Head	Budget-2024-25
1.	**ICAR-CAFRI, Jhansi**	
	Capital (Grant for creation of Capital Assets	29.00
	Establishment Expenses (Grant in Aid-Salaries)	733.88
	Grant in Aid-General (Pension Benefits)	127.85
	Grant in Aid-General	250.00
	Total	**1140.73**
2.	**Plan Schemes**	
	All India Coordinated Research Project on Agroforestry (AICRP on Agroforestry)	1246.37
	Harvesting processing and value addition of natural resins and gums (HPVA of NRG	10.50
	National Agriculture Innovation Fund (NAIF) Scheme IP&TM	4.92
	Comparative study on carbon dynamics and functional rhizosphere microbial biomass of agroforestry system in dry and wet-tropical climatic situations	23.16
	Efficacy of fumigant molecules against storage insect pest of agricultural commodities under field conditions	3.54
	Network Project on Conservation of lac Insect Genetic Resources (CLIGR)	8.50
3.	**Externally funded projects**	
	Trees Outside Forests in India (TOFI)	26.94
	Task Force on Himalayan Agriculture-NMSHE (2nd Phase)	159.00
	Development and Evaluation of Pomegranate based agroforestry system in Bundelkhand region for higher productivity and economic returns in farmers field	1.659
	In vitro regeneration of multipurpose & medicinally important Butea monosperma Lam. and its assessment for mass propagation of genetically uniform quality planting material	7.50
	Strengthening community resilience by diversifying cropping system through agroforestry interventions in Central India	32.923
	Tissue-specific physiological, molecular, and metabolomics analysis of green gram (*Vigna radiata)* for shade adaptive traits in the context of agroforestry	13.12
	Large scale screening, Identification and Promotion of Azadirachta indica accessions for high Azadirachtin yield	7.35
	RKVY-Quality Planting Material (QPM)	18.18
	Fostering agroforestry based incubation to booster the agribusiness in Uttar Pradesh	22.00
	Development and implementation of seedling certification framework	22.60
	Evaluation the performance of Sea weed Extract, Humic acid, Protein Hydrolysates, Biochemical, and Botanical Extracts	0.997
4.	**Resource Generation 2024-25 (up to 31-Dec., 2024)**	**49.15**
5.	**SCSP Fund**	
	Capital	19.99
	General	28.39
	Total	**48.38**

2. Research Achievements

2.1. Agroforestry System Research Programme

NRMA/CAFRI/SIL/2021/003/00127

Assessment of conservation agroforestry

(Asha Ram and Inder Dev)

The project on assessment of conservation agroforestry was initiated in the year 2021, focusing on three agroforestry systems: Teak-based agroforestry, Bael-based agroforestry and Teak+Bael-based agroforestry. Plantation of these tree species were done in year 2014 with 9 m x 4m spacing. In the Teak +Bael combination, a pattern of alternating Teak and Bael was adopted within rows, with a spacing of 4m. Two cropping systems, namely Sorghum-Chickpea and Maize-Linseed, were selected for investigation, each implemented with and without residue retention and employing both minimum and conventional tillage methods. The experiment was laid out in a completely randomized block design with eight treatments comprising tillage (conventional and minimum), cropping system (sorghum-chickpea and maize-linseed), and residue management (residue retention and no retention). The results revealed that conventional tillage with residue retention significantly (P <0.05) increased plant height and dry matter accumulation in linseed and chickpea. Conventional and minimum tillage both remained at par in terms of crop yield. However, residue retention significantly (P <0.05) increased the crop yield in linseed and chickpea (Fig. 1). The overall productivity of both linseed and chickpea crops increased with the application of conservation agricultural practices. Residue retention resulted in 20 to 37% higher soil organic carbon than no residue retention. Likewise, other nutrient availability (N, P, K, S, Zn, Fe, Mn, and Cu) also increased with minimum tillage and the retention of crop residue. Similar results have also been observed in *kharif* crops (sorghum and maize) in all these three agroforestry experiments (Fig. 2). Thus, it is recommended that adoption of conservation agriculture practices in maize-linseed and sorghum-chickpea cropping systems in teak, bael and teak+bael-based agroforestry system have the potential to increase crop yield and soil fertility.

PCA biplot analysis of soil chemical properties revealed that soil organic carbon and nutrient availability is more with residue application with minimum tillage in sorghum-chickpea and maize-linseed cropping systems (Fig. 3).

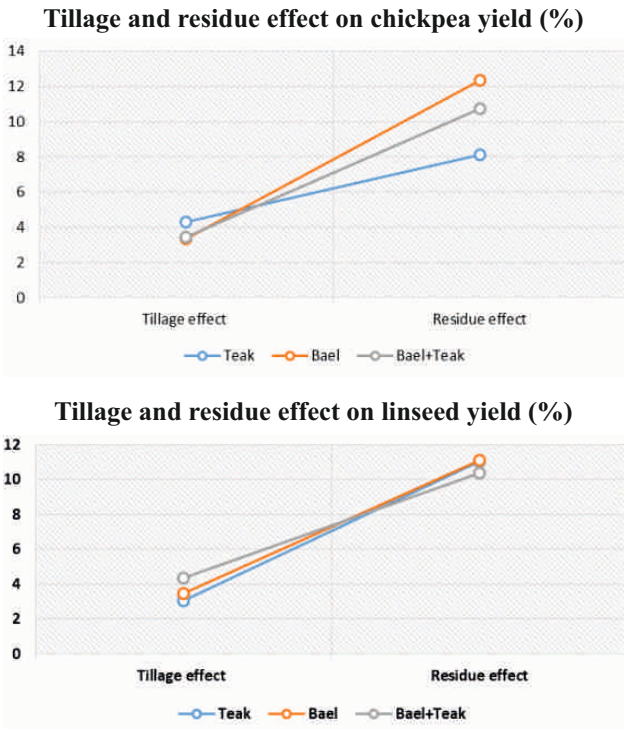


Fig. 1. Effect of residue application on chickpea and linseed yield in conservation agroforestry systems

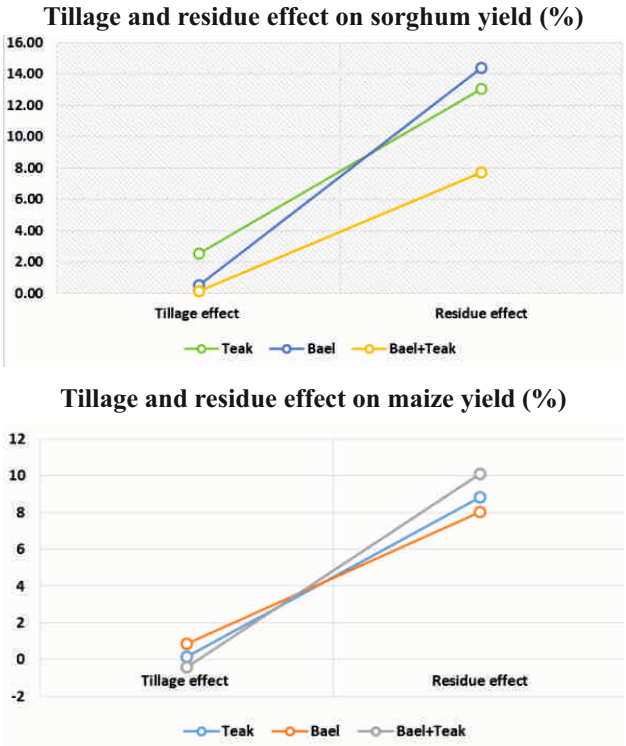


Fig. 2. Effect of residue application on grain yield of chickpea and maize in conservation agroforestry systems

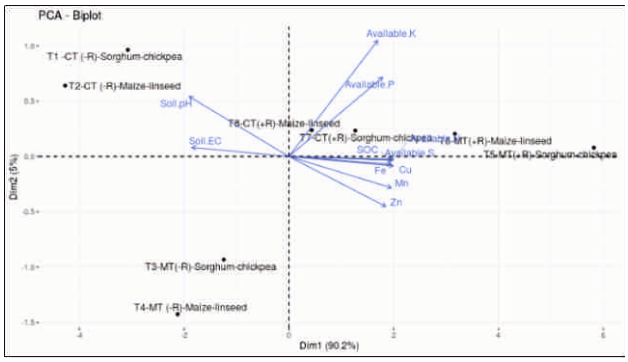


Fig. 3. PCA biplot analysis of soil nutrient availability as affected by the different tillage and residue treatments in teak+bael-based conservation agroforestry

NRMA/CAFRI/SIL/2021/004/00128

Assessment of *Melia dubia* based agroforestry system under semi-arid conditions

(Naresh Kumar, Ashok Yadav and Kamini)

The project entitled "Assessment of *Melia dubia* based agroforestry system under semi-arid conditions" was approved during the IRC meeting in 2021 with the objectives: 1. To study the comparative ecological performance of *Melia dubia* based agroforestry on farmers' fields and research farm 2. To study the farmers' rationale for multifunctional uses of *Melia dubia* 3. To study the economic viability of *Melia dubia* based agroforestry system. As per the technical programme, *Melia dubia* was planted in 2022 at the Experimental Farm of the Institute, following a spacing of 7×3 meters. The experiment comprises seven treatments under a Randomized Block Design (RBD), with three replications. The treatments of the study are: T1 Melia + crop 1, T2 Melia + crop 2, T3 Melia + crop 3, T4 Pure crop 1, T 5 Pure crop 2, T6 Pure crop 3 and T7 Pure *Melia dubia.* The intercrops grown across different seasons include: Kharif season - 1. Finger millet, 2. Barnyard millet and 3. Bajra; and Rabi season: 1. Mustard 2. Chickpea and 3. Barley. To assess the growth performance of *Melia dubia*, plantations were also established on selected farmers' fields. Additionally, its growth was monitored in plantations along roadside, field bunds, and boundaries within the institute premises.

The observations on growth parameters like height, clean bole and dbh of *M. dubia* were recorded. The *Melia dubia* planted at Experimental Farm of CAFRI, as well as at farmers' field recorded almost same growth trend. The plant height ranged from 4.80 to 7.70 m, clean bole 3.10 to 5.30 m, and dbh from 5.42 to 11.36 cm. The growth and yield attributes of intercrops were also studied. It was observed that intercrop growth and yield were negatively affected in proximity to the *Melia* rows, leading to comparatively lower yield. Leaf fodder quality parameters of *Melia dubia* viz., crude protein, neutral detergent fibre, acid detergent fibre and acid detergent lignin were analyzed in the laboratory of ICAR- Indian Grassland and Fodder Research Institute, Jhansi. The results indicated that the fodder quality of *Melia dubia* leaves was within the acceptable range for fodder trees. The plant mortality resulted due to stray animals and other factors has also been replaced by planting the new plants.

***Melia dubia* at Farmers' Field**

***Melia dubia* at Experimental Farm**

Stall feeding of *Melia dubia* fodder

NRMA/CAFRI/SIL/2021/005/00129

Developing multifunctional agroforestry system for nutritional security in semi-arid tropics

(Ashok Yadav and Arun Kumar Handa)

Under the present study, several surveys were conducted periodically in different parts of India to collect plants suitable for a multifunctional agroforestry system (food forest and bee forest). The following work has been done in the project for food forest and bee forest

- Survey, collection of plant species having food value
- Propagation and multiplication of the collected plant species
- Characterization of some plant species for food value
- Field preparation and layout of the multifunctional agroforestry system

- Fencing of the experimental field was done to avoid the problem of blue bulls
- Planting the different plant species in the food forest
- Till now 60 species have been planted in the food forest which belongs to fruits, vegetables, medicinal, and spices
- Several surveys resulted in the identification of 110 crops that had nectariferous and polliniferous values based on the bee activities of *Apis dorsata, Apis indica* and stingless bees. Out of these crops, 55 crops species planting material were raised successfully and planted in the bee forest

NRMA/CAFRI/SIL/2021/006/00130

Assessment of soil biological and biochemical characters in predominant agroforestry-based land use systems

(*Sovan Debnath and Suresh Ramanan S*)

Randomized soil sampling was performed in the intercropped and tree rhizosphere zone of the experimental agroforestry systems (Teak + cropping, Melia + cropping, Ber + cropping, Aonla + cropping, and an agricultural (sole) cropping system) and samples were collected in triplicates from topsoil depth (0-15 cm) and subsoil (15-30 cm) with the help of an auger. Analysis of soils revealed significant (P <0.05) variations in the measured soil properties among the agroforestry systems at both soil depths. Mineralization of organic N increased with the increasing day of incubation (0-60 day). In contrast, there was a net P immobilization before it gets mineralized, which started between 30 and 60 days of incubation. Mineralization of organic N and P was higher at surface than subsurface soil and at the rhizosphere soil than at the inter-cropped soil. Cumulative N mineralization was higher in inter-cropped soil (11.7 mg N kg^{-1} soil 60 d^{-1}) over rhizosphere soil (7.02 mg N kg^{-1} soil 60 d^{-1}) and was higher in agricultural (sole) cropping system (15.5 mg N kg^{-1} soil 60 d^{-1}). Aonla and teak based agroforestry showed higher P mineralization capacity both in the intercropped (0.96 and 1.87 mg P kg^{-1} soil 60 d^{-1}) and tree rhizosphere (3.22 and 2.88 mg P kg^{-1} soil 60 d^{-1}) zone, while agricultural (sole) cropping system (0.46 mg P kg^{-1} soil 60 d^{-1}) showed the least (Fig.1).

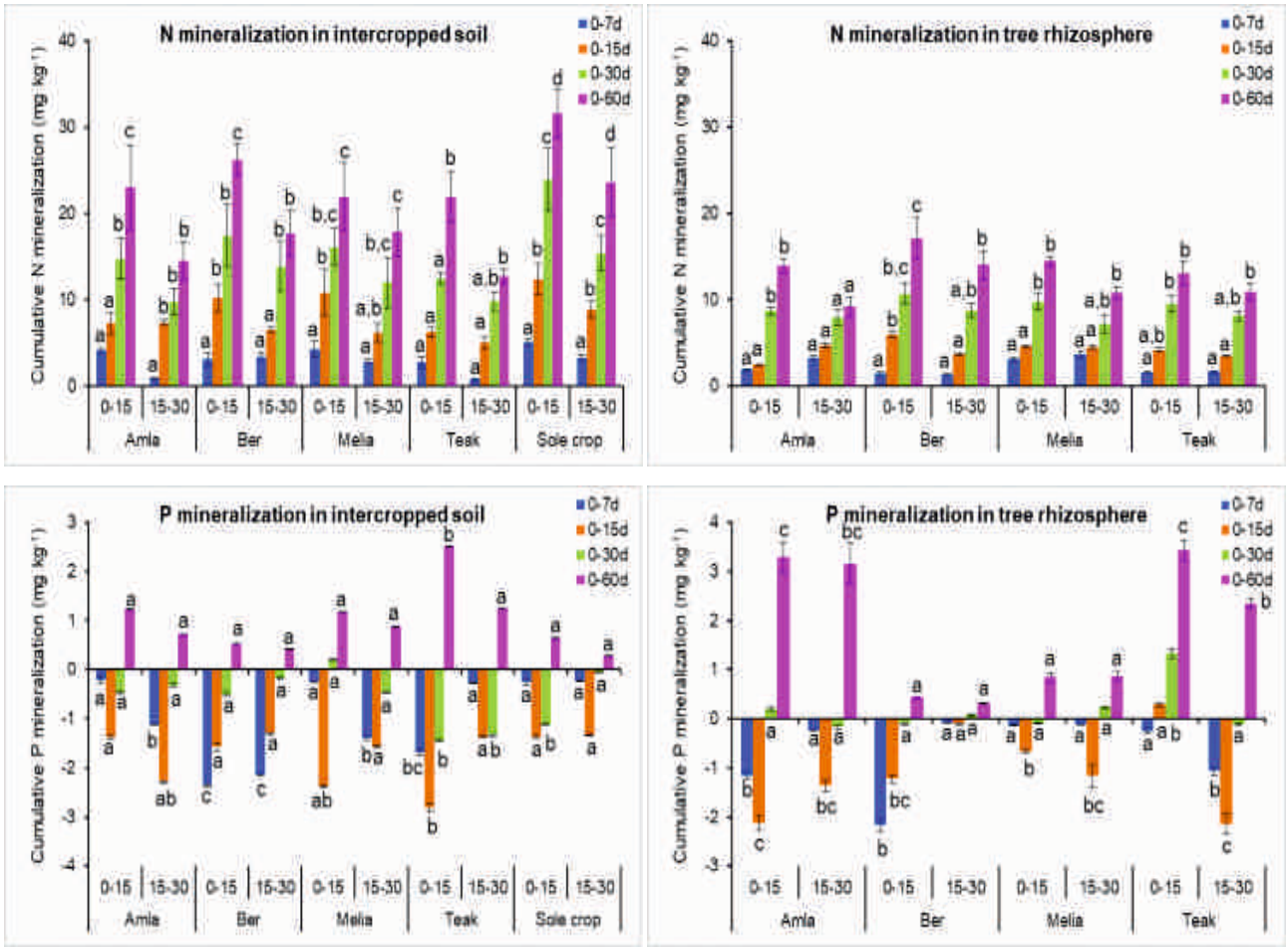


Fig. 1. Cumulative N and P mineralization observed at the studied agroforestry lands. Columns followed by letter in uncommon differ significantly (P <0.05) within a particular incubation period as per Fisher's LSD test. Vertical bars on the column indicate standard error (n = 3).

NRMA/CAFRI/SOL/2024/002/00162

Insect diversity in Teak and Bael-based agroforestry system: Insights and Implications.

(Y N Venkatesh and M Ashajyothi)

Insect pests are the most important group of organisms causing injury to trees and crops in agroforestry systems. The dynamics of insect pests and their natural enemies are governed by the complexity and composition of the agroforestry system. Therefore, the management of insect pests in these systems is crucial for sustainable production. An understanding of what aspects of trees modify insect pest populations should help in determining future agroforestry practices, with this background, the current project has been proposed to study Insect diversity in teak and bael based agroforestry system. In teak and bael based agroforestry system insects were monitored and collected every 15 days interval throughout the season and collected insects were brought to laboratory and preserved for identification. Biology and life cycle of teak defoliator, *Hyblaea puera* Cramer and teak skeletonizer, *Eutectona machaeralis* Walker were studied and total life cycle of *H. purea* male and female was completed in about 26 to 37 and 26 to 38 days with an average of 32±5.56 and 32.6±6.1 days, respectively. Whereas total life cycle of *E. machaeralis* male and female was completed in about 30 to 33 and 30 to 40 days with an average of 31.5±1.5 and 34.6±5.50 days, respectively. Percent leaf area and number of larvae/leaves were also recorded. A total of seven insect orders were recorded in this system. Among them Lepidoptera order recorded total 12 species followed by Hymenoptera (Eight species), Hemiptera (Four Species) (Fig. 1)

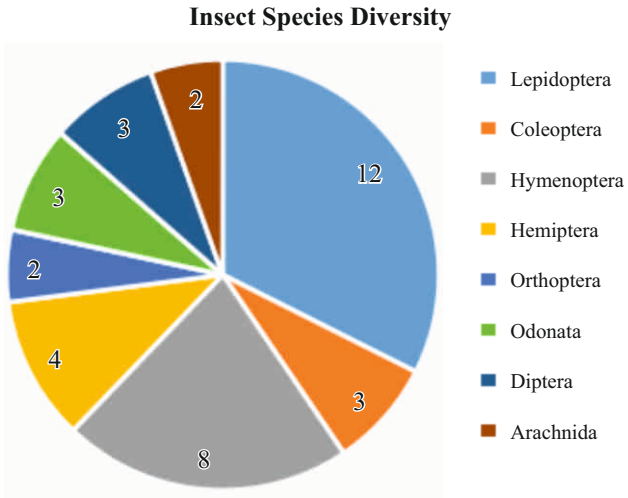


Fig. 1. Insect order diversity in Teak and Bael based agroforestry systems

2. Research Achievements

2.2. Tree Improvement Research Programme

NRMA/CAFRI/SIL/2021/007/00131

Evaluation of *Melia dubia* clones

(A K Handa and Naresh Kumar)

Evaluation of *Melia dubia* clones with an objective to understand the growth performance of different clones of *Melia dubia* in semi-arid region of central India consists of 15 clones of *Melia dubia* developed by ICFRE along with MTP2 clone developed by FCRI, Mattupalayam and one clone of WIMCO. These clones planted in the research farm of the institute with nine plants per clone in two replications. The growth data of different clones at the age of two years presented in Table 1 exhibited that the *Melia* clone FRI/MD/20235 is performing better than other clones.

Table 1. Average plant height and collar diameter of different *Melia* clones after one year of plantation

S.No.	Clone	Average plant height (cm)	Average collar diameter (cm)
1.	MTP2	2.10	33.18
2.	2026	1.95	39..38
3.	2087	3.65	61.25
4.	261	3.15	59.50
5.	260	2.80	54.65
6.	75	2.55	67.00
7.	2028	3.33	64.30
8.	2056	2.60	57.25
9.	WIMCO	2.10	35.75
10.	2099	3.40	67.50
11.	2068	2.25	48.50
12.	2059	2.06	53.25
13.	2061	3.80	55.50
14.	2094	4.20	71.25
15.	2035	4.45	90.76
16.	2037	3.05	44.21
17.	2021	2.65	43.25

NRMA/CAFRI/SIL/2021/009/00133

Collection and evaluation of Moringa germplasm for better adaptability and year fruiting for accelerating agroforestry based nutritional security under semi-arid climate

(Hirdayesh Anuragi and K Rajarajan)

Drumstick [*Moringa oleifera* Lam.], is a climate-smart species often considered as 'Superfood' or 'Wonder tree' owing to its exceptionally high nutritional and therapeutic properties capable of curing above 300 human diseases. Its fast-growing and drought tolerance nature make it a very suitable agroforestry species for ensuring nutritional and livelihood security besides farmland ecosystem restoration and biodiversity conservation. The present study tried to capture the total available genetic variation in the Moringa germplasm representing region from central India and evaluating their genetic potential for year-round fruiting and higher adaptation to dry and hot Bundelkhand region of central India. A total of thirty moringa germplasm (CAFRI/MO-001 to CAFRI/MO-030) with varied characteristics were collected and preserved at ICAR-CAFRI, Jhansi as a field gene bank. Morphological and physico-chemical characterization have identified CAFRI/MO-008, CAFRI/MO-012 and CAFRI/MO-024 with annual, prolonged flowering and fruiting behavior along with higher climatic adaptability. Physio-chemical analysis revealed higher CCI, carotenoids, malondialdehyde, phenol content, proline content, antioxidant activity, RWC, CMSI, *etc.*, in the superior germplasm. Also, tp understand the actual genetic variation existed at DNA level, molecular genetic diversity analysis was performed using 46 simple sequence repeats (SSRs) markers.

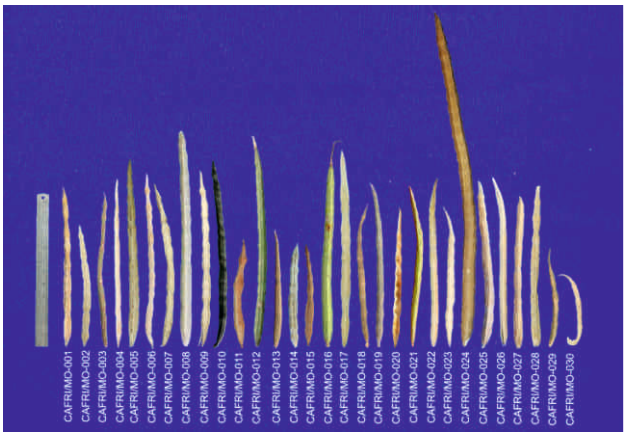


Fig. 1. Genetic variations in the pod morphology of 30 *Moringa oleifera* germplasm conserved at ICAR-CAFRI, Jhansi

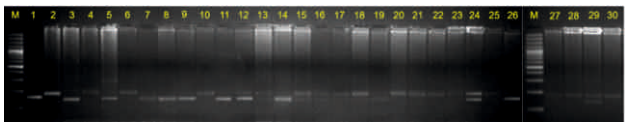


Fig. 2. PCR amplification profile of SSR marker 'MO58' in 30 *Moringa oleifera* germplasm

Fig. 3. View of *Moringa oleifera* field gene bank preserved at institute research farm

NRMA/CAFRI/SIL/2022/007/00153

Developing a *Bacillus subtilis* based bioformulation for the management of *Melia dubia* vascular wilt disease incited by *Fusarium solani*

(*M Ashajyothi and K Rajarajan*)

During the year, 2023-2024, effect of bioformulation Micro shuttle-1 was tested on the growth and development and nutrient status of *Melia dubia*. Micro shuttle-1 in three different treatments (20 ml, 10 ml and 5 ml) applied along sterile distilled water that served as control. The growth and development were observed for one year and plant height, stem girth and chlorophyll content were recorded accordingly in monthly intervals. Micro shuttle-1 positively influenced (Table 1) the growth rate of *Melia dubia by* enhancing the plant height (25.84 cm), stem girth (3.63 cm) and leaf chlorophyll (18.12) in T2 over control (18.37 cm, 2.2 cm, 6.6) respectively. Further, the nutrient composition was studied by destructive sampling method. Samples were collected, washed with 1N HCl and distilled water and kept in oven at 60°C until they were in fully dried condition and later crushed to a fine powder. For total Nitrogen analysis, one gram of sample was digested with Hydrochloric acid and copper sulphate and titration was performed by Automatic Nitrogen Analyzer (Velp Scientifica UDK 159 Automatic Distillation & Titration System) using 35% NaOH, 4% Boric Acid, Bromocistrol green and Methyl red indicators. For Potassium and Phosphorus, 0.5 grams of dried samples were pre-digested with Nitric Acid by microwave digestor. The extracts were filtered using Whatman filter paper 42 and further diluted hundred times with distilled water and analysed by flame photometer (Elico CL 378) for Potassium and double beam spectrophotometer (Systronics India Limited) for Phosphorus. Analysis revealed that the nutrient composition of Micro shuttle-1 treated plants backed the growth rate observed in *Melia dubia.*

Table 1. Effect of *Bacillus subtilis* PBs 12 Bioformulation Micro shuttle-1 on growth and development of *Melia dubia*

Treatment	Plant height		Growth rate (cm)		Stem girth		Growth rate (cm)		Chlorophyll		Rate of change	
	Initial	Final	GR/ Year	GR/ Month	Initial	Final	GR/ Year	GR/ Month	Initial	Final	RC/ Year	RC/ Month
Sterile water	31.97	44.22	18.37	1.53	2.866	4.283	2.20	0.17	23.65	28.05	6.60	0.55
Bacillus subtilis PBs12 (20 ml)	27.61	44.84	25.84	2.15	2.389	4.811	3.63	0.30	30.26	42.34	18.12	1.51
Bacillus subtilis PBs12 (10 ml)	33.08	49.5	24.63	2.05	2.65	5.116	3.69	0.30	21.91	33.66	17.62	1.46
Bacillus subtilis PBs12 (5 ml)	26.02	42.27	24.37	2.03	2.256	4.779	3.78	0.31	24.81	35.65	16.26	1.35

Fig. 1. Testing of *Bacillus subtilis* based bioformulation for the management of *Melia dubia* vascular wilt disease

2. Research Achievements

2.3. Carbon & Climate Change Research Programme

NRMA/CAFRI/SIL/2021/010/00134

Influence of Plant morphological characteristics on soil properties in agroforestry systems

(Rajendra Prasad and Badre Alam)

During the year, the fractions of soil carbon *viz.* very labile, labile, less labile and non-labile in different layers of soil profile of all agroforestry systems *viz. A. indica, D. sissoo, H. binata, A. nilotica, A. senegal* and a pure agriculture field (control) were estimated. Total organic carbon was estimated by combustion method. Also, initiated a new trial to quantify leaf litter production from agroforestry trees and its in-situ decomposition pattern. For collection of litter fall, litter trap of 50x50x20cm size and for litter decomposition, litterbag techniques are used.

Soil carbon stock and its fractions in soil profile

Total organic carbon in the soil profile (0-100cm) was maximum in *H. binata* (113.6 Mg ha^{-1}) based agroforestry and the least (37.1 Mg ha^{-1}) in pure agriculture field (Fig. 1). All the agroforestry systems recorded more total SOC in soil profile than pure agriculture field. The distribution of SOC in different layers of profile varied from species to species. *A. indica* accumulated maximum SOC and *H. binata* the least in surface layers of 0-15cm. On an average, upper layers (0-30 cm) shared 40.1% of the total SOC of the profile while lowest layer (90-100cm) only 6.3% (Fig. 2).

In all agroforestry systems and pure agriculture field, the different SOC fractions varied with soil depths and the trees. In general, the non-labile fraction of SOC was maximum in all the studied agroforestry systems including pure agriculture field. All the carbon fractions declined with the depth in the soil profile with few exceptions. The order of different fractions in the soil profile of different agroforestry system was as below:

A. indica: Non labile> labile> very labile>less labile

D. sissoo: Non labile> labile> less labile> very labile

H. binata: Non labile>less labile> labile> very labile

A. nilotica: Non labile> labile> less labile> very labile

A. senegal: Non labile> labile> less labile> very labile

Pure agriculture field: Non labile> very labile> labile> less labile

The active soil carbon pool (very labile and labile fraction put together) was far less than the passive soil carbon pool (less labile and non-labile put together) in all the systems.

Leaf litter production and its *in-situ* decomposition pattern

For collecting leaf litter, eight litter trap (four litter trap within the tree-canopy and four trap at the border of tree-canopy in staggered position covering all directions- east, west, north and south) were placed at one selected tree of each agroforestry system on 1st November 2024 (Plate 1). Leaf litter fallen in each litter-trap was collected fortnightly and stored in litter bag. In the month of November, maximum litter was accumulated in *D. sissoo* while *H. binta* recorded the least (Fig. 4). The observations on monthly litter-production will continue up to October 2025.

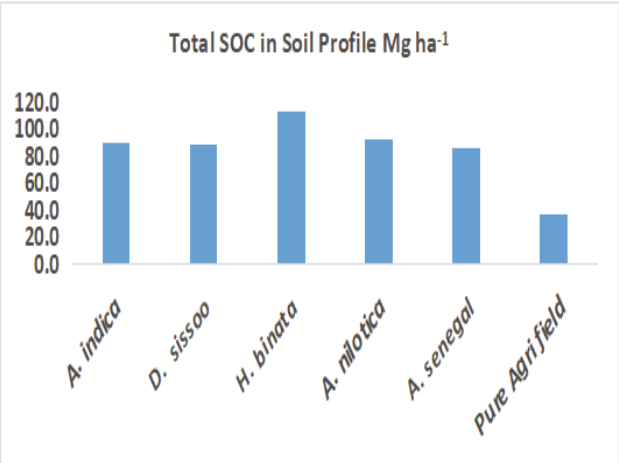


Fig. 1. Total soil organic carbon in soil profile (0-100cm) of different agroforestry systems

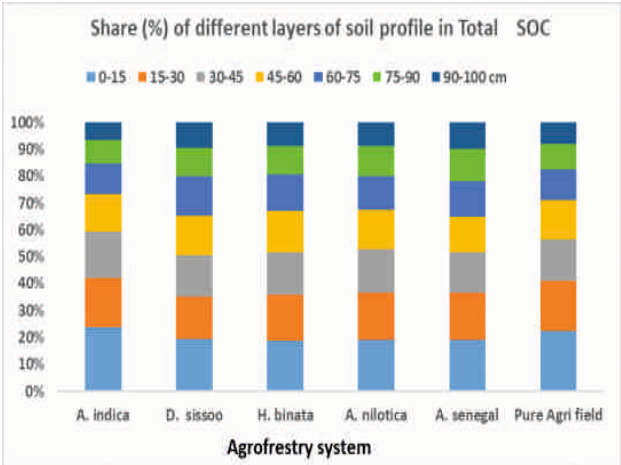


Fig. 2. Contribution of different layers in total SOC of soil profiles of different agroforestry systems

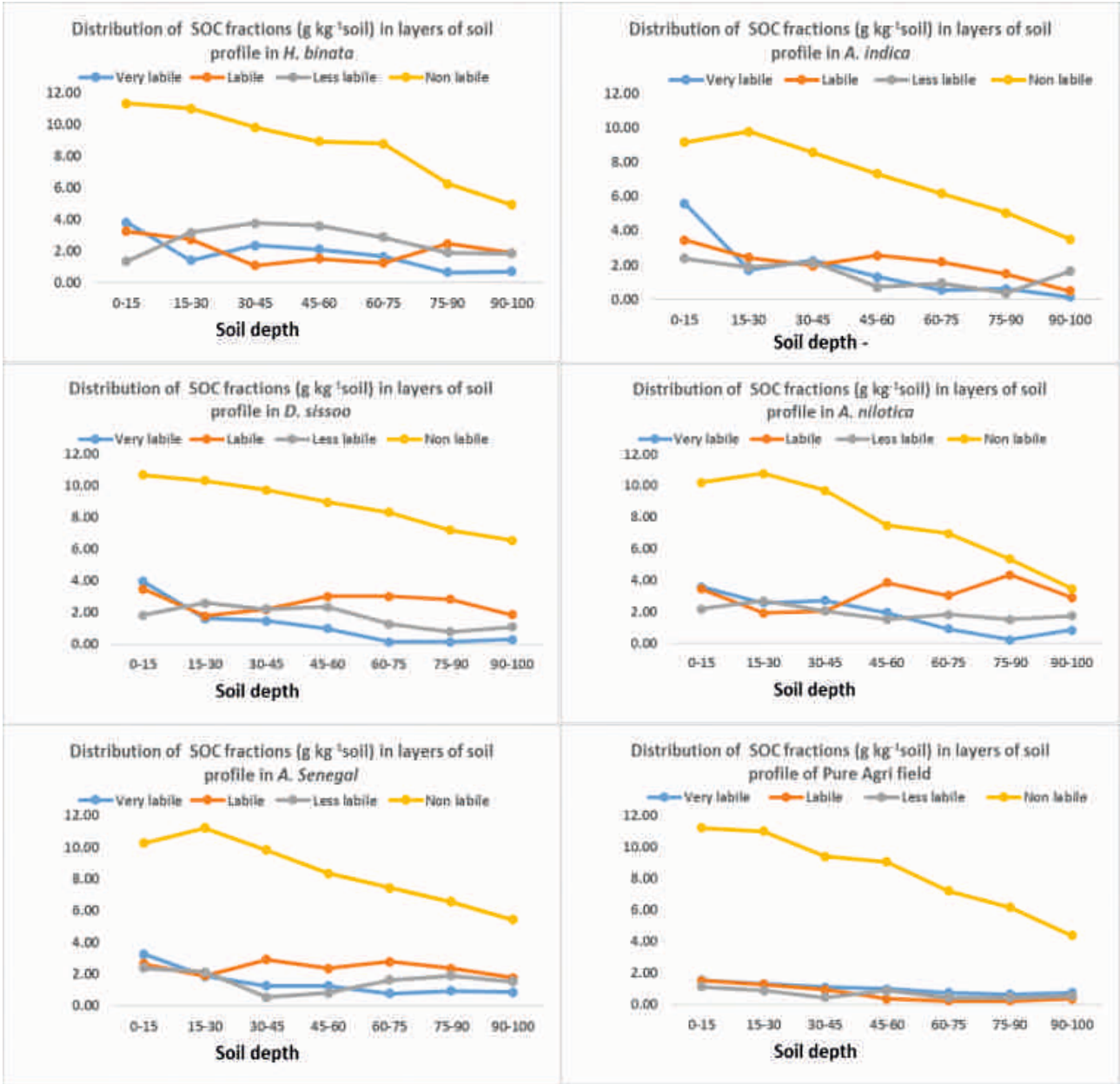


Fig. 3. Fractions of SOC in soil profiles of different agroforestry systems

Plate 1. Placement of litter-trap at *D. sissoo* for quantification of leaf litter production

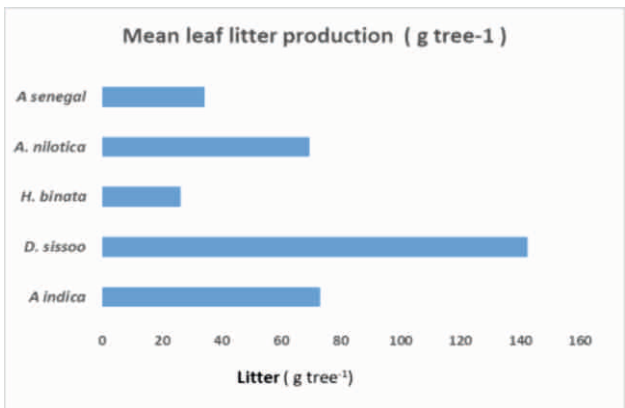


Fig. 4. Leaf litter production in November 2024 from the trees of agroforestry systems

NRMA/CAFRI/SIL/2021/011/00135

Eco-physiological dynamics for assessing climate change mitigation potential of contrasting tree populations of *Pongamia pinnata*

(*Badre Alam, Rajendra Prasad and Sukumar Taria*)

To unravel the dynamics of ecophysiological responses in clonal and seedling populations of *Pongamia pinnata* have been studied in greater details. Distinct differential trends in the ecophysiological responses in contrasting dry harsh summer and conducive post-monsoon seasons have been revealed (Fig. 1). Despite having extremely dry hot harsh summer climate photosynthetic CO_2 acquisition functioning of the plants have been sustained relatively better in the clonal populations, whereas, it was highly downregulated in seedling populations. Differential mechanistic insights for photosynthetic carbon assimilation which were aggravated by dry hot summer climate are being studied to get the ecophysiological determinants. Hot summer-induced physiological constraints for the tree species will help to throw light on the critical impact as it has made on the underlying stress-tolerance potential responses. Chlorophyll being one of the main components of the carbon acquisition systems in the trees, ecophysiological dynamics of chlorophyll content index (CCI) have also been investigated. Differential responses in CCI was clearly noted in the tree populations with respect to the contrasting seasonal attributes (Fig. 2). Further analysis relating to physio-biochemical purposes to unravel the differential ecophysiological responses in the clonal and seedling populations are being conducted. Pod formation in the trees were very less which may be due to low flowering and drop of flowers. Estimation of oil contents from the seeds is being made from the collected pod samples. Moreover, relevant data collection and analysis for unravelling the dynamics of ecophysiological responses are progressing.

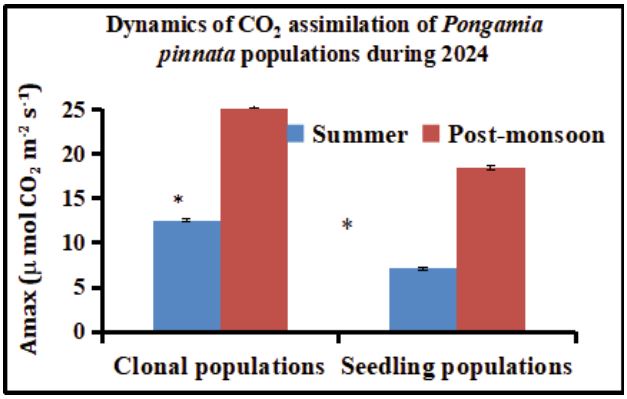


Fig. 1. Dynamics of CO_2 assimilation of *Pongamia pinnata* tree populations

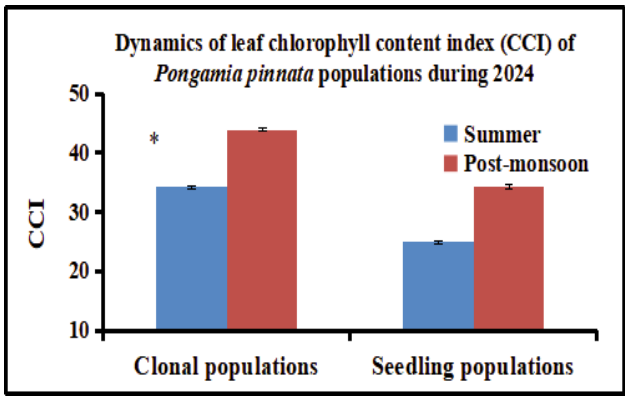


Fig. 2. Dynamics of leaf chlorophyll content index (CCI) of *Pongamia pinnata* tree populations

NRMA/CAFRI/SIL/2021/012/00136

Assessment of ecosystem services in silvipastoral system in semi-arid conditions

(*Asha Ram and Inder Dev*)

A pioneering project was initiated to field scale assessment of ecosystem services in silvipastoral systems under semi-arid conditions in year 2021. This project was established in year 2016 with two tree species viz., teak (*Tectona grandis* L.) and mahagony (*Swietenia mahagoni*) and two grasses *Cenchrus ciliaris* and *Stylosanthes seabrana*. Trees were planted at 5m x 5m distance and grasses were intercropped at 50cm x 50 cm distance in alternate row pattern. The project comprised seven treatment combinations *viz.*, T1: Sole Pasture; T2: Sole Teak (*Tectona grandis*); T3: Sole Mahogany (*Swietenia mahagoni*); T4: Teak + Mahogany + Pasture; T5: Teak + Mahogany + Pasture + Half-Moon Basin (HMB); T6: Teak + Mahogany + Pasture + Vegetative Hedge (VH); and T7: Teak + Mahogany + Pasture + Contour Staggered Trenches (CST). Initial observations highlighted teak's resilience, exhibiting favorable survival and growth parameters. Conversely, mahogany faced challenges due to insect infestations and blue cow attack, resulting in lower survival rates.

For provisioning services, biomass production from grasses and sesbania was measured and found highest biomass in treatment T7 (Teak+Mahagony+Pasture+ Contour Staggered Trenches) followed by T5 (Fig. 1). The lowest biomass production was recorded in T2 (Teak+Mahagony+Pasture). Among regulating services, soil moisture dynamics were monitored at every 15 days intervals, revealing higher moisture content in treatments with soil and moisture conservation measures, notably in T7 (Fig. 2). In contrast, sole mahogany plots exhibited the lowest soil moisture levels due to poor water holding capacity.

In 2024, nine rainfall events were meticulously recorded. Runoff analysis revealed the significant differences among the different treatments. The highest runoff was recorded in sole mahogony plots followed by sole teak plots. Treatment with contour staggered trenches observed with lowest runoff. Soil and nutrient loss assessments corroborated

these findings, with T7 demonstrating superior soil and nutrient retention capabilities, contrasting with elevated losses in sole mahogany and sole teak plots. Sediment trapping efficiency of half-moon basin and contour staggered trenches were also recorded and found that CST has the high sediment trapping efficiency. Soil biological properties were also recorded higher in the treatment having tree+grass combination with soil and moisture conservation measures (Fig. 3).

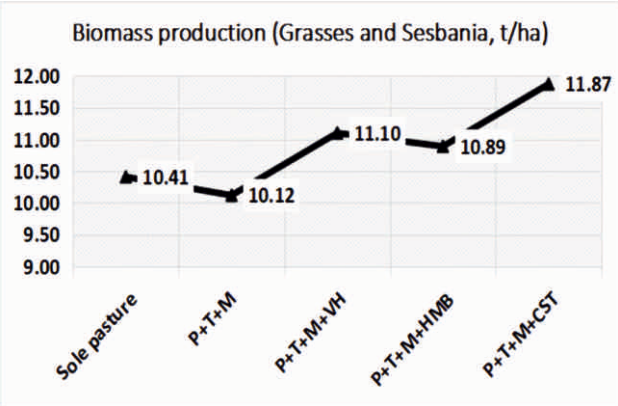


Fig. 1. Biomass production of grasses and sesbania

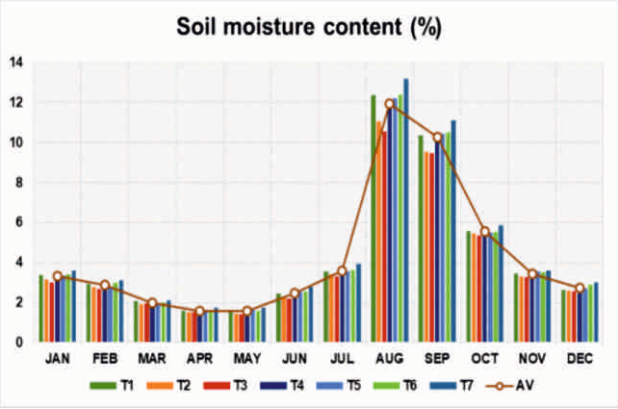


Fig. 2. Soil moisture dynamics in different treatments in silvopastoral system

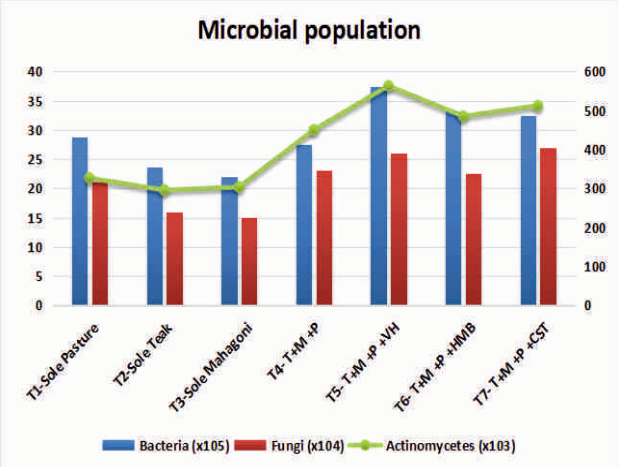


Fig. 3. Microbial population in different treatments in silvopastoral system

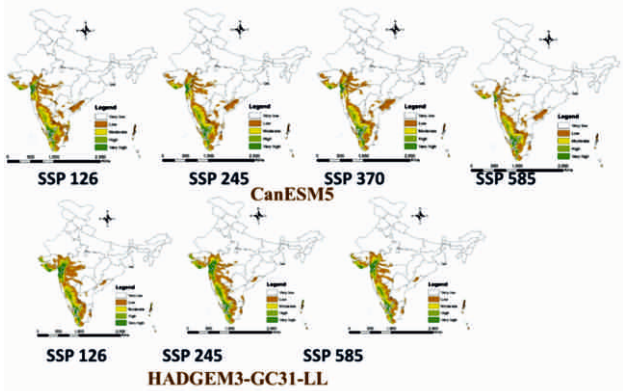
NRMA/CAFRI/SIL/2023/002/00155

Developing Niche modelling framework for upscaling *Melia dubia* based agroforestry

(Suresh Ramanan S and A. Arunachalam)

The *Melia* trees are endemic to the Indian sub-continent. Thus, the proposed research project will be of great relevance at the National level given that our country is a net importer of wood and wooden products, promoting an indigenous fast growing tree species will have greater relevance in self-sustaining the wood market by bringing clarity on the species grown in different parts of the country. This will help selective inclusion of *Melia dubia* in agroforestry being promoted in the country in large-scale. Moreover, the tree is not regulated by any of the state legislations, which makes them apt for a pan-India promotion. Since the study proposes to use the species distribution modelling to delineate the potential areas for promotion of *Melia* shall be meaningful. The project was carried out with two objectives i) what are the potential area for cultivation of *Melia dubia* in the current climatic condition. ii) how will the climate change impact the area under cultivation of *Melia dubia* in future?

MaxEnt software was used to analyze the data and create a model predicting the climatic niche of *Melia dubia* in India. The climatic niche of the species is characterized by the temperature seasonality of 1.5°C (amount of temperature variation over a given year); the isothermality of 60-65%; precipitation of warmest quarter~400mm and precipitation of coldest quarter ~1000-2000mm. The MaxEnt model (version 3.4.3) with an overfitting regularization value of 1 predicted that 3.92% of India's total geographical area is highly suitable for cultivating *Melia dubia*. This study suggests that *Melia dubia* has the potential to be cultivated in a significant portion of India, particularly in areas with moderate temperature variations, consistent temperatures throughout the year, and distinct wet and dry seasons. With regard to the climate change impact on the *M. dubia* faces a decline in suitable habitat under more severe climate scenarios based on the CanESM5 and HADGEM3-GC31-LL under SSP 126, SSP 245, SSP 370 and SSP 585, indicating vulnerability of the species.



NRMA/CAFRI/SIL/2023/006/00159

Evaluating 3R's for carbon neutrality in melia based agroforestry system

(Sushil Kumar, Sovan Debnath and Suresh Ramanan S)

A field experiment with two tillage practices and five nitrogen management options on wheat in a green manure-wheat cropping sequence was conducted under a five-year-old *Melia dubia* plantation (Fig. 1). Data on plant growth, yield attributes and yield were recorded. Nitrogen management options significantly (p=0.05) influenced the performance of the wheat crop; however, tillage practices remain statistically at par with each other (Fig. 2). Among nitrogen management options, the application of 100% RDN recorded higher plant height (105 cm), number of tillers (148.81), length of the spike (9.97 cm), number of grains per spike (52.94), and thousand-grain weight (37 g). Between tillage practices, conventional tillage recorded comparatively higher growth, yield attributes, and yields than zero tillage. Concerning yields, the application of 100% RDN further proved to be advantageous, resulting in higher grain (17.50%), straw (28.08%), and biological yield (23.32%) over the control treatment. In addition to the above, the obtained data showed that the combination of 100% RDN and conventional tillage found to be better than the rest of the treatment combinations, yielding higher growth, yield attributes and yields of wheat.

Fig. 1. Field view of the experiment

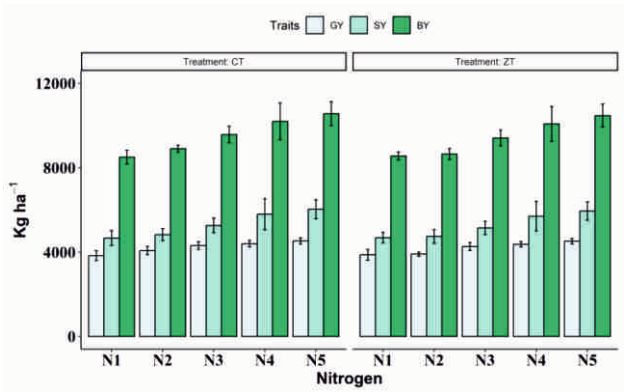


Fig. 2. Effect of nitrogen and tillage on grain, straw and biological yield of wheat

2. Research Achievements

2.4. Agroforestry Extension Research Programme

NRMA/CAFRI/SIL/2021/014/00138

Constraints in adoption of agroforestry in Bundelkhand region of Central India

(R P Dwivedi, Sushil Kumar and Priyanka Singh)

Data collection were made from Bundelkhand villages. From preliminary focused group discussion, it is revealed that the major constraint in adoption of agroforestry is stray animals (21.75%). The data tabulation and entry is under the progress from other identified villages.

NRMA/CAFRI/SIL/2021/015/00139

Impact assessment of agroforestry and water conservation interventions on livelihood of farmers in Garhkundar-Dabar watershed

(Sushil Kumar and Priyanka Singh)

As per the project plan, surveys were conducted to assess the impact of Garhkundar-Dabar watershed development on the livelihoods of its inhabitants. The data indicated that watershed development has significantly improved the availability of drinking and irrigation water, which subsequently positively affects agriculture and allied enterprises in the area. Regular cultivation of *Kharif* and *Rabi* crops in the watershed area has changed the cropping pattern, resulting in an increase in gross cropped area, cropping intensity, and crop rotation intensity. This change has renewed farmers' interest in farming, leading to increased use of farm inputs like fertilizers and pesticides. Moreover, interventions in the watershed area have improved farming by enhancing the productivity of all types of crops (20-50%), increased the availability of quality fodder, reduced migration patterns, and *Anna Pratha*. Concerning tree density as per the land use types, the highest density was observed in grazing land, followed by boundary and cropland (Table 1). A converse trend was observed for species diversity, being highest for trees planted in boundaries compared to other land use types. The Shannon diversity index for the cropland was minimum, with an average H' of 0.93 per farm (Table 1). Therefore, it is said that the interventions not only ensured food security but also reduced income variability among farmers in the Garhkundar-Dabar watershed.

Table 1. Density and diversity of tree species for different land use type within household surveyed.

Land use area	Households	Tree density (No./Acre)	Shannon index
Boundary	93	6.51	2.24
Cropland	45	3.64	0.93
Grazing land	15	9.85	1.45

NRMA/CAFRI/SIL/2021/016/00140

Economic impact of ICAF-CAFRI interventions in Parasai Sindh Watershed

(Priyanka Singh and R P Dwivedi)

The above study was conducted in three treated villages namely Parasai, Chhatarpur and Bachauri and three control villages *viz*; Rajapur, Imliya were selected. Primary data was collected from the rural households in the villages on various socio-demographic, institutional, economic and farm characteristics. Using advanced econometric modelling data were analyzed and results revealed that:

- Joint adoption of practices (soil bunding and/or forage stripping) with agroforestry bund plantation only account for 21% while with block plantation of trees it is 15%.
- The probability of adoption of only technology was highest for soil bunding (8%) followed by boundary plantation of trees (6%), block plantation of trees (4%) and forage grass stripping (3%).
- Around 29% of the sample household did not adopted any of the interventions suggesting that a lot needs to be done in popularization and creating awareness on NRM practices among farmers.
- The estimated results of the ordinary least square (OLS) model showed that a 1% increase in the tree density and tree diversity on farm significantly increases food consumption score (FCS) by 0.231% and 0.141% points, respectively, ceteris paribus.
- The results further indicated that integrating trees on farm has a significant negative effect on income variability. Unit percentage increase in the tree density and tree diversity decreases income variability by about 0.38% and 0.16%, holding all things constant.

NRMA/CAFRI/SIL/2023/007/00160

Valuation of ICAR-CAFRI technologies

(Priyanka Singh and R P Dwivedi)

The economic impact of ber budding and pruning technique was assessed using "*Economic Surplus Model (ESM)*". Weighted production gain per tree was calculated (Table 2) and then cumulative number of beneficiaries and

cumulative output of ber for the year 2008-2023 was estimated (Fig. 1). Cumulative ber output was calculated considering ber budding was performed on the field of 15 farmers every year (2 trees per farmer) from 2008 and there is 26% horizontal extension (farmer to farmer adoption) of technology (CAFRI annual Report 2010). The supply and demand elasticity of the Ber was assumed to be 0.50 and 0.50, respectively. The price of ber was sourced from reports of Directorate of Marketing & Inspection (DMI), Ministry of Agriculture & Farmers' Welfare, GoI.

The economic benefits of Ber budding and Pruning technology in Bundelkhand region of central India are presented in Table 3. It is evident that with the assumption of price elasticity of supply 0.50 and price elasticity of demand 0.50, the net economic surplus due to this technology is 31.20 lakhs from the period 2008 to 2023. The producer's surplus formed around 55 per cent while the consumer surplus formed 45 per cent of the surplus (Table 3). Thus, producers benefited more than consumers. The farmers are earning an annual return of around Rs. 6500 from the adoption of this improved ber budding technology.

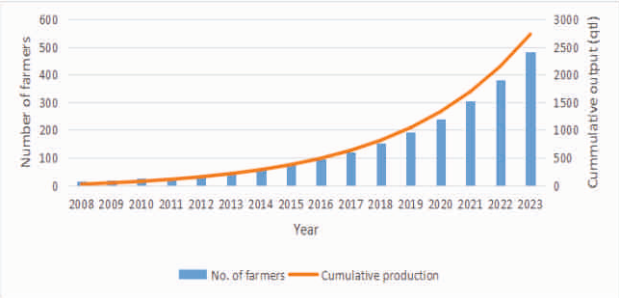


Fig. 1. Number of technology adopters and cumulative production over time

Table 1. Economic Parameters for ESM

Parameter	Value
Yield advantage (%)	25
Annual extension cost (at 2023-24 prices)	Rs. 6000
Additional input cost	Nil (0.001)
Maximum adoption rate in per cent	26
Supply elasticity	0.50
Demand elasticity	0.50
Probability of success (%)	100

Table 2. Estimation of weighted production gain per tree

Farmers (No.)	Average production gain (Kg)	Weight	Weighted production gain (Kg)
38	45	0.4523	
34	65	0.4047	60.9523
12	100	0.1428	

Table 3. Impact of Ber budding and pruning technology using Economic Surplus method

Parameters	Value
Estimation period	2008-2023
Consumer surplus (Rs. Lakhs)	13.99
Producer surplus (Rs. Lakhs)	17.21
Total economic surplus (Rs. Lakhs)	31.20
Annual benefit per farmer (in Rs.)	6500

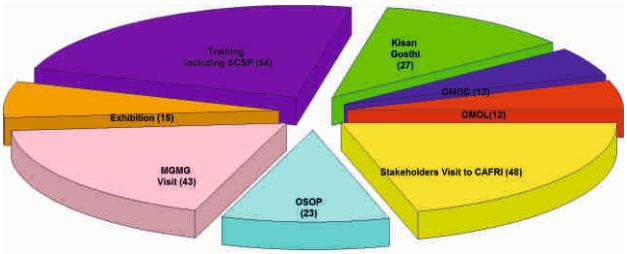
Scientific Social Responsibility in Agroforestry

scientific social responsibility (SSR) is the ethical obligation of "giving back" to less endowed stakeholders of science, technology, and innovation as well as society at large, some of the benefits that science derives from it. The relationship between science and society being a two-way engagement, SSR is not only about scientific impact upon society, but also about social impact upon science. So, ICAR-CAFRI along with AICRP Centres located in different agro-climatic zones would therefore strengthen the knowledge ecosystem in agroforestry and tree sciences to bring efficiencies in harnessing science for societal benefits of society. It is believed that the SSR would also bring about an attitudinal change in the mind set and work style of the scientific community, thereby enhancing the social reputation of our Institute/Organisations. Thus, SSR has the potential to fundamentally transform society by improving the lives of our citizens while helping the nation to achieve its goals for sustainable development.

कृषकों की दिशा एवं दशा बदलने हेतु कृषिवानिकी

भूमि उपयोग पद्धति के रूप में कृषिवानिकी की उत्पत्ति मानव सभ्यता के आरंभ से ही हुई है। पेड़ और अन्य लकड़ी वाले बारहमासी पौधे हमेशा से ही खेती के महत्वपूर्ण घटक रहे है, जैसा कि दुनिया भर के सभी कृषि समुदायों द्वारा किया जाता है। वनीकरण, पुनर्वनीकरण और कृषि परिदृश्य पर पेड़ लगाना पर्यावरण सुरक्षा के साथ–साथ टिकाऊ खाद्य उत्पादन के सर्वोत्तम विकल्पों में से एक माना जाता था। कृषिवानिकी को बढ़ावा देने हेतु यह दस्तावेज (कृषकों की दिशा एवं दशा बदलने हेतु कृषिवानिकी) "तकनीकी बुलेटिन" के रूप में प्रकाशित किया गया है, जो कि कृषिवानिकी में अनुसंधान, विस्तार और मानव संसाधन विकास में महत्वपूर्ण भूमिका प्रदान करेगा तथा कृषिवानिकी के सभी हितधारकों को लाभान्वित करेगा।

CAFRI Outreach Activities



2. Research Achievements

2.5: Other Research Activities

Exploration of foliar neem microbiome to evaluate against neem dieback disease

(M Ashajyothi, Y N Venkatesh and A Arunachalam)

Neem (*Azadirachta indica*) culturable prokaryotic microbiome from adaxial and abaxial surfaces was isolated by leaf imprinting method. The leaf samples representing the entire tree were excised from the upper, middle and lower crown positions of the neem tree. The leaves were collected in sterile sample bags transferred samples immediately from the field to the lab. The leaves representing all three positions were taken for imprinting. For adaxial imprinting, the leaf was placed so that the upper surface was in firm contact with the medium. The leaf was gently pressed by a sterile L- spreader. The leaf lamina was left undisturbed for about three hours on the nutrient agar, and the plates were incubated for 48 hours at 28°C. Similarly, the abaxial surface of the leaf was also imprinted. Finally, the confluence of colonies on the plates was imaged (Fig. 1). The bacterial colonies of the adaxial surface, on an average, was calculated as 511, while that of abaxial surface was calculated as 460 for each leaf with an area of 18.9 cm^2. Then, the different individual colonies were marked and separated by S-shaped streaking on nutrient agar (Fig. 2). Subculturing of the colonies was performed by streaking them on the nutrient agar to obtain pure culture in the form of single colonies (Fig. 3). A total of 112 colonies were obtained from adaxial surface and 48 colonies from abaxial surface which were documented and preserved in glycerol at -80°C for further analysis. For isolation of neem endophytic bacteria, fresh leaves were collected in sterile sample bags and transferred to the lab. The leaves were surface sterilized in sodium hypochlorite (1%), ethyl alcohol (70%) followed by series of washing in sterile 1X Phosphate Buffered Saline with 0.1% tween20 for two times and sterile deionized water for five times and used after blot drying. One gram of leaf sample was aseptically grinded in Phosphate Buffered Saline and decimal dilution up to 10^{-5} was prepared and one mL of 10^{-2} to 10^{-5} dilutions pour plated onto nutrient agar plates and incubated at 28°C for 48 hours. For each dilution, three replicates were maintained. Sterility check was performed by plating 1.0 mL of fifth wash on nutrient agar medium. A total of 23 colonies were obtained which were streaked as S-shaped onto the nutrient agar medium (Fig. 4). Subculturing of the colonies has been performed by streaking them on the nutrient agar to obtain pure culture.

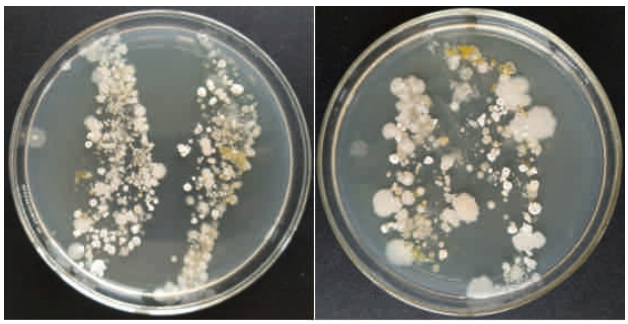
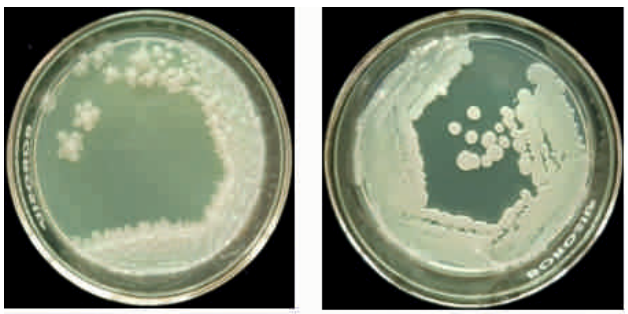
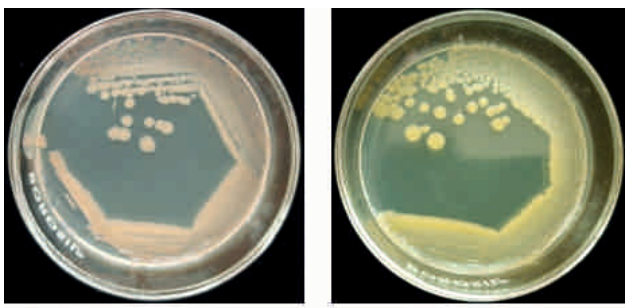


Fig. 1. Leaf imprinting of adaxial and abaxial surface of neem

Fig. 2. Separation of epiphytic microbial colonies from adaxial surface of neem leaves

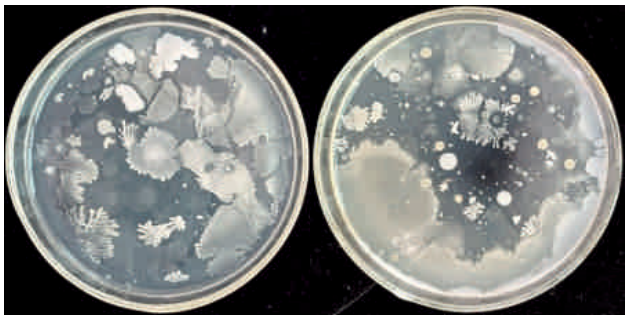


Bacterial colonies of adaxial surface



Bacterial colonies of abaxial surface

Fig. 3. Representative images of epiphytic bacterial colonies in pure culture form isolated from neem leaves



Neem endophytic bacterial colonies in 10^{-3} and 10^{-5} dilutions

Fig. 4. Bacterial endophytes isolated from neem leaves

Agroforestry based integrated farming system (Institute activity)

(Asha Ram)

The agroforestry-based farming system model is a multifunctional agroforestry model which started during the year 2016. In this model various crops, *viz.*, wheat, chickpea, field pea (*rabi* season), maize, urd bean and paddy (*kharif* season) were grown successfully. From the roadside moringa plantation, about 300 kg moringa pods were harvested. In agri-horti block about 3.0 t guava fruits were harvested from 40 guava plants. Bunds were utilized in agroforestry plantation (Teak and *Melia dubia*) along NB hybrid grass. From bunds, around 7.0 – 8.0 tonne of grass was harvested (on a fresh weight basis). In animal unit of farming system, duckery, poultry, fishery and goat rearing were also carried out successfully. During year 2024, total goat flock was increased by nine male/female goats. This farming system model has been demonstrated to hundreds of farmers during trainings and exposure visits to ICAR-CAFRI, Jhansi. It has evolved into a dynamic hub for experiential learning, serving as an exemplary model for the cultivation of climate-resilient production systems.

Barley+Guava

Farmers' training at fish pond of agroforestry based farming system

Harvesting of guava from agroforestry based farming system model

Fish production in rain water harvesting pond constructed in agroforestry based farming system

2. Research Achievements

2.6: Externally Funded Projects

ICAR Network Project

NRMA/CAFRI/SOP/2008/001/00077

Harvesting, Processing and Value Addition of Natural Resins and Gums

(Rajendra Prasad, Badre Alam and A K Handa)

For the ICAR-CAFRI Jhansi centre of the NP-HPVANRG, two sub projects are approved *viz.* i) Documentation of Indigenous technical knowledge (ITKs) on harvesting, processing and value addition of NRG's in India (duration: April 2023- March 2026) and ii) Feasibility for inclusion of NRG plants into economically viable agroforestry models (duration: April 2023- March 2026). During 15th annual workshop it was suggested that need based tools and equipment under sub project on ITK should be developed based on survey report, and in sub project two it was opined that statistical analysis should be included in the project report. The progress made during the year is discussed below.

Sub-Project -1: Documentation of Indigenous technical knowledge (ITKs)

Survey of tribal area for ITK

During the year Niwari district of M.P. was surveyed with the help and cooperation of divisional forest officer. The details of villages and the occupation of tribal communities are given in Table 1. The main occupation of tribal in Niwari district was agriculture as small and marginal farmers. They cultivate agricultural crops (wheat, chickpea, mustard, coriander, garlic, potato *etc.*). Rearing of animal/ cattle and collection of non-wood forest produce (NTFPs) remain secondary source of livelihood. The main gums and resins collected by tribal in Niwari include *Acacia catechu* (khair gum) *Butea monosperma* (palas gum) *Sterculia urens* (karaya gum) *etc.* The prices at which different NTFPs are sold by tribal is given in Table 2. During interactions gum tappers informed that they do not adopt any post-harvest value addition processes except cleaning of the gums tears.

Development of gum tapping tool- CAFRI-Thorny Tree Gum Amasser

Based on ITK, a gum tapping tool- *CAFRI-Thorny Tree Gum Amasser* has been developed to tap gum from thorny trees like *Acacia nilotica, Acacia senegal, Acacia catechu etc.* This tool is likely to increase the efficiency of gum collectors and reduce their drudgeries particularly of tribal women who do not dare to climb on thorny trees. The CAD design was developed with the help of ICAR-CIAE, Bhopal. Two prototypes were got fabricated locally and bamboo sticks was fixed as handle. During summer season the CAFRI-Thorny Tree gum amasser was used for collecting gum tears from the trees of *Acacia nilotica* (Plate 1). It is easy to use and a laborer collected 15 gum tears (65.0 g) in 10 minute. Total gum collection depends on presence of exuded gum tears on the tree. It increased

Table 1. Tribal villages surveyed for ITK on gum tapping and its uses in Niwari district of M.P.

Districts	Forest range	Beat	Village	Tribal community	Total no. of tribal families	No. of respon-dents	Latitude	Longitude
Niwari (M.P.)	Niwari	Teharka	Teharka	Sor (Sahariya) Adivasi	200	20	25º16'56.2"	78º53'53.9"
	Prithvipur	Chandpura	Chandpura	Sor (Sahariya) Adivasi	100	7	25º18'17.8"	78º41'2.69"

Table 2. List of NTFPs prices in surveyed areas of Niwari districts of Madhya Pradesh.

District	Forest produce	Price (Rs./Kg)
Niwari	Khair gum	100 to 150
	Palas gum	100 to 120
	Satawar roots	80 to 150
	Kali gudi	
	Arjun bark	Rates are fixed
	Jamun Bark	

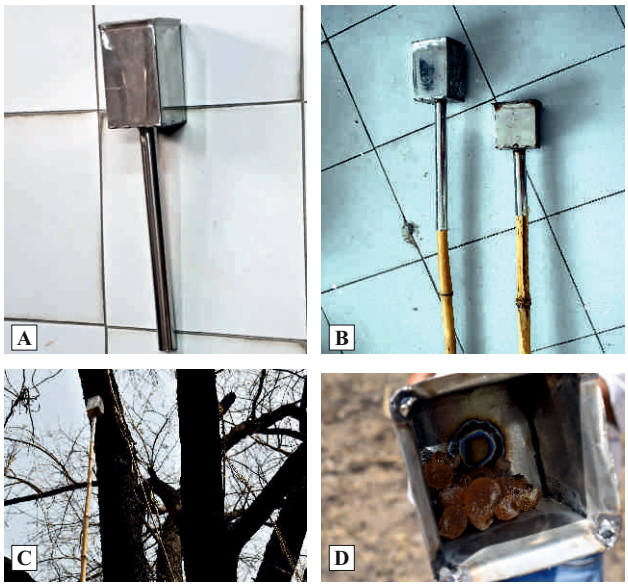


Plate 1. Locally fabricated prototype of CAFRI-Thorny Tree Gum Amasser (A), prototypes with fixed bamboo handle (B), Collection of gum tears from *A. nilotica* (C), and collected gum-tears of *A. nilotica* in Gum amasser (D)

efficiency of laborer collecting gum from thorny tree and also increased quantity of total gum collected in comparison to tapping gum manually by climbing on the tree. Further, it also reduced drudgery of laborer and risk of being pierced with thorn. The concept and design of CAFRI-Thorny Tree Gum Amasser has been registered in ITMU of ICAR-CAFRI, Jhansi.

Sub-Project -2: Feasibility for inclusion of NRG plants in Agroforestry

i) Promising gum yielding trees for economic viability in agroforestry

The agroforestry models viz., multi-component based agri-horti-silvicultre, rainfed agri-silviculture, silvi-herbal, bio-fence, and block planting on rocky site and gum gardens are being maintained on the research farm of the institute. The data on tree growth, gum yield and intercrop production from these models are recorded.

In *A. senegal* based multi-component agri-horti-silviculture model, maximum GBH and canopy spread was observed in *A marmelos* followed by *A senegal* and *C. limon* while the minimum (collar dia) in *C. carandas* (Table 3). Maximum tree height was recorded in *A. senegal*. During summer season, the field was green manured with dhaincha (*Sesbania aculeata*) by which green biomass of 3.8 t ha^{-1} was added.

As an intercrop barley was grown during winter season and data were recorded for different crop parameters to assess tree-crop interactions. Presence of trees as well as distance from tree trunk has shown variable effects on growth and yield characters of barley intercrop (Table 4). The grain yield was significantly affected by the type of woody species and the distance from the tree trunk. In comparison to control, irrespective of distance from tree trunk, decline in grain yield was 19.9, 25.8 and 20.9% in association of *A.*

Table 3. Growth of woody perennials in *A. senegal* based multi-component model (15 years old)

Woody plants	GBH (cm)	Height (m)	Canopy spread (m^2)	Pruned biomass (kg $tree^{-1}$)
A. Senegal	52.4 ± 5.16	5.9 ± 0.37	25.6 ± 4.85	4.4 ± 0.49
C. limon	28.8 ± 1.56	4.5 ± 0.23	16.9 ± 2.51	4.6 ± 0.59
A. marmelos	57.5 ± 4.36	5.7 ± 0.32	34.8 ± 3.83	4.1 ± 0.54
C. carandas	4.7 ± 0.34 (CD)	2.2 ± 0.11	2.6 ± 0.33	--

Table 4. Effect of woody perennial on yield of intercrop (Barley) in *A. senegal* based multi-component model

Parameters	Distance (m)	Plant species			Mean	Control
		A. senegal	*C. limon*	*A. marmelos*		
Plant population/m^2	1.0	29.7	27.3	28.0	28.3 (37.7)	
	2.5	33.7	31.3	34.0	33.0 (27.5)	
	4.5	34.7	34.3	37.0	35.3 (22.3)	
	Mean	32.7 (28.1)	31.0 (31.8)	33.0 (27.4)		45.5
	CD for trees: NS; CD for distance: 2.165; CD for Trees x distance: NS					
Grain yield (g/m^2)	1.0	135.0	130.7	129.2	131.6 (33.86)	
	2.5	161.7	138.7	163.3	154.6 (22.33)	
	4.5	181.3	173.5	179.67	178.2 (10.47)	
	Mean	159.3 (19.9)	147.6 (25.8)	157.41 (20.9)		199.0
	CD for trees: 7.702 ; CD for distance: 7.702; CD for Trees x distance: NS					

Figures in parentheses are percentage reduction in comparison to control.

senegal, C. limon and *A. marmolos,* respectively. Similarly, irrespective of woody species, grain yield reduced to the tune of 33.86, 22.33 and 10.47% at distance of 1.0 m, 2.5 m and 4.5 m, respectively over control. During the year, 180 kg lemon, 156 kg karonda 1550 kg of bael fruits were produced from the fruit yielding components of the model. The fruits were auctioned on standing trees.

In rainfed agri-silviculture model, both the trees *viz. A. nilotica* and *A. senegal* attained more GBH at 10x10m spacing in comparison to trees planted at 10x5m and 5x5m (Table 5). However, in case of tree height the trend was variable. The *A. nilotica* recorded maximum height in 10x10m spacing while *A. senegal* in 5x5m. *The A. nilotica* recorded maximum canopy spread at 5x5m and in *A. senegal* at 10x10 m. During summer season of 2024, green manuring was practiced with dhaincha crop and biomass of 1.99, 2.89 and 4.41 ton/ha was added in soil in 5x5 m, 10x5m and 10x10 m spacing, respectively. During winter season, taramira (*E. sativa*) was sown on conserved moisture as an intercrop.

The tree species did not influence crop parameters while the tree spacing significantly affected the plant population, pods/plant and grain yield. (Table 6). Maximum grain yield was recorded in 10x10 m spacing followed by 10x5 m and 5x5 m. In comparison to control, maximum reduction in grain yield was noticed at 5x5 m followed by at 10x5 m. There was no reduction in grain at 10x10 m spacing. In silvi-herbal model-I and II *A. nilotica* attained more GBH, height and canopy spread than *A. senegal* and *T. arjuna* (Table 7). Maximum survival, growth and biomass yield of lemon grass were recorded in tussocks planted at 100x100cm spacing.

Data on growth of trees in gum garden (Table 8) revealed that *A. senegal* attained maximum GBH (33.6 cm) in ten years old gum garden while the maximum height (5.0 m) was recorded in 15 years old block plantation at rocky hillock. In both the gum garden, performance of *B. monosperma* was very poor.

The naturally exuded mean gum yield of 107, 24.0, 13.6 and 26.7g per tree was obtained from *Acacia senegal* in multi-component model, old gum garden, new gum garden and rainfed model, respectively (Table 9). Similarly, from *A. nilotica* the mean gum yield was 43.7 and 7.2g per tree respectively, in silvi-herbal model and rainfed agri-silvicultre. (Table 10)

Table 5. Growth of trees in rainfed agri-silviculture model

Agroforestry models	GBH (cm)	Height (m)	Canopy spread (m^2)	Pruned biomass (kg $tree^{-1}$)
A. senegal				
10 m × 10 m	52.1 ± 7.40	5.1 ± 0.60	17.1 ± 4.53	5.8 ± 1.02
10 m × 5 m	39.3 ± 3.20	4.8 ± 0.28	14.1 ± 2.35	4.1 ± 0.49
5 m × 5 m	42.2 ± 1.52	5.3 ± 0.14	16.1 ± 1.02	3.9 ± 0.55
A. nilotica				
10 m × 10 m	68.5 ± 6.11	6.1 ± 0.44	17.2 ± 3.99	5.3 ± 1.14
10 m × 5 m	51.6 ± 3.53	5.5 ± 0.24	16.7 ± 2.32	4.2 ± 0.54
5 m × 5 m	45.9 ± 1.57	5.7 ± 0.12	18.1 ± 0.91	4.0 ± 0.55

Table 6. Effect of tree species and planting spacing on yield of *E. sativa* in rainfed agri-silviculture model

Parameters	Tree species	Spacing			Mean	Control
		10 × 10	10 × 5	5 × 5		
Plant population/m^2	*A. Senegal*	7.0	6.3	4.7	6.0	
	A. nilotica	8.0	6.0	4.7	6.2	
	Mean	7.5	6.2	4.7		8.33
LSD (P=0.05)	For trees: NS; For Spacing: 1.148; For Trees x Spacing: NS					
Pods/plant	*A. Senegal*	117.5	96.6	75.1	96.4	
	A. nilotica	117.0	104.8	58.9	93.6	
	Mean	117.25	100.7	67.0		117.07
LSD (P=0.05)	For trees: NS; For Spacing: 9.823; For Trees x Spacing: NS					
Seed yield (g/m^2)	*A. Senegal*	41.3	33	22	32.1 (17.7)	
	A. nilotica	38.3	28.3	20	28.9 (25.9)	
	Mean	39.8	30.7 (21.4)	21.0 (46.2)		39
LSD (P=0.05)	For trees: NS; For Spacing: 4.109; For Trees x Spacing: NS					

Data on performance of *A. senegal* in different bio fence models (Table 11) revealed that. Maximum collar diameter (48.5mm) and tree height (3.1m) was obtained in outer row of double-row model-3 planted at 1.5m apart. The minimum collar dia (25.7mm) of *A. senegal* was observed in outer row of double row of bio fence model-4. Maximum canopy spread (1.9m) was observed in Model-2. Only sanitation pruning was done in all the biofence models.

Table 7. Growth of trees in Silvi-herbal model

Agroforestry models	GBH (cm)	Height (m)	Canopy spread (m^2)	Pruned biomass (kg $tree^{-1}$)
Silvi-herbal model-I				
A. nilotica	69.2 ± 5.81	6.9 ± 0.38	23.3 ± 3.92	11.4 ± 1.63
T. arjuna	38.6 ± 1.18	5.1 ± 0.13	8.3 ± 0.42	18.6 ± 1.33
A. senegal (at boundary)	52.8 ± 2.96	6.2 ± 0.24	17.1 ± 2.97	7.7 ± 1.10
Silvi-herbal model-II				
A. nilotica	105.0 ± 5.02	9.6 ± 0.24	76.5 ± 9.13	16.5 ± 2.16
T. arjuna	35.2 ± 0.72	4.2 ± 0.12	6.7 ± 0.32	18.1 ± 1.57
A. senegal (at boundary)	41.0 ± 1.09	5.9 ± 0.39	23.6 ± 3.69	10.1 ± 0.91

Table 8. Growth of *Acacia senegal* in gum-gardens and block plantation on rocky hillock

Tree species/ Agroforestry models	GBH (cm)	Height (m)	Canopy spread (m^2)	Pruned biomass (kg $tree^{-1}$)
A. Senegal				
Old gum garden (10 years old)	33.6 ± 0.95	4.6 ± 0.11	12.7 ± 0.76	3.1 ± 0.35
New gum garden (9 years old)	28.3 ± 0.91	4.2 ± 0.09	9.1 ± 0.45	2.9 ± 0.27
B. monosperma				
Old gum garden	1.4 ± 0.21 (CD)	0.8 ± 0.74	0.1 ± 0.03	-
New gum garden	1.6 ± 0.12 (CD)	0.8 ± 0.07	0.2 ± 0.03	-
Block plantation on rocky hillock (15 years old)				
A. senegal (at boundary)	31.7 ± 0.20	5.1 ± 0.08	13.1 ± 0.25	-

Table 9. Gum yield from *Acacia senegal* tree (natural exudation)

Parameter	Agri-horti-silviculture		Old Gum Garden		New Gum Garden		Rainfed agri-silviculture	
	No. of tears $tree^{-1}$	Gum yield (g $tree^{-1}$)	No. of tears $tree^{-1}$	Gum yield (g $tree^{-1}$)	No. of tears $tree^{-1}$	Gum yield (g $tree^{-1}$)	No. of tears $tree^{-1}$	Gum yield (g $tree^{-1}$)
Count	02		05		05		07	
Mean	4.5	107.0	2.2	24.0	2.2	13.6	5.14	26.71
Minimum	4	86.0	1	4.0	1	2.0	1	3.0
Maximum	5	128.0	4	48.0	5	32.00	15	71.00
SD	0.50	21.0	0.58	9.36	0.73	5.35	1.77	10.28

Table 10. Gum yield from *Acacia nilotica* tree (natural exudation)

Parameter	Silvi-herbal		Rainfed agri-silviculture	
	No. of tears $tree^{-1}$	Gum yield (g $tree^{-1}$)	No. of tears $tree^{-1}$	Gum yield (g $tree^{-1}$)
Count	07	8		
Mean	13	43.7	3.38	7.25
Minimum	2	10.0	1	2.0
Maximum	45	136.0	10	17.0
SD	5.73	17.51	1.07	1.78

Table 11. Growth of 5-years old *A. senegal* in different bio-fence model at research farm

Bio-fence models	CD (mm)	Height (m)	Canopy spread (m^2)	Pruned biomass (kg $tree^{-1}$)
Model-1 (Single row): *A. senegal* alternated with C. carandas at 1.0, 1.5 & 2.0m apart				
A. senegal	42.2 ± 4.81	2.3 ± 0.16	1.8 ± 0.35	0.5 ± 0.10
C. carandas -1.0m	5.3 ± 0.27	0.5 ± 0.07	0.03 ± 0.01	–
C. carandas -1.5m	8.4 ± 1.25	0.9 ± 0.12	0.11 ± 0.02	–
C. carandas -2.0m	6.3 ± 0.85	0.5 ± 0.07	0.06 ± 0.02	–
Model-2 (Double row): Distance between plant to plant within row and row to row 2.0m				
A. senegal (outer row)	37.6 ± 3.99	2.3 ± 0.17	1.9 ± 0.29	0.6 ± 0.09
C. carandas (inner row)	7.5 ± 0.57	0.8 ± 0.08	0.1 ± 0.02	–
Model-3 (Double row): Distance between plant to plant within row 2.0 and rows are placed apart 1.0, 1.5 and 2.0m				
A. senegal (outer row) - 1.0m	28.4 ± 4.18	2.4 ± 0.26	0.6 ± 0.18	0.6 ± 0.09
A. senegal (outer row) - 1.5m	48.5 ± 3.40	3.1 ± 0.15	1.5 ± 0.10	0.6 ± 0.07
A. senegal (outer row) - 2.0m	27.9 ± 3.19	2.5 ± 0.28	0.9 ± 0.19	0.6 ± 0.08
A. senegal (inner row) - 1.0m	47.3 ± 6.81	3.1 ± 0.30	1.2 ± 0.21	0.6 ± 0.06
A. senegal (inner row) - 1.5m	39.4 ± 2.89	2.8 ± 0.17	1.1 ± 0.12	0.6 ± 0.08
A. senegal (inner row) - 2.0m	46.0 ± 4.80	3.0 ± 0.17	1.8 ± 0.17	0.6 ± 0.07
Model-4 (Double row) : Distance between plant to plant within row 2.0m and rows are placed apart 1.0m				
A. senegal (outer row)	25.7 ± 1.99	1.4 ± 0.09	0.34 ± 0.09	0.5 ± 0.07
A. senegal (inner row)	30.4 ± 2.31	1.5 ± 0.11	0.80 ± 0.13	0.6± 0.09

ii) Evaluation gum-tapping tools/techniques for feasibility of adoption in agroforestry

Evaluation of IINRG- gum tapping Blazer- 75 and Blazer-150

To assess feasibility of using IINRG-gum tapping Blazer-75 and Blazer-150 in agroforestry trees. The trials were conducted on existing trees at research farm of the institute for tapping gum-butea *(B. monosperma)*, gum-dhwara (*A. latifolia*), gum-gatti (*A. pendula*), gum babul (*A. nilotica*) and gum Arabic *(A. senegal)*. Single cut was made on a tree (Plate 2) with blazer-75 and blazer-150 by hammering with hammer. Three replications were used for each tree species. Observation on gum exudation was recorded and exuded gum collected. The findings revealed that use of Blazer-75 yielded negligible gum only in *B. monosperma* (2.0 g/cut) and *A. latifolia* (1.0 g/ cut) and in other species such as *A. pendula, A. nilotica* and *A. senegal* no gummosis was observed when gum was tapped using Blazer-75. The Blazer-150 was tested on *A. latifolia* (Gum-dhawara) and the results are not encouraging. The cut made with Blazer-150 did not yield gum. Further, hammering requires force and it takes about 20-25 min to make single cut with the Blazer.

Plate 2. Use of Blazer-75 on *A. pendula* (A), *A. senegal* (B) and *A. nilotica* (C)

Assessment of months-wise and seasonal variability in exudation of Palash gum

The trial for assessing month-wise and seasonal variability in gum exudation in Palash (*Butea monosperma)* was concluded. The results revealed that gum exudation and its yield varies significantly in different months (Fig. 1) and seasons of the year. Maximum gum yield is obtained in the month of December (40.80g/ sample stem area) followed by January (39.5g) and February (26.1g). From December to June the gum yield declines reaching to the minimal in the month of July, August and September. The maximum potential total gum yield (613.5g/tree) was recorded in winter season (November to February) followed by

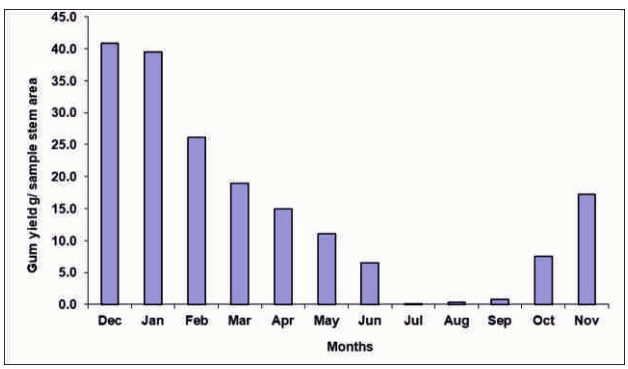


Fig. 1. Month-wise pattern of gum exudation from *B. monosperma*

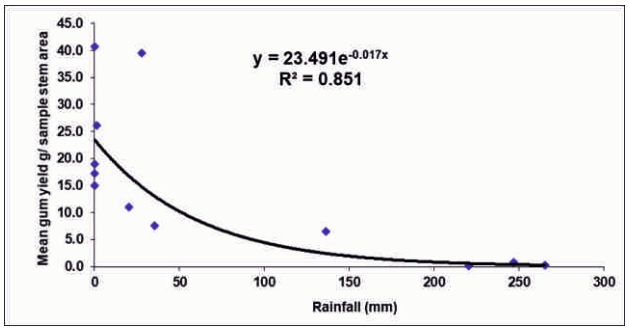


Fig. 2. Relationship between rainfall and gum exudation in *B. monosperma*

summer (March to June) (223.4g/tree) and minimum (38.9g/tree) in rainy or monsoon season (July to October). The gum yield exponentially declined (R^2 0.851) with the increase in rainfall (Fig. 2). The findings of the trial concluded that months of December and January of winter season are the best time to tap butea trees for maximum gum yield.

iii) Demonstration and development of gum yielding tree based agroforestry models on farmers' fields

During the year, visits were conducted to villages Garhkundar, Binwara, Ambabai and Kochhabhawar to see agroforestry models developed on farmers' fields and growth of trees was monitored. The farmers were motivated to adopt more agroforestry on their farm. About 500 seedlings of *A. senegal* raised in nursery were supplied to farmers. Besides, the agroforestry models including bio-fence models developed at the research farm of the institute were demonstrated to visiting farmers. Data on tree growth on farmer's field reveals that the GBH of *A. senegal* on farmer's field ranged from 22.4cm in village ambabai to 41.9cm in garhkundar (Table 12).

NRMA/CAFRI/SOL/2021/017/00141

Trees Outside Forests in India (TOFI)

(A Arunachalam, A K Handa, Suresh Ramanan S, Naresh Kumar and Priyanka Singh)

Trees Outside Forests in India (TOFI) is a joint initiative by the United States Agency for International Development (USAID) and the Ministry of Environment, Forest and Climate Change (MoEFCC) of the Government of India. The initiative is aimed to improving the area under trees outside forests (TOF) for the benefit of livelihoods and the ecosystem. The project focuses on 7 states (Andhra Pradesh, Assam, Haryana, Odisha, Rajasthan, Tamil Nadu, and Uttar Pradesh). ICAR-CAFRI (Central Agroforestry Research Institute), Jhansi is one of the partner of this program. The institute has focused on identifying potential tree species for deregulation in the TOFI states and has carried out state-specific initiatives to support the deregulation of selected species. The toolbox created by the CAFRI TOFI teams highlights the importance of tree deregulation and its role in advancing agroforestry and tree plantation projects outside Recorded Forest Areas (RFA). Additionally, online meetings have been held with stakeholders from the TOFI states to collect feedback on the toolbox. Beyond these activities, ICAR-CAFRI has also documented the

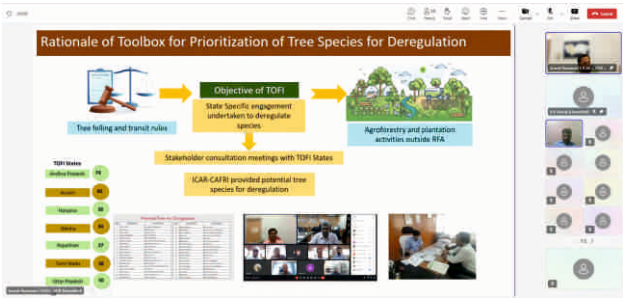


Table 12. Growth of *A. senegal* on farmers in different villages

Plant species	GBH (cm)	Height (m)	Canopy spread (m^2)
Shri Himmat's field in Garkundar (14 years old)			
A. senegal (boundary)*	41.9 ± 3.95	4.7 ± 0.31	7.1 ± 1.08
E. officinalis	67.4 ± 2.76	5.6 ± 0.20	24.4 ± 1.66
Shri Ghanshyam in Garkundar (11 year old)			
A. senegal (boundary)*	27.9 ± 1.82	2.7 ± 0.11	–
Shri Tiwari in Binwara (07 years old)			
A. senegal (boundary)*	38.1 ± 1.52	4.2 ± 0.09	–
Shri Mani Ram in Ambabai (11 year old)			
A. senegal	22.4 ± 0.65	3.1 ± 0.17	7.0 ± 1.11
Shri Janaki Prasad Kushwaha in Kochhabhawar (02 years old)			
A. senegal (boundary)*	18.8 CD (mm)	1.3	–
C. lemon	13.8 CD (mm)	0.9	–
C. carendas	9.7 CD (mm)	0.6	--

agroforestry potential area while evaluating and improving Trees outside Forests (TOF) and green infrastructure across the TOFI states. As part of the project, we have focused on domestication process of tree species suitable for TOF plantation activities, particularly those that have been typically neglected, such as *Terminalia catappa* and *Parkinsonia aculeata.*

NRMA/CAFRI/SOL/2021/018/00142

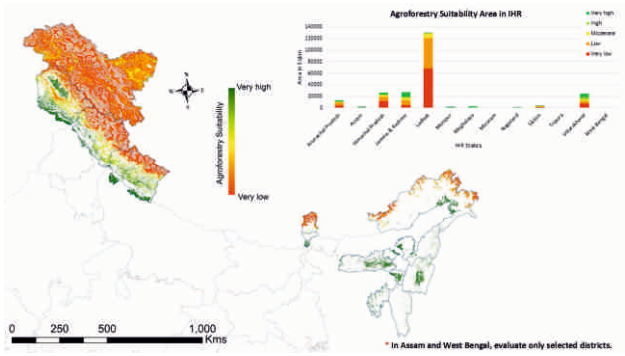
National Mission on Sustaining Himalayan Ecosystems (NMSHE) -Task Force on Himalayan Agriculture

(A Arunachalam, A K Handa and Suresh Ramanan S)

The Indian Himalayan Region (IHR) extends over approximately 2,500 kilometers across 13 states, including Assam and West Bengal, and is home to nearly 50 million people. This region heavily relies on sustainable agricultural practices as a primary source of income, which is essential for economic viability. Diversification of livelihoods is critical, as it not only creates opportunities for off-farm income but also encourages external development activities. Sustainable agricultural systems in the IHR incorporate modern technology, innovative seed and soil conservation methods, and the cultivation of horticultural crops and livestock. However, shifts in socioeconomic conditions have significantly influenced food security strategies among households in these mountainous areas. The Task Force collaborates with the Indian Council of Agricultural Research (ICAR) to focus on three distinct regions: the cold arid Himalayan region, the lower and middle Himalayan region, and the North-Eastern Himalayan region. The objectives of the Task Force include developing high-resolution seasonal climate scenarios, assessing agroecosystem changes due to extreme weather events, and creating block-level vulnerability assessments for selected districts. They aim to project climate change impacts on agriculture and formulate adaptation strategies to enhance farmers' resilience and incomes. During this period, pilot-testing of strategic adaptation technologies will occur alongside the development of ICT tools for disseminating these technologies. Training stakeholders is also a priority in building human resources for climate-resilient agriculture in the IHR. These initiatives are crucial for adapting agricultural practices to ongoing environmental changes while supporting local communities in maintaining food security amid evolving challenges.

The Objectives are:

1. To develop the bias-corrected high-resolution seasonal ensemble climate scenarios for the Indian Himalayan Region (IHR).
2. To characterize the agroecosystem changes in the past about extreme weather events and temporal changes.
3. To develop block-level vulnerability assessment for selected districts/states/ AEZ.
4. To project the integrated impacts of climate change on major agri-horticultural crops, livestock, and fisheries in IHR.
5. To develop adaptation strategies under climate change scenarios for each state of IHR.
6. To pilot-test the strategic adaptation technologies for improving the resilience and incomes of farmers in different agroecological zones of IHR.
7. To develop ICT tools for adaptation technology dissemination.
8. To train the stakeholders and develop human resources for climate-resilient agriculture.



NMSHE (Phase-2) Partner Institutes and their Location

The NMSHE Phase-II, part of the National Mission for Sustaining the Himalayan Ecosystem (NMSHE), focuses on understanding farmers' perspectives on climate change and piloting adaptation technologies to address vulnerabilities in agricultural communities within the Indian Himalayan Region (IHR). ICAR-CAFRI organized a one-day Ecological Niche Model workshop at the ICAR-Central Agroforestry Research Institute in Jhansi, Uttar Pradesh. This workshop aimed to equip NMSHE project staff with advanced tools and methodologies to improve resilience and adaptability to changing environmental conditions. Such capacity-building initiatives are crucial for empowering stakeholders with the knowledge to implement effective adaptation strategies in response to climate variability. Collectively, these initiatives illustrate a comprehensive approach towards sustainable agriculture that not only addresses immediate challenges posed by climate change but also promotes long-term ecological health and economic viability in the Himalayan region. Furthermore, a three-day training workshop on Carbon Farming and Assessment of Ecosystem Services was conducted, focusing on educating participants about carbon farming practices carbon budget, carbon pricing, carbon policy and contributing to climate change mitigation efforts. ICAR-CAFRI assessed agroforestry potential in IHR using GIS modeling, which evaluates factors such as soil moisture, slopes, NDVI (Normalized Difference Vegetation Index), and drainage. Approximately 48.23% of

Assam's land is identified as suitable for agroforestry. Additionally, ICAR-CAFRI is engaged in estimating soil loss in Assam over multiple years (2013, 2017, 2022) to address vulnerabilities related to floods and erosion. The findings emphasize the need for proactive measures to mitigate soil erosion challenges and promote sustainable land management. The IHR offers significant opportunities for agroforestry—a sustainable land-use system that integrates trees and shrubs with crops and livestock. However, climate change is impacting the Himalayan tree line ecotone, leading to ecological changes. Research utilizing Geographic Information Systems (GIS) and Analytic Hierarchy Process (AHP) techniques assesses environmental parameters affecting land productivity and suitability for Trees outside Forests (TOF) and agroforestry practices in Jammu & Kashmir. This study identifies optimal regions for different agroforestry systems aimed at enhancing agricultural productivity, improving biodiversity, urban green space, and contributing to climate resilience. A comprehensive agroforestry suitability map has been developed using advanced geospatial technologies and remote sensing data. The study uses Landsat-8 data and Digital Elevation Model products to understand farm landscape characteristics. The Western Indian Himalayan Region (WIHR) has a moderate to highly agroforestry suitable area (17.74%), while the Eastern Indian Himalayan Region (EIHR) has a higher forest cover (9.36%). The map identifies regions ideal for different agroforestry systems, aiming to enhance agricultural productivity, improve biodiversity, and contribute to climate resilience. Overall, these initiatives under the NMSHE Phase-II project underscore a multifaceted strategy towards sustainable agricultural practices that are vital for ecological resilience and economic sustainability in the Indian Himalayan Region.

A one-day workshop on the Ecological Niche Model

A one-day training workshop on Carbon Farming and Assessment of Ecosystem Services

NRMA/CAFRI/SOL/2021/021/00145

Pilot the solutions of chip-based technology for real-time and RFID-passive monitoring of gene-bank and agroforestry species for scaling up

(K Rajarajan and H Anuragi)

The real-time chip performance has been validated by optimization of chip signal information by artificial disturbance like shaking the branches, in addition to natural occurrence of heavy wind we had an alert notification such as severity-critical or tree is at risk in the SAMS portal. Similarly, the passive tags (RFID) of all the installed chips were scanned and updated the growth data at different frequency has been validated in the SAMS portal. The same has been approved by the super admin of this project at NBPGR, New Delhi. The RFID technology has been successfully implemented in agroforestry. This could involve monitoring tree health, tracking growth rates, or preventing illegal logging. It have a potential impacts of global forestry practices. For instance, this technology would help in the conservation of endangered species or in improving the efficiency of forest management. Also, this technology in forestry, such as cost savings, improved accuracy, and real-time data collection that aids in making informed decisions. In future it may be explored for how RFID could be integrated with other technologies like drones, AI, or IoT (Internet of Things) to enhance monitoring capabilities. Inclusion of micro-climatic threatening effects to the active chips would aid in real-time monitoring tree genetic resources for future changing climate scenario. Implementing this technology in to the large-scale farmers of high value timbers/essential oil trees would aid in better understanding of the technology. The stakeholders in forestry and agroforestry to consider adopting RFID technology and investing in further research and development. With these information this project was concluded.

NRMA/CAFRI/SOL/2021/019/00146

National Agriculture Innovation Fund (NAIF) Scheme

(Suresh Ramanan S and Ashok Yadav)

ICAR has been proactive in protecting intellectual property (IP) across its institutes through the implementation of the National Agriculture Innovation Fund (NAIF) project. At ICAR-CAFRI, this initiative aims to safeguard innovations, technologies, and products developed by the institute, ensuring their strategic management and commercialization for societal benefit.

ICAR-CAFRI has made significant strides in managing its intellectual property portfolio. Under trademarks, the device mark "CAFRI KRISHIVANIKI" was granted in Trade Marks Journal No. 2139, dated 15th January 2024, with registration numbers 5010470 and 5010471. In the realm of copyrights, several achievements stand out, including the granting of four copyrights. To ensure the transfer of its technologies, ICAR-CAFRI has organized outreach programs to engage the stakeholders for technology dissemination.

NRMA/CAFRI/SOL/2022/001/00147

Agri-Drone Project

(Asha Ram)

The Project entitled "Agri-Drone" was initiated in the year 2022 with the financial support of RKVY through ICAR-ATARI, Kanpur. The main objective of the project was to demonstrate the use of drone technology in agriculture and agroforestry to the farmers. Various spray demonstration have been carried out at institute research farm and at farmers' fields in *Kharif* season (Fig. 1). Benefits of drone technology in agroforestry have also been explained to the farmers during the drone demonstrations.

Fig. 1: Drone demonstration at Lathesara village in Tahrauli, Jhansi.

NRMA/CAFRI/SOL/2022/002/00148

Evaluating the performance of seaweed extract, humic acid, protein hydrolysate, biochemical and botanical extracts

(Ashok Yadav, A Arunachalam, Asha Ram, Mahesh Kumar Dhakad and D R Bhardwaj)

Spray of CAD Grow Powder/Flakes in strawberries, revealed significant differences among all plant growth and yield parameters compared to the control. All biostimulants applied treatments showed higher yield compared to the control. In strawberry, the spray of biostimulant *i.e.* CAD Grow Powder/Flakes revealed significant differences among all plant growth and yield parameters. Maximum plant height (20.69 cm) was observed in T3 treatment (RDF+150 g/acre), and maximum plant spread (NS & EW), fresh root weight, dry root weight, number of flowers, number of fruits, fruit weight, fruit yield/plant was observed in the T4 treatment (RDF+ 200 g/acre), whereas all traits showed minimum value in the control. Significant differences were observed in yield per plant of strawberry fruits with the highest fruit yield per plant (676.68 g) observed in T4 followed by T3 (587.87 g), T2 (464.04 g), and T1 (400.97 g) and all biostimulants applied treatments showed higher yield compared to the control. In pea sprays of biostimulant *i.e.* CAD Grow Powder/Flakes revealed significant differences among all plant growth and yield parameters except plant spread (NS & EW). Maximum plant height (89.13 cm) and plant spread (EW) were observed in the T2 treatment (RDF+ 150 g/acre), maximum spread (NS) was observed in the T3 treatment whereas fresh root weight, dry root weight, number of flowers, number of pods, pods weight, pods yield/plant was observed in the T4 treatment (RDF+ 200 g/acre), whereas all traits showed minimum value in the control.

In tomato spray of biostimulants *i.e.* CAD Grow Powder/Flakes revealed significant differences among all plant growth and yield parameters. Maximum plant height (74.84 cm), maximum plant spread (EW), fresh root weight, dry root weight, number of branches, number of flowers, number of fruits and fruit weight, fruit yield/plant were observed in T4 treatment (RDF+ 200 g/acre) and maximum plant spread (NS & EW), were observed in T3 treatment (RDF+ 150 g/acre), whereas all traits showed minimum value in the control. Significant differences were observed in yield per plant of tomato fruits with the highest fruit yield per plant (2.47 Kg) observed in T3 followed by T4 (2.34 Kg), T2 (1.44 Kg), and T1 (1.04 Kg) and all biostimulants applied treatments showed higher yield compared to the control. The

fruit set ratio was higher in all three biostimulant-applied treatments compared to the control. Among all the treatments, viral disease incidence has been observed. In mustard crops, sprays of biostimulant *i.e.* CAD Grow Powder/Flakes revealed significant differences among all plant growth and yield parameters. Maximum plant height (200.98 cm) and plant spread (EW & NS) were observed in T2 treatment (RDF+100 g/acre), maximum root biomass (fresh root weight and dry weight), number of flowers, number of pods, number of branches, and test weight and yield/ha were observed in T4 treatment (RDF+ 200 g/acre), whereas all traits showed minimum value in the control. All biostimulants applied treatments showed higher yield compared to the control. However, phytotoxicity, flower drop, and disease incidence have not been observed in all treatments applied in strawberries, pea, and mustard except in tomato crops in which there is the incidence of viral disease

NRMA/CAFRI/SOL/2022/003/00149

Development and evaluation of pomegranate-based agroforestry system in Bundelkhand region for higher productivity and economic returns at farmer's field.

(Ashok Yadav and A Arunachalam)

The traditional farming systems, in the semi-arid regions of the Bundelkhand, are largely subsistence in nature and are need-based. Besides, they are not necessarily efficient in the utilization of resources for a given location. Despite several challenges like frequent droughts, the increasing costs of cultivation, and lower compensation of labour and inputs have also made farming a challenging enterprise. Therefore, the above project is being implemented by ICAR-Central Agroforestry Research Institute, Jhansi, with financial support from NABARD Lucknow. During the last year following activities have been performed under the project.

- Several systematic surveys were conducted in the Bangra and Baragaon blocks for successful implementation of the pomegranate-based agroforestry system at farmers' fields.
- Conducted time-to-time survey and gave a demonstration of field layout, digging pits, bed preparation, and planting of pomegranate to all selected beneficiary farmers' fields completed.
- Tissue culture plants of pomegranate were purchased from Jain Irrigation Ltd., Jalgaon, Maharashtra and distributed uniformly to all the farmers of both blocks.
- To reduce the effect of climate change and heat waves the saplings of *Melia dubia* plants were distributed and planted in the bunds of fields at all the farmers.
- Distributed the different inputs (seeds of vegetables and spices, fertilizers, plant biostimulants, plant protection accessories) for implementation of the project.
- Planting of the BN hybrid rooted slips in the demonstration block of pomegranate at ICAR-CAFRI has been completed beside this, rooted slips were also distributed to the farmers also.
- To increase the income through crop diversification new and improved varieties of vegetables (beetroot, carrot, cabbage, broccoli and cauliflower) and spices (cumin, fennel, fenugreek, Nigella) seed were introduced and distributed to the farmers. Among vegetables beetroot and carrot performed well under Jhansi conditions.
- For better skill enhancement, Krishivaniki Schools were organized at farmers' fields in each block and experts delivered lectures as well as hands-on training, on maintenance of drip irrigation practices and maintenance pruning in pomegranates.
- Three PIMC (Project implementation and monitoring committee meetings) were conducted and discussed the project planning and implementation.

NRMA/CAFRI/SOL/2022/003/00150

***In-vitro* regeneration of multipurpose and medicinally important *Butea monosperma* Lam. and its assessment for mass propagation of genetically uniform quality planting material (Funded by NMPB, AYUSH, Govt. of India)**

(Hirdayesh Anuragi and K. Rajarajan)

Palash (*Butea monosperma*), a tree from the Fabaceae family, holds significant spiritual and medicinal value since Vedic times. Known as Dhak or Teshu, it creates a striking appearance in forest canopies during blooming, resembling flames. In Vedic literature, it is revered as a holy tree, or Brahma vriksha, and remains important in traditional medicine systems such as Ayurveda, Unani, and homeopathy. Today, Palash continues to be a valuable source of pharmacological properties for the pharmaceutical industry. The development of quality planting material (QPM) is essential for large-scale, uniform, and high-quality plantations of important tree species, particularly those with white and yellow flowers. In-vitro regeneration, or plant tissue culture, is a modern biotechnological method that can generate large quantities of QPM from small explants regardless of the time and season. However, efficient and rapid regeneration protocols are still lacking. Efforts are underway to achieve in-vitro regeneration of both red and yellow flower Palash trees, identified through local surveys. Various explants have been utilized to induce direct organogenesis using Murashige and Skoog (MS) and woody plant media (WPM) media supplemented with different concentrations of plant growth regulators (PGRs). Our study has achieved effective means of time saving tissue

culture protocol for plant regeneration in *B. monosperma* with a relatively higher shooting and rooting percentage (up to 80%). These plants are being tested for genetic homogeneity using reliable DNA-based molecular markers and survivability under primary and secondary hardening stages under controlled green house facilities.

Fig. 1. Different flower color variants (red, yellow and white) of Palash (*B. monosperma* Lam.) identified in Bundelkhand region of central India

Fig. 2. *In-vitro* regeneration of red and yellow flower colored *Butea monosperma*

NRMA/CAFRI/SOL/2022/005/00151

Strengthening community resilience by diversifying cropping system through agroforestry interventions in Central India

(A Arunachalam, A K Handa, R P Dwivedi, Naresh Kumar, Asha Ram and Suresh Ramanan S)

The project entitled "Strengthening community resilience by diversifying cropping system through agroforestry intervention in Central India" is funded by Government of Uttar Pradesh (the donor) under the Rashtriya Krishi Vikas Yojana (RKVY) and being implemented at cluster of 40 villages in Tahrauli Tehsil of Jhansi district along with ICRISAT Hyderabad as a partner of implementing consortia. The project duration is from April 2023 to March 2025, with two broad objectives *viz.*, i)-Integrating crop-livestock-tree based farming for diversified rural livelihood ii)- Developing capacity of the farming community through knowledge sharing and farmers participatory research/ demonstrations. Following activities were carried out as per project objectives:

Agroforestry Intervention: Interaction with farmers of project villages were carried out to create awareness regarding agroforestry and to undertake the agroforestry interventions at their fields. Their preference was worked out for undertaking the plantation activities on the selected farmers of the project villages. Guava, Mango, Aonla, Jackfruit, Jamun, Citrus and Karonda were the most desired among the fruit trees by the farmers of the project villages. Other tree component includes: Teak, Melia, Drumstick and Sandal. Different agroforestry models were established on the farmers' fields by including the desired tree species. In addition to establishment of agroforestry models, fruit trees were also distributed to the farmers for nutritional security and creating awareness for agroforestry plantation. Project team also assisted in carrying out the crop demonstrations and best management practices at farmers' fields of different village.

Layout activity for agroforestry demonstrations at Farmer's field at Lathesara and Silori villages

Training and capacity building programs for the farmers: Training programs aimed at raising awareness of agroforestry and enhancing farmers' capacity to implement agroforestry interventions were conducted both at farmers' fields and at ICAR-CAFRI in Jhansi. These programs included a combination of lectures and practical demonstrations, focusing on crop diversification through various agroforestry techniques. Krishak Gosthi, Scientist – farmer interactions were also organized in Lathesera, Nota and Silori villages. To inculcate the interest among the farmers, visits to Agroforestry Fields at ICAR-CAFRI were also conducted during the training programmes and other events.

Farmers-scientist interaction

Exposure visit of farmers

Demonstration of grafting techniques

Scaling up farmer's skill for production of quality planting material:

Trainings on the production of quality planting material were conducted both at farmers' fields and at the ICAR-CAFRI Nursery. Farmers received hands-on training in various grafting and budding techniques to produce quality planting material of fruit tree. This initiative has increased awareness about the importance of quality planting material and its integration into diverse agroforestry systems.

Monitoring and data recording:

The monitoring of agroforestry plantations on farmers' fields, along with data recording, is being conducted. Any plant mortality is promptly addressed by replanting new saplings. Regular advisory support for the effective management of various agroforestry components has also been provided.

Project activities at farmers' fields

NRMA/CAFRI/SOL/2022/006/00152

Tissue-specific physiological, molecular, and metabolomics analysis of green gram (*Vigna radiata*) for shade adaptive traits in the context of agroforestry (Funded by DST-SERB, Govt. of India)

(Hirdayesh Anuragi)

Sunlight is essential for plant growth and metabolism; however, shade stress from perennial trees poses a significant abiotic challenge to the annual crops in agroforestry systems. Developing crop cultivars that can tolerate shade stress could improve overall productivity in these systems. To achieve this, it is crucial to understand the morphological, physio-chemical, and molecular mechanisms involved in breeding crops for shade-stress tolerance. The green gram (*Vigna radiata* var. Virat), a widely recognized legume, was assessed under various shade stress conditions at various regimes (0% shade as control, 25%, 50%, and 75% shade) during the summer and kharif seasons of 2023 and 2024 in research farm of ICAR-CAFRI, Jhansi. Morphological studies using above-ground and below-ground root parameters clearly highlighted the negative impact of shade stress on plant growth and seed yield parameters. Physico-chemical parameters such as CCI, carotenoids, malondialdehydes (MDA), chlorophyll fluorescence, cell membrane stability (CMS), electrical conductivity (EC), phenols, prolines, antioxidant properties (catalase, peroxidase, superoxide dismutase activities), *etc.*, were varied sharply with respect to shade stress intensity. For further in-depth and comprehensive understanding, the whole transcriptomic sequencing and whole metabolomic profiling studies are being performed using latest available next-generation sequencing (NGS) tools, liquid chromatography-mass spectrometry (LC-MS) tools and bioinformatic tools that would clearly uncover the underlying candidate genes, metabolites and molecular mechanisms responsible for shade-stress response and adaptation in the green gram that would help in developing tolerant and improved varieties in future.

Effect of different shade stress regimes on the above-ground plant growth and below ground root system architecture of mungbean (*Vigna radiata* var. Virat)

NRMA/CAFRI/SOL/2023/003/00156

Large-scale screening and identification of *Azadirachta indica* accessions for high azadirachtin yield

(K Rajarajan, A K Handa and A Arunachalam)

During this year, molecular characterization and SNP identification using genotyping-by-sequencing (GBS) in 16 neem accessions as two populations west-central (WC) population and south-eastern (SE) for azadirachtin trait was carried out. In this study, genes involved in azadirachtin pathway such as cytochrome P450 (CYP), terpene synthase (TPS21), GGPs, FDPS, SQLE and AiGDs were studied for its functional SNP variation. The mapping percentage results ranged from 27.25% to 84.52%. The highest number of SNPs detected in west-central

population than south-eastern. Similarly, indels was maximum detected in WC population than SE. The chromosome wise SNP distribution was given in Figure.

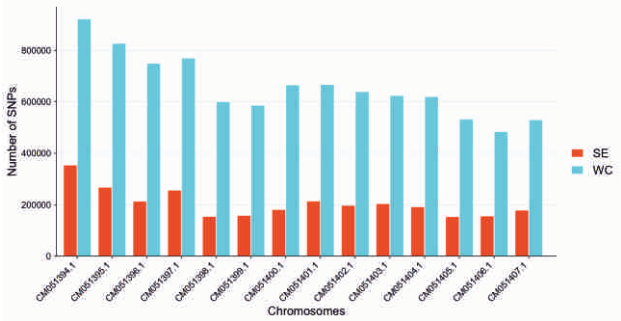


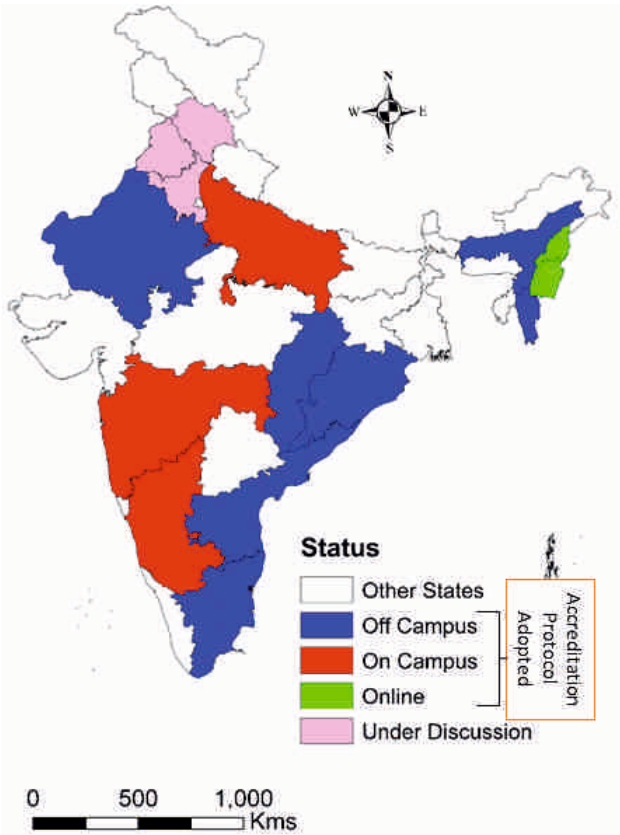
Fig. 1. Chromosome-wise SNP distribution among WC and SE population.

NRMA/CAFRI/SOL/2023/005/00158

RKVY-Quality Planting Material (QPM) Project

(A. Arunachalam, Suresh Ramanan S and A K Handa)

The ICAR-Central Agroforestry Research Institute (CAFRI), Jhansi, has been designated as the National Nodal Agency for Agroforestry under the *Rashtriya Krishi Vikas Yojana* (RKVY), as per the Ministry of Agriculture & Farmers' Welfare's notification (F.No.3-1/2021-NRM-SMAF dated 5 April 2023). This prestigious designation underscores CAFRI's pivotal role in advancing the agroforestry sector by providing technical support, capacity building related to



Quality Planting Material (QPM) activities. To ensure quality and standardization in agroforestry nurseries, ICAR-CAFRI has developed the Agroforestry Accreditation Protocol for Agroforestry Nurseries. This framework, conceptualized by Dr. A. Arunachalam, Dr. Suresh Ramanan S, and Dr. A.K. Handa, is a pioneering technology developed by ICAR-CAFRI to promote transparency, reliability, and quality in the production of planting material. The protocol has been adopted by more than 10 states across the country, underscoring its significance and utility. It serves as a cornerstone for strengthening agroforestry adoption and practice in India by ensuring the availability of high-quality planting material (QPM) for a wide range of agroforestry species.

As part of its commitment to capacity building, ICAR-CAFRI has conducted Trainer of Trainers (ToT) programs in collaboration with state nodal agencies. These programs have been implemented in multiple states, including Odisha, Uttar Pradesh, Maharashtra, Karnataka, Manipur, Nagaland, Chhattisgarh, Assam, Rajasthan, Mizoram, Andhra Pradesh, and Tamil Nadu. Over 300 individuals have been trained so far, equipping them with the technical knowledge and skills needed to accreditation of agroforestry nurseries.

NRMA/CAFRI/SOL/2024/001/00161

Comparative study on carbon dynamics and functional rhizosphere microbial biomass of agroforestry systems in dry and wet-tropical climatic situations

(Badre Alam, Sovan Debnath and Mushineni Ashajyothi)

The National Agricultural Science Fund (NASF) funded project entitled "Comparative study on carbon dynamics and functional rhizosphere microbial biomass of agroforestry systems in dry- and wet-tropical climatic situations" has been implemented at ICAR-Central Agroforestry Research Institute, Jhansi being a Lead Institute located in dry-tropical location with the following three objectives - 1) To study the carbon dynamics of selected agroforestry systems in the dry- and wet-tropical climatic locations 2) To characterize the soil microbial population and biomass contributing to carbon dynamics 3) To study the comparative carbon sequestration potential of the selected agroforestry systems in relation to the microbial components. Baseline data and information from the selected fields prior to beginning the experiments with kharif crop has been collected as per the approved technical

plan for the project. Experiments in *kharif* season have been conducted following the recommended package and practices for raising the location specific understory crop (blackgram *i.e. Vigna mungo* cv. Azad-2) in the selected agroforestry systems (Teak based and aonla based agroforestry systems) and in sole cropland in open field (without trees) for comparison at central research farm of CAFRI, Jhansi. Tree growth data *e.g.* diameter at breast height (DBH) for teak and collar diameter (CD) for aonla) have been measured for using in available allometric equations for estimation of tree biomass non-destructively which will be used for biomass carbon estimation for baseline reference.

Before initiating the *kharif* experiment soil samples were collected and analysis is progressing for soil physico-chemical parameters *e.g.* soil porosity, bulk density, pH, electrical conductivity, soil organic carbon (SOC), permanganate oxidizable C, available N, available P, available K, available trace elements, and soil microbial properties *e.g.* dehydrogenase activity, total bacterial count, total fungal count, total actinomycetes count, microbial biomass C & N, and soil microbial respiration study. Results showed that soil organic carbon, available N, P and K ranged from 2.4 to 6.7 g kg^{-1}, 79.5 to 101.5 mg kg^{-1}, 4.7 to 14.8 mg kg^{-1}, and 121.4 to 233.4 mg kg^{-1}, respectively. A glance of field experiments conducted during the kharif season in selected agroforestry systems at central research farm of CAFRI, Jhansi are depicted in selected few representative photos (Figs.1, 2 & 3). Sample collection from post-*kharif* (after harvest) phase has been done and various analysis for the samples are progressing for the experiments under the project as per the approved technical programme. Soil samples at post-*kharif* stage for rhizosphere and non-rhizosphere soil have also been collected for metagenome studies and other relevant targeted analysis. In line with the experiments at dry-tropical location being conducted on the microbial components, the representative images for the microbial studies are given (Figs. 4-6). Samples have been collected for understory crop residue biomass estimation following the harvesting of kharif crop. Data collection and sample analysis are progressing. For *rabi* season experiments, mustard (*Brassica juncea* cv. Giriraj) as understory crop has been sown following the minimum tillage practice as advised in the 1st Advisory Committee Meeting held during September 7-9, 2024 at ICAR-CAFRI, Jhansi. Litter traps have been installed in the selected agroforestry systems for collection of litters and estimation of litter biomass for its contribution for carbon input into the systems (Fig. 7). The project has also been implemented by the Co-opertating Centre *i.e.* School of Environment and Natural Resources, Doon University, Dehradun, Uttarakhand.

Fig. 1. Teak based agroforestry system with blackgram as understory crop

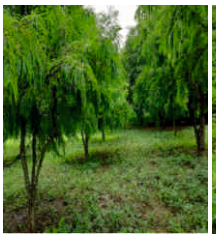


Fig. 2. Aonla based agroforestry system with blackgram as understory crop

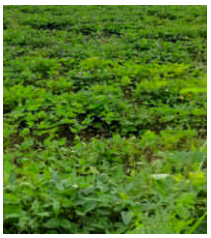


Fig. 3. Blackgram as sole crop in open field

Soil depth (cm)	Teak-based agroforestry field	Aonla based agroforestry field	Sole crop field
0-30			
30-60			

Fig. 4. Colony forming units (CFU) of soil bacteria (at 10^5 dilution) on nutrient agar media from selected agroforestry systems and sole crop at different soil depths at pre-sowing stage for baseline information.

Soil depth (cm)	Teak-based agroforestry field	Aonla based agroforestry field	Sole crop field
0-30			
30-60			

Fig. 5. Colony forming units (CFU) of fungi (at 10^4 dilution) on potato dextrose agar media from selected agroforestry systems and sole crop at different soil depths at pre-sowing stage for baseline information.

Soil depth (cm)	Teak-based agroforestry field	Aonla based agroforestry field	Sole crop field
0-30			
30-60			

Fig. 6. Colony forming units (CFU) of actinomycetes (at 10^5 dilution) on Actinomycetes isolation agar from selected agroforestry systems and sole crop at different soil depths at pre-sowing stage for baseline information

Fig. 7. Litter trap has been fixed for litter collection in agroforestry field

NRMA/CAFRI/SOL/2024/003/00163

Fostering agroforestry based incubation to booster the agribusiness in Uttar Pradesh (UPCAR)

(Suresh Ramanan S and A Arunachalam)

The project aims to augment a science-led Agroforestry Business Incubation Centre (ABiC) at ICAR-CAFRI to leverage agroforestry-based businesses and mentor incubatees for fostering startups and creating employment opportunities in Uttar Pradesh. Another core objective is to promote agri-preneurship through capacity-building programs, particularly focusing on bamboo propagation and bamboo-based agroforestry systems.

Significant progress has been made under the project, including the augmentation of ABiC at ICAR-CAFRI with enhanced facilities to support incubatees. A detailed questionnaire is being developed to assess the factors influencing the growth and challenges of agroforestry-based businesses in the region. Additionally, steps have been taken to procure essential capital equipment for establishing a industrial workshop complex to strengthen the incubation facility. Noteworthy academic outputs from the project include a submitted book chapter on the development of agroforestry incubation to nurture rural entrepreneurship in India and a conference proceeding highlighting the necessity of incubation to boost agroforestry.

NRMA/CAFRI/SOL/2024/004/00164

Efficacy of Fumigant molecules against storage insect pest of agricultural commodities under field condition.

(Y N Venkatesh)

Wood has been a cornerstone of human civilization, particularly in construction and crafts. The global trade in forest wood products is expanding, especially for export markets. However, sustainability in this trade depends significantly on effective pest management strategies. Quarantine regulations mandate fumigation to prevent infestations, as untreated wood products can become a vector for pests. Historically, methyl bromide (MBr) has been widely used for treatment of wooden logs and their products. However, it is being phased out due to its adverse environmental effects, including ozone depletion. EDN demonstrates efficacy against various insect pests and is currently approved for use in Australia, South Korea, Malaysia, and the Czech Republic. However, EDN is not yet registered for use in India. This study was conducted to evaluate the bio efficacy of EDN against the Long-horned Beetles, *Gnatholea simplex (Coleoptera: Cerambycidae)*; *Stromatium barbatum (Coleoptera: Cerambycidae*). Wooden logs of Indian rosewood measuring 30 × 5 × 5 cm (*Dalbergia sissoo*), infested with Long-horned Beetles, *Gnatholea simplex* (Coleoptera: Cerambycidae); was used for the bio efficacy studies. The infested wood samples were either placed under the wooden pallets or in between the wooden pallets covered with tarpaulins or fumigation sheets in wooden pallet stacks measuring 5-7 cubic meters, each accommodating 13 insect infested logs/replication, each infested log measuring 1.5 to 2-meter length. Five treatments were evaluated:

1. EDN at 50 g/m³
2. EDN at 100 g/m³
3. EDN at 120 g/m³
4. Standard Check: MBr at 48 g/m³
5. Untreated Control

Result

Gas concentration profiles achieved in EDN trials

The mean ± SE EDN concentrations in wooden logs fumigated at dosages of 50, 100, and 120 g/m³ are shown in Figure 1. The mean EDN concentrations in stacks treated with 50, 100, and 120 g/m³ after 30 minutes of fumigation were 33.6, 71.0, and 95.1 g/m³, respectively. While after 1 hour of exposure, the EDN concentrations decreased to 21.5 ± 1.5, 40.2 ± 6.4, and 55.5 ± 3.1 g/m³, indicating a half gas loss of EDN gas concentrations of approximately 1 hour, regardless of the dosage. After 6 hours of exposure, the mean EDN concentrations in the experimental stacks fell below 20 g/m³, even at the highest tested dosage of 120 g/m³. This significant reduction suggests that most of the EDN absorption by the treated wooden logs occurred within the first 6 hours of fumigation, with little change observed between the 12 and 24-hour marks. The terminal mean ± SE EDN concentrations after 24 hours were 0.03 ± 0.02, 0.7 ± 0.6, and 1.2 ± 0.65 g/m³ for the 50, 100, and 120 g/m³ treatments, respectively. In contrast, the mean ± SE concentration of methyl bromide in experimental stacks fumigated at 48 g/m³ was 40.67 ± 1.2 g/m³ after 30 minutes, showing only 15% reduction from the initial concentration. Moreover, it was observed that the concentration of methyl

bromide decreased over time, with a terminal concentration of 24 g/m³ after 24 hours significantly marking the half gas loss time.

Grub mortality: The mortality rates for larva across treatments revealed that EDN at 50 g/m³ and 100 g/m³ shown 58.19% and 61.31% mortality respectively and 120 g/m³, gave 91.03% mortality of larva following a 24 h exposure and standard check MBr. at 48 g/m³ shown 100% mortality, untreated control exhibited the lowest mortality (2.06%) (Fig. 1 and Fig. 2).

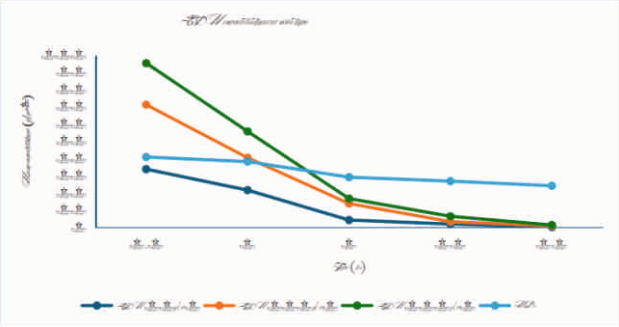


Fig. 1. EDN concentrations achieved in experimental stacks recorded during trials conducted at ICAR-CAFRI, Jhansi

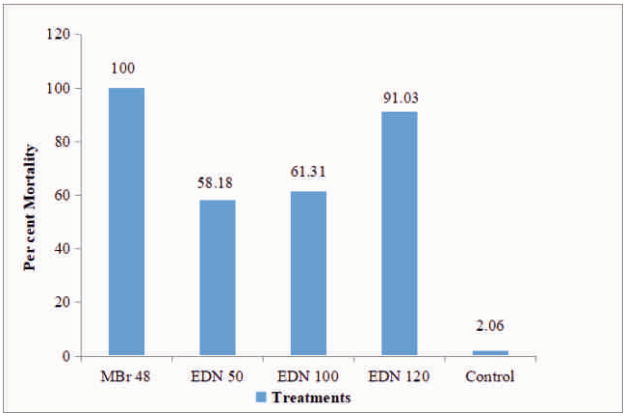


Fig. 2. Per cent mortality of long-horned Beetle, *Gnatholea simplex* (Coleoptera: Cerambycidae) against EDN fumigant

NRMA/CAFRI/SOL/2024/005/00165

Network Project on Conservation of Lac Insect Genetic Resources (NPCLIGR)

(Y N Venkatesh and Rajendra Prasad)

A detailed survey of Lac Insect Genetic Resources and its host plants, at block level in Panna, Chhatarpur and Tikamgarh districts of Madhya Pradesh coming under Bundelkhand region, was conducted from 12th December 2024 to 14th December 2024. A total of 8 Blocks of three districts; of which 3 blocks from the Panna district, 4 blocks from Chhatarpur district and 1 block from Tikamgarh district of Madhya Pradesh were surveyed. The survey was conducted with the objective to identify the various naturally occurring lac host plants in different districts of MP, to identify presence of lac insect genetic resources. The host plants were thoroughly surveyed and identified for the presence of lac, lac insects, their stage, intensity and presence of predators. The prevalence of lac insect was noticed at 5 locations where a total of 5 host trees [*Ficus benghalensis* Linn. (Baragad), *Ficus religiosa* Linn. (Peepal), *Butea monosperma* Lam. (Palas), *Ziziphus xylopyrus* Retz. (Ghont or Kath Ber), and *Ziziphus mauritiana* Lam. (Ber) were identified as natural host for the lac insect in this region. It was also noted that at almost all locations only Rangeeni strain of lac insect was observed. The collected samples of brood lac bearing mature female lac insects and newly hatched crawlers were inoculated on different hosts plants available at CAFRI, Jhansi on 2 plants of *Ficus benghalensis* (Baragad), 1 plant of *Ficus racemosa* (Cluster Fig), 2 plants of *Butea monosperma* (Palas), 2 plants of *Ziziphus mauritiana* Lam. (Ber) and were tagged properly for further observations.

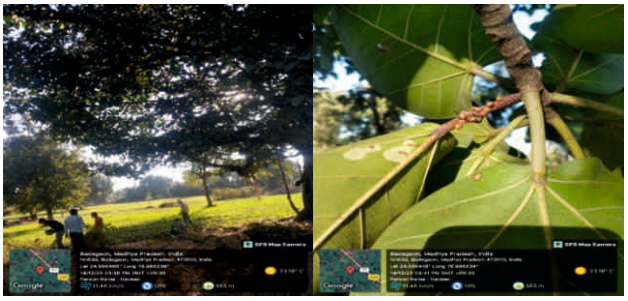


Plate 1. Survey and collection of brood lac from various available hosts in Panna, Chhatarpur and Tikamgarh districts of Madhya Pradesh during December 2024.

(A) Innoculation of brood lac sticks on hosts at CAFRI Campus

(B) Innoculation of brood lac sticks on hosts at CAFRI Farm

Plate 2. Inoculation of brood lac on different host plants available at campus and farm of ICAR-CAFRI, Jhansi, U.P. under *ex-situ* conservation.

NRMA/CAFRI/SOL/2024/006/00166

Development and implementation of seedling certification framework (SCF)

(A Arunachalam, Suresh Ramanan S, A K Handa, Syamili M S and Naresh Kumar)

This project aims to establish a standardized framework for certifying seedlings produced in agroforestry nurseries. While accreditation focuses on nursery practices, seedling certification ensures that the final product-seedlings provided to end-users-meets specific quality parameters. This includes morphological and physiological traits such

as sturdiness quotient, Dickson's quality index, collar diameter, height growth, pest and disease resistance, and nutrient deficiency symptoms.

Developing a seedling certification protocol is inherently challenging due to species heterogeneity, environmental variability, and site-specific growth patterns. Seed germination rates, disease susceptibility, and local environmental conditions, such as soil type, water availability, and climate, further complicate the establishment of universal standards. To address these complexities, ICAR-CAFRI has drafted a pilot seedling certification framework and it is has been consulted with stakeholders for suggestion. The draft standards for five key species has also been developed for *Azadirachta indica, Ailanthus excelsa, Tectona grandis* and *Melia dubia.* These species were selected for their economic importance and prevalence in agroforestry systems. The pilot framework enables testing and refining the certification process on a smaller scale, allowing for adjustments before expanding to other species.

The seedling certification framework is expected to provide long-term benefits such as improved ecosystem services, higher economic returns for stakeholders, and greater resilience to climate change. By addressing the challenges of standardization and species-specific requirements, ICAR-CAFRI aims to strengthen the quality and impact of agroforestry projects, ultimately contributing to sustainable development goals.

3. AICRP on Agroforestry

All India Coordinated Research Project on Agroforestry

The All India Coordinated Research Project (AICRP) on Agroforestry was started in 1983 with 20 centres and it has now expanded to 37 centres - 26 in SAUs, 10 in ICAR and 01 in ICFRE Institutes representing all the agro-climatic zones in the country (Fig. 1). The Coordinating unit of AICRP-Agroforestry was shifted from ICAR Headquarters to CAFRI, Jhansi w.e.f. 1st April, 1997 with the following specific mandates:

- ✓ Screening and genetic upgrading of selected plant species for their compatibility in different agroforestry systems
- ✓ To optimize tree-intercrop combination for different regions
- ✓ Performance enhancement of the pre-dominant agroforestry systems being already practiced by the farmers
- ✓ To upgrade and refine the existing technologies for higher productivity and sustainability.

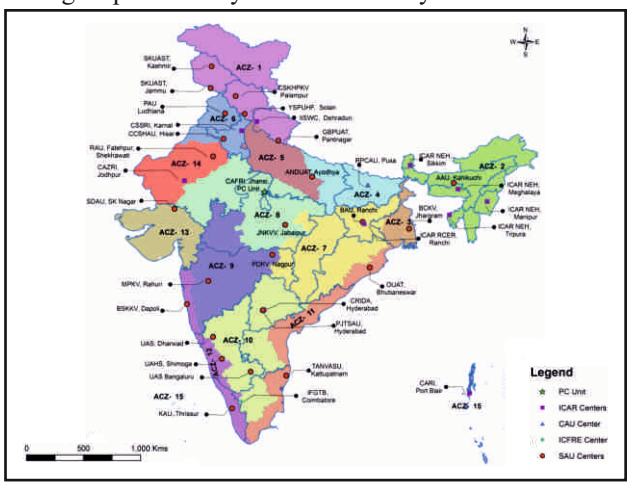


Fig. 1. AICRP-Agroforestry Centres across the country

Objectives

- Diagnostic survey and appraisal of existing farming system and agroforestry practices and farmers' preference.
- Collection and evaluation of promising tree species, cultivars of fuel, fodder and small timber for agroforestry interactions.
- Studies on management practices of agroforestry systems such as agrisilviculture, boundary plantation, silvipasture, silvihorticulture, agrisilvihorticulture, multistorey, homestead, *etc.*
- To analyze economical relation of agroforestry systems.
- To explore the role of agroforestry in environment protection.
- To conduct studies on post-harvest technology, fishery, apiculture, lac, *etc.* in relation to agroforestry systems

Diagnostic and Design survey

A comprehensive survey by SK University of Agricultural Science & Technology-K, Srinagar in Karnah Valley, Kupwara District, identified four major agroforestry systems: Home Gardens, Agri-Horticulture, Boundary Plantation, and Horti-Silviculture, with key species like Willow, Black Poplar, and various fruit trees. In SK University of Agricultural Science & Technology-K, Jammu, a diagnostic survey in the Kandi areas of Kathua District explored the adoption of agri-silvi-horticultural and agro-silver-pastoral systems, involving 72 farmers, where 32 tree species, including fruit and fodder trees, were identified. Dr. YS Parmar University of Horticulture & Forestry, Nauni, Solan conducted a survey in Pooh and Kalpa regions of Kinnaur District, identifying 34 plant species used for traditional animal healthcare, with Rumex nepalensis, Salix daphnoides, and Heracleum lanatum being the most commonly used for various ailments. CSK Himachal Pradesh Krishi Vishwavidyalaya, Palampur undertook a 10-year gap survey in Palampur and Band Bihar villages, documenting the significant impact of the TAF system on improving the livelihoods of rural women, noting a rise in their contribution to family income from 51.3% in 2013 to 79% in 2023. Assam Agricultural University, HRS, Kahikuchi in Loharghat village, Kamrup District, highlighted the popularity of homestead gardens and intercropping systems, with a special focus on the use of bamboo, teak, and sisu in forest-based agroforestry systems. GB Pant University of Agriculture & Technology, Pantnagar in Gagar village, Uttarakhand, explored the role of agroforestry, particularly in using tree fodder for livestock, with farmers relying heavily on multi-purpose tree species for emergency use. Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya conducted a survey in villages like Pithla and Dobhiyara, emphasizing the economic viability of the agri-silvi-horti system, with Casuarina equisetifolia proving highly profitable due to its demand in the brick industry and as fuelwood. Dr. Rajendra Prasad Central Agricultural University, Pusa Samastipur in Pusa Block, Samastipur,

Bihar, identified six key agroforestry systems, particularly focusing on Litchi-based systems, which have shown high biomass and carbon stock accumulation while contributing to improved soil quality. Orissa University of Agriculture and Technology, Bhubaneswar in Agapala village, District Jagatsinghpur, evaluated the roles of perennial and annual tree components in homestead agroforestry, such as windbreaks, shading, and soil fertility improvement, also conducting an economic evaluation of each component. Bidhan Chandra Krishi Vishwa Vidyalaya, RRS, Jhargram in Jhargram District, West Bengal, piloted agroforestry technologies on 2.81 hectares of land in Ramnagar Mauza and other villages, aiming to enhance biomass productivity and promote trees outside forests for increased income and nutrition. SRI Karan Narendra Agriculture University, RRS, Fatehpur Shekhawati in Garinda village, Sikar, revealed a growing interest in horti-agriculture systems involving fruit species like pomegranate and citrus, with traditional agri-silviculture practices involving Prosopis cineraria and Tecomella undulata. Dr. Panjabrao Deshmukh Krishi Vidyapeeth, COA, Nagpur in Yavatmal, Maharashtra, studied agroforestry systems involving teak, eucalyptus, and mango, with a focus on how forest-based industries contribute significantly to the local economy through minor forest products like bamboo and gum. Professor Jayashankar Telangana State Agricultural University, Hyderabad conducted a survey across Bhadradri Kothagudem and surrounding districts, highlighting diverse agroforestry systems, including Eucalyptus-based intercropping systems with cotton, maize, and fodder, as well as oil palm-based agroforestry. Dr. Bala Saheb Konkan Krishi Vidyapeeth, Dapoli in Divan Khavati village, Ratnagiri, explored homestead gardening and agroforestry systems, such as mango, teak, and cashew plantations, while addressing challenges like lack of technical knowledge and insufficient government policies on agroforestry**.** Tamil Nadu Agricultural University, FCRI, Mettupalayam in Coimbatore District focused on diverse agroforestry practices, including teak plantations and intercropping systems such as Melia with curry leaf, along with windbreak systems in certain blocks of Mettupalayam. University of Agricultural Sciences, Dharwad in Uttar Kannada District studied the wide adoption of agri-silviculture systems and silvi-pastoral practices, with a strong emphasis on multi-purpose tree species in home gardens and boundary planting. Kerala Agricultural University, Thrissur explored green leaf manuring practices in Ollukkara and Wadakkancheri blocks, identifying key tree species like Gliricidia sepium and Mangifera indica used for soil fertility enhancement, while addressing challenges such as labor shortages and transportation issues. University of Agricultural and Horticultural Sciences, COF, Ponnampet in Kodagu district, Karnataka, highlighted the popularity of native fruit-bearing and timber trees like Black Rosewood and Honne in home gardens, emphasizing the region's rich tree diversity, especially in Virajpet.

System Research and Tree Germplasm Collection, Evaluation and Improvement works

Name of the centre/State	MPTS working upon	Agroforestry models under trial/development
Sher-e-Kashmir University of Agricultural Science and Technology of Kashmir, Srinagar	Salix	Apricot based agroforestry system, apple-based horti-pasture agroforestry system, walnut-based agroforestry system, horti-silvi-medicinal agroforestry system
Sher-e-Kashmir University of Agricultural Science and Technology of Jammu, Jammu	*Terminalia chebula*	*Terminalia chebula* under silvipastoral system, *Melia composite* based agroforestry system
Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Solan	*Myrica esculenta* and *Betula utilis*	*Morus alba* based agroforestry system
Chaudhary Sarwan Kumar Himachal Pradesh, Krishi Vishidyalaya, Palampur	*Toona ciliate* and *Sapindus mukorossi*	Harar-based silvipastoral system, *Leucaena leucocephala* based silvipastoral system,
Assam Agricultural University-HRS, Kahikuchi	*Gmelina arborea*	*Acacia mangium* based AF system, Jackfruit based AF system, *Gmelina arborea* based agri-silvicultural system,
Punjab Agricultural University, Ludhiana	*Populus* spp., *Dalbergia sissoo*, and *Melia composita*	Agroforestry with intercropping, poplar based agroforestry system
GB Pant University of Agriculture & Technology, Pantnagar	*Diploknema butyracea, Populus* spp., *Dalbergia sissoo, Dalbergia latifolia*	Poplar based agrisilviculture system, Eucalyptus based agrisilviculture system, Bamboo based agrisilviculture system

Acharya Narendra Deva University of Agriculture & Technology, Ayodhya	*Dalbergia sissoo, Eucalyptus*	Agri-silviculture system, Agri-silvi-horti system, Silvi-pastoral system
Dr. Rajendra Prasad Central Agricultural University, Samastipur	*Populus spp., Dalbergia sissoo, Melia dubia, Dalbergia latifolia*	Eucalyptus based agroforestry system,
Orissa University of Agriculture and Technology, Bhubnesshwar	*Eucalyptus tereticornis, Casuarina equisetifolia,* and *Melia dubia*	Fruit-based agri-silvi-horticultural system, Silvipastoral system, Gambhar-based agrisilvicultural system
Bidhan Chandra Krishi Vishwa Vidyalaya, Jhargram	*Acacia auriculiformis, Gmelina arborea*	*Melia dubia* - Citrus sinensis agroforestry system, *Gmelina arborea* and *Zizyphus mauritiana* (gamhar-ber) agroforestry system, mahogany-sweet orange agroforestry system
Birsa Agricultural University, Ranchi	*Gmelina arborea*	*Gmelina arborea* based agri-silvicultural system, *Melia azedarach* silvi-pastoral system
Chaudhary Charan Singh Haryana Agricultural University, Hisar	*Eucalyptus, Dalbergia sissoo, Melia composita, Casuarina*	Tree-crop intercropping system
Sri Karan Narendra Agriculture, RRS, Fatehpur Shekhawati	*Prosopis cineraria, Dalbergia sissoo*	*Ailanthus excelsa* based agri-silviculture system, *Prosopis cineraria* based agri-silviculture system, *Hardwickia binata*-based agri-silviculture system
Sardarkrushinagar- Dantiwada Agricultural University,	*Eucalyptus, Ailanthus excelsa, Azadirachta indica*	Agri-silviculture system with intercropping and boundary plantations
Sardarkrushinagar Mahatama Phule Krishi Vidyapeeth, Rahuri	*Melia composita Khaya grandiflora, Azadirachta indica, Anogeissus latifolia, Acacia tortilis, Terminalia bellirica, Acacia nilotica* and *Pongamia pinnata*	Agri-silviculture, integrating forestry (teak) and agriculture (crops), and Agri-Horticulture, focusing on fruit trees (mango, custard apple) combined with seasonal intercrops
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, COA, Nagpur	*Tectona grandis* and bamboo spp.	Bamboo under agri-silviculture system
Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur	*Dalbergia sissoo, Dalbergia latifolia*	*Dalbergia sissoo* based horti-silviculture system, *Gmelina arborea* based agri-silviculture system, agri-horti-silviculture system (with mango plantation and intercropping of linseed and soybean)
Professor Jayshankar Telangana State Agricultural University, Hyderabad	*Azadirachta indica, Pongamia pinnata, Melia dubia*	Custard apple based horti-pastoral system, *Melia dubia* based silvi-pastoral system, *Melia dubia* based agri-silvi system
Dr, Bala Saheb Konkan Krishi Vidyapeeth, Dapoli	*Tectona grandis, Acacia mangium, Acacia auriculiformis, Acacia holosericea, Gliricidia sepium, Casuarina equisetifolia, Albizia lebbeck, Pterocarpus marsupium,* Bamboo species, *Dalbergia sissoo, Dalbergia latifolia, Morus alba, Melia dubia,*	*Dendrocalamus stocksii* Munro based agroforestry system, Asana based horticultural systems

	Gmelina arborea, *Garcinia indica,* *Mellittia pinnata,* *Santalum album,* *Anacardium occidentale,* *Alphonso* Mango	
Tamil Nadu Agricultural University, Mettupalayam	*Ceiba pentandra,* *Melia dubia*	Kapok based agroforestry system, Pulpwood based agroforestry system, Dendroenergy based agroforestry system, *Melia Dubia* based agroforestry system
Tamil Nadu Veterinary and Animal Sciences University, Kattupakkam	-	*Cocos nucifera* based hortipasture system, Guava based hortipasture system, *Leucaena leucocephala* based multitier hortipasture system
University of Agricultural Sciences, Dharwad	*Tamarindus indica,* *Azadirachta indica,* *Pongamia pinnata,* *Carissa carandas,* *Aphanomixis polystachya,* *Madhuca indica,* *Calophyllum inophyllum,* *Bakula, Surati,* *Saraca ashoka,* *Soapnut,* *Garcinia indica,* and *Amura*	Tamarind based agroforestry system, Sapota timber species based agroforestry system, Fodder tree species under agroforestry system
University of Agricultural Science, Bengaluru	*Tamarindus indica*	Teak based agroforestry system, Sandal based agroforestry system, Mahogany based agroforestry system
Kerala Agricultural University, Thrissur	*Acacia mangium,* *Tectona grandis,* and various bamboo sp.	Fodder grass-tree mixture systems, Bamboo (*Dendrocalamus stocksii*) based agroforestry system
University of Agricultural and Horticultural Science, COF, Ponnampet	Bamboo species, *Grevillea robusta* and *Swietenia macrophylla.*	*Dendrocalamus stocksii* Munro based agroforestry practice, *Litsea chinensis* based agroforestry models

Subsidiary Activities

Quality Planting Materials

More than 425,000 seedlings of different MPTs wre produced in nurseries and were sold and/or distributed besides different other intercrop.

Farmers' Outreach

The AICRP-Agroforestry centres registered a net outreach of agroforestry technologies to benefit over 8000 farmers. In addition, our centres provide agroforestry/tree-centric agro-advisories to the agroforestry practitioners. Promising farmers are appreciated for their efforts and were recognized as agroforestry ambassadors**.**

STC and SCSP Component

The All India Coordinated Research Project on Agroforestry has carried out extensive Tribal Sub-Plan (TSP) and Scheduled Caste Sub-Plan (SCSP) activities across India, aiming to improve the agricultural and socio-economic conditions of marginalized farming communities. These programs focus on agroforestry, sustainable agricultural practices, and livestock improvement, benefiting tribal and scheduled caste farmers with essential resources, technical guidance, and tools to enhance productivity and livelihoods.

A key component of these initiatives is the distribution of high-quality planting materials such as hybrid seeds, tree saplings, and horticultural seedlings. For example, farmers in Himachal Pradesh received apple, poplar, and salix plants, while those in Assam and Uttarakhand were provided with boundary plantation saplings like Assam lemon, black pepper, and arecanut. These efforts help diversify farming systems and increase income opportunities through the inclusion of fruit trees, vegetables, and fodder crops.

In addition to planting materials, the project also provided crucial farming tools and equipment to reduce manual labor and improve operational efficiency. Items such as sprayers, knapsack pumps, foot baton assemblies, and

small implements like sickles and spades were distributed to farmers in regions like Jammu and Kashmir, Telangana, and Gujarat. These tools ease farm operations, particularly for SC and ST farmers, contributing to better productivity.

Livestock health and productivity were also a priority, with Vitamin Mineral Mixtures distributed to dairy farmers in Jammu to enhance cattle health and milk production. In Tamil Nadu, training sessions focused on concentrate feed and nutrient supplements improved livestock care, leading to better outcomes for farmers in the region.

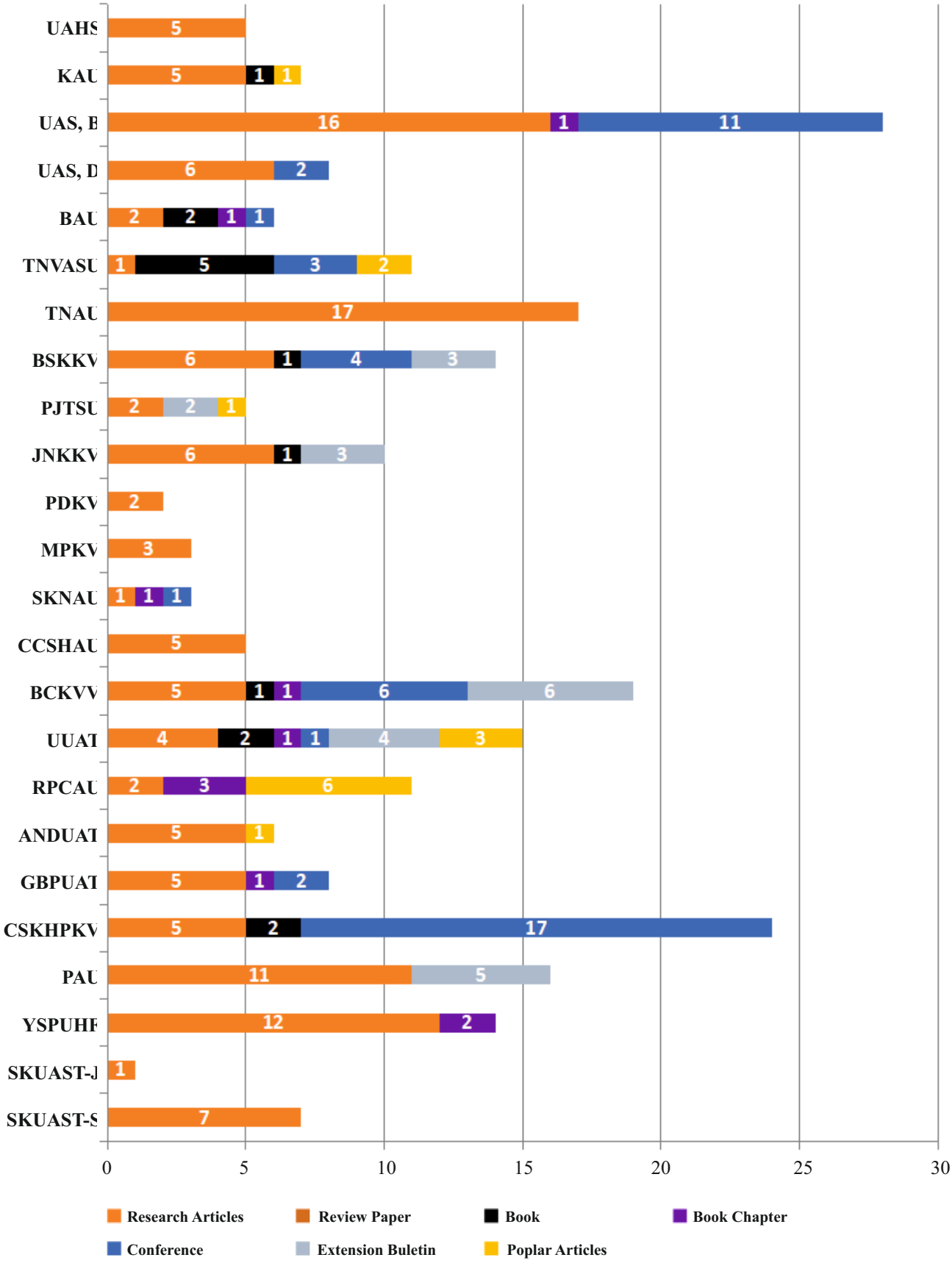
Soil fertility and crop yield enhancement were supported through the provision of fertilizers, nano urea, and compost. Farmers in Gujarat and West Bengal received organic and inorganic fertilizers that improved soil health and boosted crop yields, while in Jammu and Himachal Pradesh, the introduction of hybrid maize and improved vegetable seeds resulted in better harvests and increased farmer incomes.

The program also emphasized education, with numerous training sessions on agroforestry systems, plant protection, and sustainable farming practices. These sessions empowered farmers with knowledge and skills, enabling them to adopt integrated farming systems that improved both crop and livestock productivity.

Annual Group Meeting of Agroforestry at YSPUHF

The three-day Annual Group Meeting of the All India Coordinated Research Project on Agroforestry commenced 27-29 January 2025 at Dr. YS Parmar University of Horticulture and Forestry, Solan. The event is being jointly organized by ICAR-Central Agroforestry Research Institute, Jhansi, and the university. Dr. S.K. Chaudhari, DDG (NRM), ICAR, graced the occasion as the Chief Guest, while Professor Dr. R. S. Chandel chaired the session. Dr. A. Arunachalam, Director of ICAR-CAFRI, presented the coordinator's report. The meeting was attended by Dr. S.K. Dhyani, Country Director of CIFOR-ICRAF India, Dr. B.P. Bhatt from the NRM Division of ICAR, along with the Director of Research, Director of Extension, Dean of CoF, Dean of CoH, and delegates from 28 coordinating centers nationwide. During the meeting, the Annual Report of the project, along with 30 publications from CAFRI and the coordinating centers, was released. Additionally, an exhibition showcasing various technologies and products developed under the AICRP Agroforestry was held.

Research Publications



4. Awards and Recognitions

a) Institutional Awards/Recognitions

- Indian Council of Agricultural Research, New Delhi on 16th July, 2024 certified that the ICAR-CAFRI, Jhansi is the lead developer of the "Protocol for Agroforestry Entrepreneurship Training"; [ICAR-NRM-CAFRI-Protocol-2024-068].
- Indian Council of Agricultural Research, New Delhi on 16th July, 2024 certified that the FAO and ICAR-CAFRI, Jhansi are jointly lead developer of the "Agroforestry Extension Framework (Technology)"; [ICAR-NRM-CAFRI-Methodology-2024-069].
- Indian Council of Agricultural Research, New Delhi on 16th July, 2024 certified that the ICAR-CAFRI, Jhansi and AICRP on AF are jointly lead developer of the Package of practice for "*Har Med Par Ped*" (Technology); [ICAR-NRM-CAFRI-Methodology-2024-071].
- ICAR-CAFRI, Jhansi conferred with the Green Campus Award on 13th December, 2024 by the Save the Environment Society (STE), Kolkata/Gurugram; The campus having 64% tree cover and green space all around along with special attraction points to enthuse agroforestry and environment sustainability amongst masses.

b) Team Awards/Recognitions

- Indian Council of Agricultural Research, New Delhi certified that Dr. A. Arunachalam, Mr. Suresh Ramanan S and Dr. A.K. Handa (Lead Developers) of ICAR-CAFRI, Jhansi have developed the technology "Accreditation protocol for agroforestry nurseries" on 16th July, 2024. [ICAR-NRM-CAFRI-Methodology-2024-061].
- Indian Council of Agricultural Research, New Delhi certified that Dr. Badre Alam (Lead Developer), Dr. A. R. Uthappa, Dr. A.K. Handa, Dr. Ram Newaj and Dr. O.P. Chaturvedi (Associate Developers) of ICAR-CAFRI, Jhansi have developed the technology "Eco-physiological traits and microclimate dynamic for assessing efficiency of crops under agroforestry system" on 16th July, 2024. [ICAR-NRM-CAFRI-Policy -2024-062].
- Indian Council of Agricultural Research, New Delhi certified that Mr. Suresh Ramanan S. (Lead Developer), Dr. A. Arunachalam, Dr. Hirdayesh Anuragi, Dr. A.K. Handa and Dr. Naresh Kumar (Associate Developers) of ICAR-CAFRI, Jhansi have developed an android-based 'Learn Agroforestry' mobile app for capsule course on agroforestry (Technology) on 16th July, 2024. [ICAR-NRM-CAFRI-Product-2024-063].
- Indian Council of Agricultural Research, New Delhi certified that Dr. Sangram B. Chavan (Lead Developer), Dr. R.H. Rizvi, Dr. Badre Alam, Dr. A.K. Handa, Dr. Rajendra Prasad, Dr. Ajit, and Dr. Ram Newaj (Associate Developers) of ICAR-CAFRI, Jhansi have developed the technology "Methodology for carbon sequestration potential of traditional agroforestry in Rajasthan" on 16th July, 2024. [ICAR-NRM-CAFRI-Methodology-2024-064].
- Indian Council of Agricultural Research, New Delhi certified that Dr. A. Arunachalam (Lead Developer), Dr. R.H. Rizvi, Dr. A.K. Handa and Suresh Ramanan S (Associate Developers) of ICAR-CAFRI, Jhansi have developed the "Techniques for area estimation of agroforestry in India" on 16th July, 2024. [ICAR-NRM-CAFRI-Methodology-2024-065].
- Indian Council of Agricultural Research, New Delhi certified that Dr. Ashok Yadav, Dr. A. Arunachalam and Dr. Rajbir Singh (Lead Developers) of ICAR-CAFRI, Jhansi have developed the technology; "Package of practice for strawberry production in Bundelkhand" on 16th July, 2024. [ICAR-NRM-CAFRI-Technology-2024-066].
- Indian Council of Agricultural Research, New Delhi certified that Dr. Naresh Kumar (Lead Developer), H. Anuragi, Asha Ram, K. Rajarajan, A.K. Handa, Inder Dev, C.K. Bajpai and Ashok Yadav. (Associate developer) of ICAR-CAFRI, Jhansi have developed the technology "Noval kit for tree plantation and breeding of agro-forestry" on 16th July, 2024. [ICAR-NRM-CAFRI-Product-2024-067].

c) Individual Awards/Recognitions

- Dr. A. Arunachalam elected as a Fellow of the Society for Agro-environmental Sustainability, Haridwar.
- Dr. A. Arunachalam, Director, CAFRI, Jhansi conferred the STE Dr. Praloy O. Basu Lifetime Achievement Award-2024 by Save the Environment (STE), Kolkata.
- Dr. A. Arunachalam, Director, CAFRI conferred the Innovative Researcher of the Year 2024 by the Scientific Laurels Committee.

- Dr A. Arunachalam nominated as Member, Board of Management in Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, Madhya Pradesh.
- Dr. Hirdayesh Anuragi was honored with "NESA Best Scientist Award 2024" by the National Environmental Science Academy, New Delhi, India, during an international conference on TMT3D-2024 (21-23 November 2024) at BHU Campus, Varanasi.
- Dr. Sukumar Taria, conferred with "SKSS Young Scientist Award-2024" by Sarvhit Kalyan Seva Samiti, Meerut, U.P. during the International Conference on Nature, Science, and Modern Life Style: Issues and Perspectives, held on 28-29 December 2024 at PMS, Lucknow.
- Dr. Raghunandan Prasad Dwivedi, Principal Scientist, Agricultural Extension, ICAR-CAFRI, Jhansi Conferred with SKSS Lifetime Achievement Award-2024 during International Conference on Nature, Science, and Modern life Style: Issues and perspectives, held on 28-29 December 2024 at PMS, Lucknow, organized by Sarvhit Kalyan Seva Samiti, Meerut.
- Indian Council of Agricultural Research, New Delhi certified that Mr. Suresh Ramanan S (Lead Developer) of ICAR-CAFRI, Jhansi has developed the technology "Redefined logarithmic for spiral trenching to understand the root structure and distribution of trees" on 16th July, 2024. [ICAR-NRM-CAFRI-Methodology-2024-070].
- Dr. Ashok Yadav received the best poster award at the national conference on Shaswat Shristi Sanrakshan. A pledge for protecting the world against natural hazards: Agri-biotechnological approaches jointly organized by STE, ICAR-CAFRI Jhansi, ISAF, SSCCE, SKSS, and Bundelkhand University Jhansi from 23-24 August, 2024.
- Dr. Sukumar Taria, Conferred with Best Oral Presentation entitled "Regulation of Shade Responses in Crops- An Agroforestry Standpoint" during National Conference on Shashwat Srishti Sanrakshan held on June 23-24, 2024, at CAFRI, Jhansi, jointly organized by Save The Environment (STE), Kolkata/Gurugram and ICAR-CAFRI, Jhansi, Uttar Pradesh.
- Dr. Sukumar Taria, conferred with the best oral presentation during the International Conference on Nature, Science, and Modern Life Style: Issues and Perspectives, held on 28-29th December 2024 at Lucknow, organized by Sarvhit Kalyan Seva Samiti, Meerut.
- Suresh Ramanan S (2024; Awarded PhD in Forestry at Mizoram University) Ecological Prospecting of Genus Melia in India. (Supervisor: Dr. A. Arunachalam and Co-Supervisor: Dr. U.K. Sahoo)

Software Development ® Packages)

- **hrtlFMC:** Half Replicate of Two Level Factorial Run Order with Minimum Level Changes (2024). Authors: Arpan Bhowmik, Eldho Varghese, Seema Jaggi, **Bijoy Chanda**, Anindita Datta, Tanuj Misra. https://doi.org/10.32614/CRAN.package.hrtlFMC
- **equiBSPD**: Equivalent Estimation Balanced Split Plot Designs (2024). Authors: **Bijoy Chanda**, Arpan Bhowmik, Cini Varghese, Seema Jaggi, Eldho Varghese, BN Mandal, Anindita Datta, Soumen Pal. https://doi.org/10.32614/CRAN.package.equiBSPD
- **minFactorial:** All Possible Minimally Changed Factorial Run Orders (2024). Authors: Arpan Bhowmik, **Bijoy Chanda**, Seema Jaggi, Eldho Varghese, Cini Varghese, Anindita Datta. https://doi.org/10.32614/CRAN.package.minFactorial

Technology Developed

- Technology-Antioxidant enzyme-based detection of phosphine resistance in red floor beetle, *Tribolium castaneum*. Certified by-Technology Certification Committee, ICAR- Crop Science, Division. Technology developer- Sabtharishi Subramanian, Satyapriya Singh, Suresh M. Nebapure, **Sukumar Taria**, Doddachowdappa Sagar

5. Ongoing Research Projects (2024)

Title of the Project	PI/Co-PI
(A) Agroforestry System Research (ASR) Programme	
Assessment of conservation agroforestry	**Asha Ram/** Sovan Debnath
Assessment of *Melia dubia* based agroforestry system under semi-arid conditions	**Naresh Kumar/** Ashok Yadav & Kamini, IGFRI-Jhansi
Developing Multifunctional Agroforestry System for Nutritional Security in Semi-arid Tropics	**Ashok Yadav/** A.K. Handa
Assessment of soil biological and biochemical characters in predominant agroforestry-based land use systems	**Sovan Debnath/** Suresh Ramanan S
Insect Diversity in Teak and Bael-Based Agroforestry System: Insights and Implications	**Venkatesh Y.N./** M. Ashajyothi
(B) Tree Improvement Research (TIR) Programme	
Multi-locational evaluation of *Melia dubia* clones	**A.K. Handa/** Naresh Kumar
Collection and evaluation of Moringa germplasm for better adaptability and year round fruiting for accelerating agroforestry based nutritional security under semi-arid climate	**Hirdayesh Anuragi/** K Rajarajan
Developing a Bacillus subtilis-based bio-formulation for the management of *Melia dubia* vascular wilt disease incited by Fusarium solani	**M. Ashajyothi/** K Rajarajan
(C) Carbon & Climate Change Research (CCCR) Programme	
Influence of plant morphological characteristics on soil properties in agroforestry systems	**Rajendra Prasad/** Badre Alam
Ecophysiological dynamics for assessing climate change mitigation potential of contrasting tree populations of *Pongamia pinnata*	**Badre Alam/** Rajendra Prasad & S. Taria
Assessment of ecosystem services in silvipastoral system in semi-arid conditions	**Asha Ram/** Ashok Yadav
Developing Niche modelling framework for upscaling Melia dubia based Agroforestry	**Mr. Suresh Ramanan S/** Dr. A.Arunachalam
Evaluating 3R's for carbon neutrality in melia based agroforestry system	**Sushil Kumar/** Sovan Debnath & Suresh Ramanan S
(D) Agroforestry Extension Research (AER) Programme	
Constraints in Adoption of Agroforestry in Bundelkhand Region of Central India	**R.P. Dwivedi/** Priyanka Singh & Sushil Kumar
Valuation of ICAR-CAFRI technologies	**Priyanka Singh/** R.P. Dwivedi

All-India Network/Multi-Institutional Projects and Others supported by ICAR

Title of the Project	PI/Co-PIs CC-PI/CC-Co-PIs	Duration	Agency	Budget (Rs in lakhs)
Harvest and post-harvest processing and value addition of natural resins, gums and gum-resins	**Rajendra Prasad** A K Handa & Badre Alam	2008 - Ongoing	ICAR-NISA, Ranchi	179.62
National Agriculture Innovation Fund (NAIF) Scheme*	**Suresh Ramanan S,** Ashok Yadav	2017 - Ongoing	ICAR-NAIF	7.40 annual
Comparative study on carbon dynamics and functional rhizosphere microbial biomass of agroforestry system in dry and wet-tropical climatic situations	**Badre Alam,** Sovan Debnath & Mushineni Ashajyothi	April, 2024-March, 2027	National Agricultural Science Fund (NASF)	57.72
Efficacy of fumigant molecules against storage insect pest of agricultural commodities under field conditions	**Venkatesh Y N**	Aug, 2024-March, 2025	ICAR-NRCIPM (collaboration)	3.54
Network project on conservation of lac insect genetic resources (CLIGR)	**Venkatesh Y N** Rajendra Prasad	Sept,2024-Aug, 2026	Network Project, NAIP	16.78 (for 2024-25)

*Earlier it was IPR

All India Coordinated Research Project on Agroforestry

Title of the Project	PI/Co-PI	Duration	Agency	Budget (Rs in lakhs)
All India Coordinated Research Project on Agroforestry (AICRP-Agroforestry)*	**Dr. A. Arunachalam** (Project Coordinator) **Dr. A.K. Handa** (Nodal Scientist) **Suresh Ramanan S** (Associate Scientist)	1997-Ongoing	ICAR	1539.17

*AICRP-Agroforestry Secretariat

Externally Funded Projects (Ongoing)

Title of the Project	PI/Co-PIs CC-PI/CC-Co-PI	Duration	Agency	Budget (Rs. in lakhs)
Trees Outside Forests in India (TOFI)	**A. Arunachalam** A.K. Handa, Naresh Kumar, Suresh Ramanan S. & Priyanka Singh	Oct, 2021 - Mar,2026	USAID	CAFRI Component: 1.67 Cr.
Task Force on Himalayan Agriculture-NMSHE (2nd Phase)	**A. Arunachalam** A.K. Handa, Suresh Ramanan S,	Oct, 2021 - Mar,2026	DST, New Delhi	952.6 (CAFRI Component: 1.74 Cr.)
Development and Evaluation of Pomegranate based agroforestry system in Bundelkhand region for higher productivity and economic returns in farmers field	**Ashok Yadav** A. Arunachalam	Oct, 2022 - Oct, 2025	NABARD, Uttar Pradesh	30.40
In vitro regeneration of multipurpose & medicinally important *Butea monosperma* Lam. and its assessment for mass propagation of genetically uniform quality planting material	**Hirdayesh Anuragi,** K. Rajarajan, Harjeet Singh (CCRAS-CARI)	Oct, 2022 - Mar, 2026	NMBP, Ministry of AYUSH, Govt. of India	23.16
Strengthening community resilience by diversifying cropping system through agroforestry interventions in Central India	**A. Arunachalam** A.K. Handa, R.P. Dwivedi, Naresh Kumar, Asha Ram, Suresh Ramanan S,	Apr, 2023 - Mar, 2025	ICRISAT, Hyderabad	73.27

Tissue-specific physiological, molecular, and metabolomics analysis of green gram (*Vigna radiata)* for shade adaptive traits in the context of agroforestry	**Hirdayesh Anuragi**	Dec, 2022 - Mar, 2026	DST-SERB, Govt. of India	31.97
Large scale screening, Identification and Promotion of *Azadirachta indica* accessions for high Azadirachtin yield	**K Rajarajan,** A.K. Handa & A. Arunachalam	2023 - Aug, 2025	CIFOR-ICRAF, New Delhi	14.70
RKVY-Quality Planting Material (QPM)	**A. Arunachalam** A.K. Handa, Suresh Ramanan S.	Nov,2023 - Mar, 2027	MA & FW, GOI	28.56
Fostering agroforestry based incubation to booster the agribusiness in Uttar Pradesh	**Suresh Ramanan S,** A. Arunachalam	Jun, 2024 - May, 2027	UPCAR	22.00
Development and implementation of seedling certification framework	**A Arunachalam** Suresh Ramanan S A.K. Handa, Ms. Syamili, M.S., Naresh Kumar	Sept, 2024 - Dec, 2025	ICAR-ICRAF Work Plan	22.60

Research Project concluded in 2024

Title of the Project	PI/Co-PI	Duration
Genetic characterization of neem germplasm for high azadirachtin yield	**Dr. K. Rajarajan** Dr. H Anuragi	Aug-2021 to April-2024

Externally Funded Projects concluded in 2024

Title of the Project	PI/Co-PIs	Duration	Agency	Budget (Rs. in lakh)
Pilot the solutions of chipbased technology for realtime and RFID-passive monitoring of field genebank and agroforestry species for scaling up	**K. Rajarajan,** H. Anuragi	2022 - Jun, 2024	ICRAF-ICAR Work Plan	8.11
"Agri-Drone Project"	**Asha Ram**	Aug, 2022 - Mar, 2024	ICAR, New Delhi	17.50
Evaluation the performance of Sea weed Extract, Humic acid, Protein Hydrolysates, Biochemical, and Botanical Extracts	**Ashok Yadav,** A. Arunachalam, Asha Ram, Mahesh Kumar Dhakad & D.R. Bhardwaj	Aug, 2022 - Aug,-2024	IRM Enterprises Pvt. Ltd. Ahmedabad	41.96
The Economics of Ecosystems and Biodiversity (TEEB) for Agriculture and Food Initiative in India	**A. Arunachalam-** A.K. Handa, Nodal Member & Suresh Ramanan S., Member	Jun, 2023 - Mar, 2024	UNEPs Nairobi Kenya	76.94
Laboratory bio-assay of newer fumigant molecules against storage insects	**Venkatesh Y.N.**	Jun, 2023 - Mar, 2024	ICAR-NCIPM, New Delhi	3.13

6. Important Events/Meetings/Days Observed

Events Observed

Ministry of Agriculture released a document on Accreditation Protocol for Agroforestry Nurseries

Dr. A. Arunachalam, Director, ICAR-CAFRI, Jhansi presented the framework of "Accreditation Protocol of Agroforestry Nurseries" on 29th January, 2024. Hon'ble Agriculture Minister, MoA&FW, GoI released the document and appreciated efforts of ICAR. Dr. Himanshu Pathak, Secretary, DARE and Sh. Manoj Ahuja, Secretary, DA&FW also appreciated the efforts. Several international, national institutes, agencies, NGOs participated in the launching programme.

Neem Summit and Global Neem Trade Fair

ICAR-CAFRI and WNO jointly organized the Neem Summit-2024 and Global Neem Trade Fair-2024 in New Delhi on 19th-20th February, 2024. The Summit was inaugurated by Dr Himanshu Pathak, Secretary DARE and DG, ICAR. Dr. P. K. Singh, APC, GoI graced the function as Guest of Honour. About 250 participants from ten countries participated in the Summit and 21 companies showcased their neem products in the trade fair.

Hindi Workshop

ICAR-CAFRI, Jhansi organized quarterly Hindi Workshop on 28th February, 2024. On the occasion, Dr. Sunil Kumar, Principal Scientist and Officer-in-Charge of Official Language at the Indian Grassland and Fodder Research Institute, Jhansi was the chief guest of the programme and and Dr. Kumar stressed its importance in contemporary communication. Furthermore, he discussed the theme for this year's National Science Day, which was "Indian Indigenous Technology for Developed India." Dr. Badre Alam, Principal Scientist, also contributed by providing a brief overview of National Science Day, highlighting its significance and the nation's scientific achievements. The programme was attended by all the scientific, technical administration staff, research associated and young professionals.

National Workshop on NAP

CAFRI organized National Workshop on National Agroforestry Policy (NAP) chaired by DG, ICAR; Co-chaired by DDG (NRM), ICAR at New Delhi on 5th April, 2024. More than 40 leading and learned panelists, discussants and delegates participated. Rich discussion was held for reviewing NAP looking into emerging challenges and recent development.

National Conference on Agro-ecological Basis of Agroforestry

On 27th foundation day of Indian Society of Agroforestry, ICAR-CAFRI Jhansi organised two days National Conference on "Agro-ecological Basis of Agroforestry Interaction, Innovation and Incubation" supported by GIZ India, CIFOR-ICRAF India & NABARD, on 18th-19th June, 2024. The Chief guest for valedictory session was Dr. U.S. Gautam, DDG, Extension, ICAR and Guest of Honor Dr. Pankaj Kaushal, Director, ICAR-IGFRI, Jhansi. The Director, ICAR-CAFRI Jhansi Dr. A. Arunachalam

presided the conference and shared his views on innovation in Agroforestry. Scientists and Farmers were awarded under various categories in Valedictory session.

Ek Ped Maa Ke Naam

On 20th July 2024, ICAR-CAFRI joined hands with the Uttar Pradesh Government's Campaign on "Plant Tree-Save Tree' 2024 and hosted the event in the Bundelkhand Region with the tagline of `Ek Ped Maa Ke Naam' (One Tree in Mother's Name) in the ICAR-CAFRI Campus. Together with the help of Forest Department, Jhansi planted about 11000 seedlings in CAFRI premises. The Program was chaired by Smt. Rajni Tewari, Hon'ble Minister of Higher Education, Uttar Pradesh. Shri Anurag Sharma, Hon'ble MP (Jhansi) also joined the program. Shri. Ravindra Nayak, IAS Nodal Officer for Jhansi region gave an account of the program that was joined by Shri Avinash Kumar, IAS, DM, Jhansi; Shri S. Rajesh IPS, SSP, Jhansi; Dr. K.K. Singh IFS, CCF, Jhansi; Shri Shende, IFS, DFO, Jhansi and all the officers and staff of Forest Department. In the program, all employees of ICAR-CAFRI and several school students also participated and planted a tree sapling in their mother's name. Jai Krishivaniki!

6th QRT

The 6th Quinquennial Review Team constitute by ICAR for reviewing the progress of ICAR-CAFRI, Jhansi and AICRP on Agroforestry conducted a meeting at the Institute during 7th to 9th May, 2024 and reviewed the institute work done during 2018-2023.

The Chairman of the 6th QRT constituted by ICAR, New Delhi to review the progress of ICAR-CAFRI and AICRP Agroforestry for the period 2018-2023 presented and submitted the report to Dr. Himanshu Pathak, Hon'ble DG, ICAR, New Delhi on 22nd July 2024, at Krishi Bhavan, New Delhi in the presence of Deputy Director General, NRM, ICAR. The meeting was attended by Dr. A. Arunachalam, Director of the institute and Dr. A.K. Handa, Member Secretary, QRT.

Van Mahotsava

On 24th July 2024, ICAR-CAFRI, Jhansi organized 'Van Mahotsava' programme and distributed tree saplings among farmers in Kharang village of Datia district, Madhya Pradesh and also, demonstrated tree plantation techniques.

Developing Business Opportunities in Agroforestry

On 30th July 2024, ICAR-CAFRI, Jhansi organised an insightful and engaging session on "Developing Business Opportunities in Agroforestry: Learnings from Consortium of Industrial Agroforestry Success Story from Tamil Nadu" in hybrid mode. Sh. K.K. Singh, CCF IFS from UP Forest Department, joined the event as Expert Participant, adding a wealth of knowledge and experience. Scientists from ICAR-CAFRI contributed their expertise, fostering a rich dialogue on agroforestry business opportunities.

Capsule Course on Agroforestry R&D Methodologies

On 17th August 2024, ICAR-CAFRI, Jhansi marks the beginning of a 21-day Capsule Course on "Agroforestry R&D Methodologies" aims to enhance the capacity of ICAR-CAFRI project staff in agroforestry practices, empowering them with cutting-edge methodologies and insights.

National Conference on Shashwat Srishti Sanrakshan

National conference on "SHASHWAT SRISHTI SANRAKSHAN", "A Pledge for Protecting World against Natural Hazards: Agro-Biotechnological Approach" was organised during August 23-24, 2024 by Save The Environment, Kolkata/Gurugram; Indian Society of Agroforestry and ICAR-CAFRI, Jhansi. The program was inaugurated Prof A.K. Shukla (V.C., RVSKVV, Gwalior) and Guest of honor Dr. W. Selvamurthy (President, ASTIF). More than 100 delegates participated in the conference.

Second Stakeholders Consultation on *Melia dubia*

The second stakeholders consultation on *Melia dubia* : a significant tree species in the Indian subcontinent, was held on 23rd August, 2024 (Hybrid Mode). Meeting focused on reviewing its status across the country and ICAR-CAFRI, Jhansi took a lead to develop discussion paper. The consultation also highlighted the need for future areas of research. *Melia* dashboard developed by ICAR-CAFRI was also highlighted in the event.

Workshop for SC communities

On September 9th, 2024, ICAR-CIRG, Makhdoom organised a capacity building workshop for SC communities in collaboration with ICAR-CAFRI, Jhansi, KVK-Datia and ICAR-IIWSC Centre, Datia. The program was graced by Director, CAFRI, ADG (NASF) and Former Director, IISS Bhopal. On the occasion, welfare materials and quality planting materials for agroforestry were also distributed and plantation drive was organized.

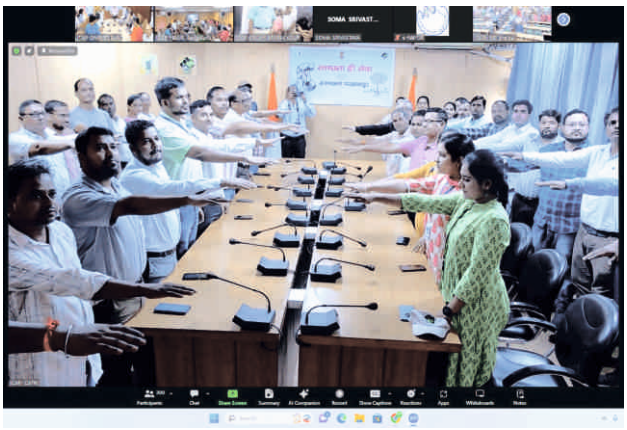
Focus Group Discussion in FAO

Dr. A. Arunachalam, Director, ICAR-CAFRI was deputed for the Study Tour to Italy as part of FAO's Technical Cooperation Programme (TCP) support to developing protocols for Quality Planting Material (QPM) and certification of Nurseries for Timber and Non-timber agroforestry species (TCP/IND/3904/C2) from 16th to 20th September, 2024.

Special Plantation Drive

ICAR-CAFRI, Jhansi organized a one day special plantation drive on 17th September, 2024 in line with the Campaign "Ek Ped Maa Ke Naan" launched by Hon'ble Prime Minister of India on 5th June, 2024 on the occasion of World Environment Day.

Swachhta Hi Seva (SHS) 2024 Campaign / Swachhta Campaign 4.0



ICAR-CAFRI, Jhansi has organized "Swacchta Hi Seva 4.0" and "Swacchta Sarvekshan" programmes from October, 2024 to December, 2024.Various programs like swacchata pledge, swacchta awareness programs and Swacchta Mitra Health Camps along with mass cleaning

drives in the Institute , nearby villages and local sites were conducted. Digital reports were also uploaded on SHS (swachhta hi sewa) portal as well as on various social media platforms to create an impact and create awareness on mass level regarding "Swacch Bharat Abhiyan". In this programme scientists, technical staff and research scholars participated in the programme.The events were widely covered in newspapers.

Hindi Pakhwada

ICAR-CAFRI organized Hindi Pakhwada from 17th to 30th September, 2024. Different competition were organized during the period involving all staff of the Institute.

Nursery Assessment and Accreditation Training in Assam

Nursery assessment and accreditation training was organised in Assam from 26th to 28th September, 2024. The training was conducted by Dr. A.K. Handa and Mr. Suresh Ramanan S. The aim of the training was to provide framework for Nursery assessment and accreditation to different stakeholder.

International Conference

ICAR-CAFRI, Jhansi being a co-organizer of the International conference on "Biodiversity, Agroforestry, Non-Wood Forest Products and Sustainable Livelihood" organized by V. Sivaram Research Foundation, India in association with CIFOR-ICRAF and ISAF during 18th-19th October, 2024 at Hilton Kota Kinabalu, Sabah state, Malaysia.

Vigilance Awareness Week

On the eve of Vigilance Awareness Week, all the employees and project staff of ICAR-CAFRI took Vigilance Pledge for a corruption-free environment in the Institute and in the Society on 28th of October, 2024.

CAFRI Interact with Expert team of FAO

On 30th October 2024, Director of ICAR-CAFRI, Jhansi interacted with a Team of Experts from FAO-Regional Office, Bangkok on agroforestry and gave inputs for fortifying the FAO study on agroforestry in the Asia-Pacific Region in general and India in particular.

Global Soil Conference

Dr. A. Arunachalam chaired one of the technical session in the Global Soil Conference held at NASC Complex, New Delhi on 19th -22nd November, 2024. During the Global Soil Conference a special issues of *Indian Journal of Agroforestry* was also released.

International Conference on Climate Smart Farming

ICAR-CAFRI being a collaborator of the International conference on 'climate smart farming: Adoption, Impact and implication for sustainable development' in BioSCon, 24 organized by Society for Biotic and Environmental Research (SBER) during 21-22 November, 2024 at college of Agriculture, Kyrdemkulai, Ri Bhoi, Meghalaya.

Meetings Observed

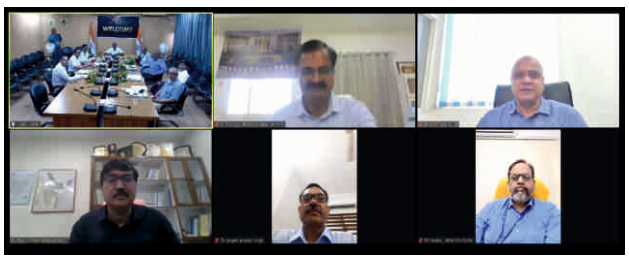
Review Meeting of RKVY-Agroforestry

Director, ICAR-CAFRI, Jhansi participated in the review meeting of RKVY-Agroforestry organized by the Ministry of Agriculture & Farmers Welfare, GoI. and presented the guidelines for agroforestry nursery accreditation on 5th January, 2024.

36th Institute Research Council Meeting

The 36th IRC (I) & (II) meetings of the ICAR-CAFRI were organized on 25th April, 2024 and 4th December, 2024, respectively under the Chairmanship of Dr. A. Arunachalam, Director of the institute. Dr. R.V. Kumar, Pr. Scientist, ICAR-IGFRI Jhansi, graced the IRC (I) meeting as external expert while Dr. B.P. Bhatt, Pr. Scientist, NRM Division, ICAR was the external expert in IRC (II) meeting. During the meetings all scientists presented the significant achievements of their respective research projects. Detailed discussions were held and suggestion for improvement were provided by the Director of the institute and external expert. Three new project proposals were accepted after deliberations.

Institute Management Committee (IMC) Meeting



The 24th Institute Management Committee meeting of ICAR-CAFRI, Jhansi held on 25th June, 2024 under the Chairmanship of Dr. A. Arunachalam, Director of the Institute in hybrid mode. After welcoming the members in the meeting, the Director presented the institute progress report. The Administrative officer placed the agenda of the meeting, which was adopted anonymously by all the members.

First National Nursery Assessment and Accreditation Committee Meeting

The first National Nursery Assessment and Accreditation Committee (NNAAC) meeting was held in Virtual mode of 16th August, 2024 to screen the proposals for nursery accreditation from State Nodal Agencies. The meeting began with a welcome note and briefing of the purpose of the meeting by Dr. A. Arunachalam, the chairman of the NNAAC and this was followed the opening remarks by the Dr. Franklin L. Khobung IFS, Jt. Secretary (NRM), MoA & FW, Govt. of India.

Meeting on Sustainable Land Restoration Initiatives (Online)

On 08th October 2024, an online meeting was held between the Centre for Policy Design (CPD), ATREE, led by Dr. Abi Tamim Vanak, and the CAFRI Team, headed by Director Dr. A. Arunachalam. The meeting was also attended by key participants, including Dr. A.K. Handa and Mr. Suresh Ramanan S. The discussion focused on the multifaceted aspects of land restoration initiatives, fostering collaboration on sustainable solutions to restore degraded lands. Exciting steps ahead for ecosystem recovery and community well-being!

Meeting with New Zealand delegation

On the 19th November 2024, ICAR had an opportunity to meet with the New Zealand delegation and discussed opportunities for collaboration and cooperation in agroforestry. The New Zealand delegation was led by Mr. Sam Keenan, DDG, New Zealand Forest Service along with 3 more colleagues. The ICAR delegation was led by Dr. S. K. Chaudhari, DDG; Dr. Rajbir Singh, ADG, NRM Division; ADG, International Relations; Dr. A. Arunachalam, Director, CAFRI and other colleagues.

RAC Meeting

The 24th Research Advisory Committee (RAC) meeting of ICAR-CAFRI was held on 5th December, 2024 in hybrid mode at the institute. The meeting was chaired by Dr. Parvinder Kaushal, Vice Chancellor, VCSGUHF, Bharsar and joined by Dr. K.T. Pathiban, FCRI, Mettupalayam. Other RAC members joined virtually. At the onset of the meeting, Dr. A. Arunachalam, Director of the institute welcomed the Chairman and members of committee and gave overall view of the workdone by the institute since the last meeting. After that the ATR of the previous meeting was presented and accepted by the committee. The research work of the institute was presented by the respective program leaders. The RAC appreciated the research achievements of the institute and gave recommendations for the further improvement to meet the current challenges.

Internal Complaint Committee (ICC) Meeting

ICAR-CAFRI organized regular quarterly meetings of Internal Complaint Committee and these meetings were held on 26.02.2024, 26.04.2024, 01.08.2024 and 10.12.2024 under the Chairmanship of Dr. Nishi Rai, In-charge, KVK, Jhansi with the purpose to address issues under the sexual harassment of women at work place. The Committee discussed and looked after various issues related to welfare of working women in the Institute.

IJSC Meeting

ICAR-CAFRI organised, IJSC quarterly meetings under the Chairmanship of Director, Dr. A. Arunachalam, and he appraised all staff welfare activities. IJSC meetings were held on 21.3.2024 and 1.10.2024.

राजभाषा कार्यान्वयन समिति की बैठकें :

भा.कृ.अनु.प.–के.कृ.अनु.सं., झाँसी में राजभाषा कार्यान्वयन समिति की वर्ष 2024 के दौरान कुल 4 बैठकों का आयोजन किया गया। इन बैठकों का आयोजन संस्थान के निदेशक एवं अध्यक्ष, राजभाषा कार्यान्वयन समिति की अध्यक्षता में दिनाँक 7 फरवरी, 2024, 26 अप्रैल, 2024, 1 अगस्त, 2024 तथा 10 दिसंबर, 2024 को संपन्न हुई। राजभाषा अधिनियम, 1963 की धारा 3(3) के उपबन्धों के तहत हिन्दी के प्रयोग को बढ़ावा देने के लिए सभी सरकारी काम–काज हिन्दी में करने तथा हिन्दी का शत–प्रतिशत प्रयोग करने के लिए बढ़ावा देने हेतु विस्तृत चर्चा के साथ पूर्व बैठक की समीक्षा की गई तथा इसके उचित कार्यान्वयन के लिए आवश्यक कदम उठाए गए।

Days Observed

Republic Day

ICAR-CAFRI, Jhansi celebrated the 75th Republic Day, the scientific fraternity and staff of ICAR-CAFRI pledge their loyalty to our Motherland and paid their respect to the farmers and Soldiers of the Nation. Dr. A. Arunachalam, Director, CAFRI unfurled the National Flag and addressed the gathering.

World Wetlands Day

On the eve of World Wetlands Day *i.e.* 2nd February 2024, Scientists of ICAR-CAFRI's Agricultural Extension Research Program led by Dr. R.P. Dwivedi was declared the 'Team of the Month' by the Institute Management and the Certificate for the same was conferred by Dr. A.K. Singh, Hon'ble Vice Chancellor, RLBCAU, Jhansi in the presence of Director, ICAR-CAFRI and Officials of UP Forest Department.

National Science Day

On 28th February 2024, ICAR-CAFRI, Jhansi celebrated the National Science Day and the theme of the programme was "Indigenous Technology for Viksit Bharat".

International Women's Day

ICAR-CAFRI, Jhansi organized International Women's Day on 8th March, 2024 in Parasai village of Jhansi, Uttar Pradesh. The women employees of the institute have graced the occasion and shared their strong opinions on gender equality and equity among the farm women. Also, emphasized on the theme of International Women's Day 2024: Invest in women – to accelerate the progress.

World Water Day

ICAR-CAFRI, Jhansi organized World Water Day on 22nd March, 2024 by involving 55 farmers from Kanpur and nearby villages. The importance of water and significance of the World Water Day was briefed to the participating farmers and others by the team of scientists. In addition to the above, role of water bodies in maintaining hydrological cycle was also highlighted. Furthermore, visiting farmers were shown institute technology by way of audio visuals and field visit of the experimental farm area on the occasion.

Earth Day

ICAR-CAFRI, Jhansi in collaboration with SCORE Livelyhood Foundation celebrated "Earth Day" on 22nd April, 2024 to raise awareness regarding planet vs plastic. On this occasion a quiz and debate competition were organized. All the staff members attended the programme and participated in debate and quiz contest.

Labour Day

On 1st May 2024, ICAR-CAFRI, Jhansi celebrated the Labour Day. To mark the occasion, the Institute organized a Training Program on Drone Applications in Agroforestry; Farmers from nearby villages participated. The agricultural laborers' working in the Institute also joined the celebration.

37th Foundation Day of ICAR-CAFRI, Jhansi

On 8th May 2024, ICAR-CAFRI, Jhansi celebrated its 37th Foundation Day. The occasion was graced by the presence of Dr. S.K. Chaudhary (DDG, NRM, ICAR, New Delhi), Dr. A.K. Singh (VC, RLBCAU, Jhansi), QRT chairman and members, Dr. Pankaj Kaushal, Director, IGFRI, Jhansi, Dr. A. Arunachalam, Director, CAFRI, Jhansi and various agroforestry stakeholders. On this occasion A video version of the institute song (Krishivaniki kulgeet), publications like Krishivaniki Sarthi, Agroforestry Success Stories and Monograph on *Acacia Senegal* were released and ten agroforestry value added products were launched by DDG (NRM), VC, RLBCAU, QRT chairman, Director IGFRI and Director CAFRI.

On this occasion ICAR-CAFRI also signed a MoU agreement with Corporate TEO VENTURES for improving soil health.

On the occasion of Agroforestry Day, ICAR-CAFRI, Jhansi distributed the vermicompost bags to various farmers under SC-SP scheme of the Govt. of India and a demonstration of Drone application in agroforestry and agriculture was given to more than 120 farmers of Jhansi and nearby districts of Bundelkhand.

International Day for Biological Diversity

ICAR-CAFRI, Jhansi organized a sensitization program on biological diversity on the eve of the International Day for Biological Diversity; Students from SR Group of Institution, Jhansi participated in the event and celebrated the services provided by the biodiversity in this Green Planet.

World Environment Day

On the eve of the World Environment Day (5th June), Dr. A. Arunachalam, Director, ICAR-CAFRI gave a keynote address on Ecosystem Restoration in Rani Lakhsmi Bai Central Agricultural University, Jhansi.

IP Awareness Day

On 14th June 2024, ICAR-CAFRI, Jhansi organised IP Awareness Programme as part of the ICAR's Initiative for NRM Institutes in particular. The theme of progrmme was Copyright under the Intellectual Property regime. Dr. Ashwini Siwal from Delhi University and Dr. Rajender Prasad from IASRI, New Delhi gave useful tips and guidance on copyright registration.

Tenth International Yoga Day (IYD 2024)

On 21st June 2024, ICAR-Central Agroforestry Research Institute, Jhansi celebrated International Yoga Day (IYD 2024) in the office premises. On the occasion, all the CAFRIan along with project staff actively participated and made the event a grand success. The participants were briefed about the benefits of yoga and urged to adopt yoga as part of their lifestyle for better health and peace.

96th Foundation Day of ICAR

On 16th July 2024, ICAR-CAFRI, Jhansi celebrated the 96th Foundation Day of ICAR and also displayed it's poster and publications at New Delhi.

Independence Day

On the 78th Indian Independence Day, Dr. A. Arunachalam, Director, ICAR-CAFRI, Jhansi hoisted the National Flag

and paid respect with all humility and responsibility. Addressing the employees and project staff of the Institute, he remembered the souls that got abode fighting for independence and manifested this country with unity in diversity. Further, he spoke about the ICAR achievements and the CAFRI achievements that gave name and fame to the Council and CAFRI. Director, CAFRI also called on the employees to contribute more and more so that CAFRI becomes an Institute of Eminence. Jai Jawan, Jai Kisan, Jai Vigyan, Jai Anusandhan.

Mahila Kisan Diwas / World Food Day

ICAR-CAFRI celebrated Mahila Kisan Diwas and World Food Day under the leadership of the institute's Director Dr. A. Arunachalam. On this occasion, Mahila Kisan were honored as Agroforestry ambassador for their contribution in the field of agriculture and agroforestry. A special training was also conducted on Nursery for Mahila Kisans.

National Unity Day

On the occasion of National Unity Day 31st October, 2024, all the employees and project staff of ICAR-CAFRI took Pledge for unity in the Memory of Sardar Vallabh Bhai Patel and his Contribution for the unity and integrity of the country. On this occasion a health check-up camp was organized by Dr. Lal Paths for the welfare of the staffs.

National Agricultural Education Day

On the eve of National Agricultural Education Day (3rd December, 2024), ICAR-CAFRI, Jhansi did various activities including student visit, training, research review meetings, field research monitoring and also enabled local artisans to develop agroforestry models. The attraction was Shri Brindavan Rajpoot, Village Raheliya, District Mohaba, Uttar Pradesh who established a live model of Agroforestry.

World Soil Day

The World Soil Day was celebrated on 5th December, 2024 at ICAR- CAFRI Jhansi with great enthusiasm under the theme "Caring Soils: measure, monitor and manage" The function was presided over by the Director Dr. A. Arunachalam. In total 70 persons including scientists, staff members and research scholars attended the program.

National Farmer's Day

On 23rd December 2024, ICAR-CAFRI, Jhansi, celebrated National Farmers Day under the chairmanship of Director Dr. A. Arunachalam. Dr. Ravindra Shukl (Ex-Agri. Minister, UP) was the Chief Guest; Mr. Dharmendra Kumar (DD, Soil Conservation, Jhansi) was the Guest of Honor in the event. Farmers from Shivpuri and Jhansi district participated in the event. Progressive farmers were declared as the Agroforestry Ambassadors.

7. Participation in Workshop/Webinars/Meetings/Symposia

Duration	Event	Organizer	Participants
03 January, 2024	Technology/Product/Concept/Germplasm registration through Institute Technology Management Committee	CAFRI, Jhansi	Dr. Sovan Debnath
04 January, 2024	Online training on Agroforestry Model in Tasar Culture	Central Tasar Research & Training Institute, Ranchi	Dr. Rajendra Prasad
05 January, 2024 & 28 March, 2024	Project implementation and monitoring meeting (PIMC) of NABARD-funded pomegranate project	NABARD, Regional Office, Lucknow	Dr. A. Arunachalam, Dr. A. K. Handa, Dr. R.P. Dwivedi, Dr. Badre Alam, Dr. Ashok Yadav, Dr.Suresh Ramanan S, Mr. Suresh Pal, Dr. Vinay Kumar & Dr. Prasant Kumar
03-06 February, 2024	Farm Tech Asia 2024-International exhibition and conference on Agriculture, Horticulture, Dairy and Food technology	RVSKVV, Gwalior	Dr. R.P. Dwivedi
08-10 February, 2024.	Uttar kshetriya kisan mela and krishi pradarshini	RLBCAU, Jhansi	Dr. R.P. Dwivedi, Dr. Priyanka Singh
13 February, 2024	Exhibited stall during 'Takniki and Machinery Pradarshini Mela'	ICAR-IGFRI, Jhansi	Dr. R.P. Dwivedi, Dr. Priyanka Singh & Dr. Bijoy Chanda
15 February, 2024	FSPF-DPR Review Meeting with Project Implementing Agencies (PIA's)	NABARD, Regional Office, Lucknow	Dr. Ashok Yadav
19-20 February, 2024	WNO Neem Summit 24 (2nd WNO Seminar & 3rd Global Neem Trade Fair)	ICAR-CAFRI, Jhansi and WNO	Dr. A.K. Handa, Dr. K Rajarajan & Dr. Hirdayesh Anuragi
04 March, 2024	Conference on Technology for Drought	Relief Commissioner, Lucknow, Uttar Pradesh	Dr. Asha Ram
12 March, 2024	Farmer training program	KVK Bharari, Jhansi	Dr. Asha Ram
28 March, 2024	Workshop on Soil Health: Measurement and Modeling	Indian Institute of Remote Sensing (IIRS), Dehradun	Dr. Sovan Debnath
30 March, 2024	A virtual meeting regarding the project implementation and monitoring meeting (PIMC) on, under the NABARD-funded pomegranate project	Virtual meeting	Dr. Ashok Yadav
03 April, 2024	Meeting on Comprehensive Guidelines for the Foreign Visits of the Scientist/ Officials of ICAR (virtual)	ICAR, New Delhi	Dr. Sovan Debnath
05 April, 2024	Workshop on National Agroforestry Policy	ICAR & Ministry of Agriculture and Farmers Welfare	Dr. A. Arunchalam, Dr. A.K. Handa & Suresh Ramanan S

26 April, 2024	Webinars on IP and the Sustainable Development Goals: Building our Common Future with Innovation and Creativity	ICAR (IP&TM unit), New Delhi	All Scientific Staff
01 May, 2024	Viksit Bharat meeting (Horticulture Crops), Virtual Mode	ICAR-DARE, New Delhi.	Dr Ashok Yadav
31 May, 2024	Cutting edge tool webinar series	International Association for Vegetation Science	Suresh Ramanan S
10-11 June, 2024	Multi-Sectoral Stakeholders Consultation Workshop on the Indian Forest and Wood Certification Scheme (PRAMAN)		Mr. Suresh Ramanan S
18-19 June, 2024	National Conference on Agro-ecological basis of Agroforestry: Interaction, Innovation and Incubation	ISAF and ICAR-CAFRI, Jhansi.	All Scientific and Technical Officer of CAFRI
24 June, 2024	Online workshop on Accreditation Protocol for Agroforestry Nurseries		Suresh Ramanan S
24-28 June, 2024	Master Trainer Orientation Program on Agroforestry systems and Forest Policies under TOFI	RLBACU, Jhansi	Dr Rajendra Prasad
05 July, 2024	The FSPF-DPR Review Meeting with Project Implementing Agencies (PIA's)	NABARD, Regional Office, Lucknow	Dr. Ashok Yadav
08 July, 2024	An online meeting with the Central Silk Board	online meeting	Mr. Suresh Ramanan S
11-13 July, 2024	International Conference on Impact of Climate Change on Bio-Diversity – A Global Perspective	Madras Veterinary College ,Chennai	Suresh Ramanan S
16 July, 2024	Bhujal Gosthi	Commissioner, Jhansi Division	Dr. Asha Ram
23 July, 2024	Virtual meeting regarding the Project Implementation and Monitoring Committee (PIMC) for the NABARD-funded pomegranate project.	A virtual meeting NABARD	Dr. A. Arunachalam, Dr. A.K. Handa, Dr. Badre Alam, Dr. R.P. Dwivedi, Dr. Ashok Yadav, Dr.Suresh Ramanan S, Dr. Vinay Kumar & Dr. Prasant Kumar
24 July, 2024	Technology/Product/Concept/ Germplasm registration through Institute Technology Management Committee	CAFRI, Jhansi	Dr. Sovan Debnath
2-7 August, 2024	International Conference on Transformation Towards Sustainable Agri-Food System.	International Association of Agriculture Economist (IAAE), New Delhi.	Dr. Priyanka Singh
10 August, 2024	A one-day awareness program on ORCHIDS-INCUBNET services for scholarly communities	Babasaheb Bhimrao Ambedkar University, Lucknow, U.P	Mr. Suresh Ramanan S
13 August, 2024	Webinar on Shaping India's Carbon Market the Centre for Science and Environment	Centre for Science and Environment, New Delhi	Mr. Suresh Ramanan S
16 August, 2024	National Nursery Assessment and Accreditation Committee (NNAAC) Meeting (Online)	Online	Mr. Suresh Ramanan S.

23-24 August,2024	National Conference on Shashwat Shrishti Sanrakshan; A pledge for protecting world against natural hazards: Agro-biotechnological approach	ICAR-CAFRI, Jhansi, STE ISAF Jhansi, SSCE New Delhi and SKSS Meerut.	All Scientific staff of CAFRI
29 August, 2024	TeO Ventures to discuss initiatives related to Biochar and carbon sequestration.	Online meeting	Mr. Suresh Ramanan S
07-09 September, 2024	First Advisory Committee Meeting of the NASF funded project	ICAR-CAFRI, Jhansi	Dr. Badre Alam Dr. Sovan Debnath
12 September, 2024	Mizoram Forest Department to discuss the accreditation of agroforestry nurseries.	Virtual meeting	Mr. Suresh Ramanan S
27 September, 2024	Webinar on Carbon Credits in Agriculture (online)	MANAGE, Hyderabad	Dr. Sushil Kumar
15-17 October, 2024	Workshop on sustainable landscape approaches and ecosystems services"	GiZ, GmbH, ¦ India	Dr. Naresh Kumar, Dr. Asha Ram, Mr. Suresh Ramanan S,
16 October, 2024	A project review meeting of UPCAR project	RLBCAU, Jhansi	Mr. Suresh Ramanan S
18-19 October, 2024	International Conference on Biodiversity, Agroforestry, Non-Wood Forest Products and Sustainable Livelihoods (ICBANS 2024)	V Sivaram Research Foundation, ISAF ICAR-CAFRI, CIFOR-ICRAF	Dr. A. Arunachalam, Dr. A. K. Handa & Dr. K. Rajarajan
24 October, 2024	A virtual meeting regarding the Project Implementation and Monitoring Committee (PIMC) for the NABARD-funded pomegranate project.	A virtual meeting	Dr. Ashok Yadav
24 October, 2024	Webinars on Vikshit Bharat @ Agriculture on i-GoT Karmayogi platform	ICAR, New Delhi	Dr. Sovan Debnath
08 November, 2024	Chara Mela (Exhibition)	ICAR-IGFRI, Jhansi	Dr. Priyanka Singh, Dr. Bijoy Chanda
11-13 November, 2024	The workshop on the Indian Forest and Wood Certification Scheme – PRAMAAN	IIFM, Bhopal,	Mr. Suresh Ramanan S
19-22 November, 2024	Global Soil Conference 2024 on Caring Soils Beyond Food Security : Climate Change, Mitigation and Ecosystem Services	ISSS (New Delhi), IUSS (Italy), ICAR (New Delhi) and NAAS (New Delhi)	Dr. A. Arunachalam Dr. Rajendra Prasad, Dr. Asha Ram, Dr. Sovan Debnath
21-23 November, 2024	International Conference on Advancement in Basic Science Environmental Studies and traditional Medicine for Translation Drug Discovery and development (TMT3D-2024)	BHU, Varanasi and NESA, New Delhi	Dr. H. Anuragi
04 December, 2024	A one-day online brainstorming meeting on enriching the technical knowledge of the staff of the Horticulture Department	The Department of Horticulture and Food Processing department	Dr. Ashok Yadav
16 December, 2024	Webinars on 'Best Practices for Project Formulation'	ICAR, New Delhi	Dr. Sovan Debnath
17 December, 2024	Discussion for Artificial Intelligence regarding AI for Social Impact	CAFRI & Wadhwani AI	All Scientific staff of CAFRI
20 December, 2024	Online annual workshop of the HPVANRG project	ICAR-NISA, Ranchi	Dr. Rajendra Prasad Dr. Badre Alam
28-29 December, 2024	International Conference on Nature, Science and Modern Life Style: Issues and Perspective (ICNSMLIP-2024)	Sarvhit Kalayan Seva Samiti, Meerut	Dr. R.P. Dweidi & Dr. Sukumar Taria

8. Publications

(A) Research Article

- Alam, B., Taria, S., Kumar, S. and Arunachalam, A. (2024) Unravelling the critical insights on the physiological and biophysical constraints for the impact of different intensity of shade in pigeonpea *Cajanas cajan* (L.). *Agroforestry Systems*. https://doi.org/10.1007/s10457-024-01017-3.
- Arunachalam, A., Ramanan, S.S., and Handa, A.K. (2024) Amendment to National Biological Diversity Act: loaded provisions and a few concerns. *Current Science,* 126 (11), 1319-1320).
- Arunachalam, A., Rizvi, R.H., Handa, A.K., and Ramanan S.S. (2024) State-wise area estimation of agroforestry in India. *Current Science,* 127(11), 1267.
- Chanda, B., Bhowmik, A., Varghese, C., Jaggi, S., Datta, A., Mandal, B. N. and Pal, S. (2024). Incomplete equivalent estimation split plot designs. *Journal of Community Mobilization and Sustainable Development*, 19(2), 357-360.
- Chandrakumar, A., Thamban, C., Jayasekhar, S., Singh, P., Hema M., Eradasappa, E., Thondaiman, V., Jyoti, Nishad, T., Raviprasad, T.N. and Adiga, J. D. (2024) Trend analysis of the raw cashewnut production in India. *International Journal of Agriculture Extension and Social Development,* 7(9), 635-643.
- Chavan, S.B., Uthappa, A.R., Chichaghare, A.R., Ramanan, S.S., Kumar, R., Keerthika, A., Arunachalam, A., Hegde, R., Jinger, D., Meena, V.S., Kumar, M., Harisha, C.B., Kakade, V.D., Morade, A.S., Rawale, G.B., Singh, R., Reddy, K.S. (2024) Past, present and future of Indian sandalwood (*Santalum album*) cultivation and commercial prospects. *Discov. Appl. Sci.,* 6, 627. https://doi.org/10.1007/s42452-024-06337-8.
- Choudhary, B.B., Sharma, P., Chaudhary, M., Mahesha, H.S., Dubey, S.K., Gautam, U.S., Burman, R.R., Kumar, S., Dwivedi, R.P. and Singh, S.K. (2024) Impact of Agricultural Technologies on System Productivity: A Case Study of the Farmer FIRST Programme in Bundelkhand Region, Uttar Pradesh, *Indian Journal of Agricultural Economics* 79: 4 (2024):1043-1052.
- Choudhary, B.B., Singh, P., Dev, I., Sharma, P., Singh, R. and Chand, K. (2024) Determinants of adoption of multiple natural resource management practices: a case study from semi-arid tropics of Central India. *Environment, Development and Sustainability*, https://doi.org/10.1007/s10668-024-04995-7.
- Choudhary, B. B., Sharma, P., Singh, P., Upadhyay, D., Kumar,S.,Gupta, G.,Kantwa,S.R. Wasnik, V.K., and Prasad, M. (2024) Modelling impact of improved forage cultivation on milk productivity and feed sufficiency in semiarid tropics of central India: A doubly robust analysis. *Animal Science Journal*, 95, e70009.
- Choudhary, G., Dwivedi, K.K., Dwivedi, L.K., Priyadarsini, P., Kaushal, P., Choudhary, R., Rana, M., Anuragi, H. and Batham, A. (2024) Expression Profiling of MSP1 Gene Involved in Mega-gametophyte Development in Ploidy Series of Guinea Grass (*Panicum maximum* Jacq.). *Journal of Advances in Biology & Biotechnology*, 27(7), 355-362.
- Das, A., Pal, M., Taria, S., Ellur, R. K., Kumar, S., Sathee, L., Krishnan, S. G., Dalal, M., Jain, P. K. and Chinnusamy, V. (2024) Multivariate analysis and genome wide association mapping for chlorophyll fluorescence and grain number per panicle under high temperature stress in rice. *Plant Physiology Reports*. https://doi.org/10.1007/s40502-024-00808-1.
- Das, D.K., Singh, S.K. and Prasad, R. (2024) Impact of Agroforestry on soil fertility and soil carbon: A Review. *Indian Journal of Agroforestry* (Special Issue): 76-82pp.
- Debnath, S., Saha, S., Biswas, T., Mal, S., Batabyal, K., Sarkar, D., Yadav, S.L., Bhattacharjee, T., Chakraborty, M., Chattopadhyay, A., Mandal, B. (2024) Trace elements profiling of hyacinth bean (*Lablab purpureus* var. *typicus* L.): A rational screening of the breeding lines for biofortification programs. *South African Journal of Botany*, 167, 40-47. https://doi.org/10.1016/j.sajb.2024.02.010.
- Debnath, S., Yadav, S.L., Ramanan, S., Ashajyothi, M., Yadav, A., Ram, A., Kumar, S., Kumar, N., Prasad, R. and Arunachalam, A. (2024) Assessing the spatial heterogeneity in soil microbial population in agroforestry systems of semiarid central India. *Journal of the Indian Society of Soil Science*.
- Deuri, M., Dutta, U., Khangam, P., Rido, L., Wangpan, T., Arunachalam, A. and Tangjang, S. (2024) Assessment of socio-economic status of agroforestry farmers: A case study in eastern Arunachal Pradesh. *Indian Journal of Agrooforestry*, 26(2), 130-137.

- Dev, R., Patidar, A., Sureshkumar, M., Kumar, S., Venkatesan, K., Saranya, R., Singh, T. and Dayal, D. (2024) Genetic diversity assessment of *Cordia gharaf* (Forsk.) germplasm for morphophysiological and fodder traits in hot-arid Kachchh region of India. *Indian Journal of Plant Genetic Resources*, 37(2), 283-293.https//:doi:10.61949/0976-1926.2024.v37i02.11.
- Dhiman, R., Arunachalam, A., Dhyani, S.K., Rizvi, R.H., Singh, A., Kumar, R., Biradar, C.M. and Rizvi, J. (2024) Circular economy of Poplar-based agroforestry in India. *Indian Journal of Agroforestry*, 26(1), 12-22.
- Dobhal, S., Kumar, R., Bhardwaj, A.K., Chavan, S.B., Uthappa, A.R., Kumar, M., Singh, A., Jinger, D., Rawat, P., Handa, A.K. and Ramawat, N. (2024) Global assessment of production benefits and risk reduction in agroforestry during extreme weather events under climate change scenarios. Front. For. Glob. Change 7:1379741. doi: 10.3389/ffgc.2024.1379741.
- Govindasamy, P., Rajarajan, K., Choudhary, M., Chaudhary, M., Prasad, M., Mahawer, S.K., Halli, H.M., Keerthi, M.C., Deb, D., Tyagi, V.C., Srinivasan, R., Gurjar, B., Rajagopal, V., Ramanan, S.S. (2024) Agroforestry Systems for Improved Above and Below Ground Biodiversity, in: Sustainable Management and Conservation of Environmental Resources in India. Apple Academic Press, New York, pp.149–180. https://doi.org/10.1201/9781003469278-7.
- Jain, A., Arunachalam, A., Singh, R., Handa, A.K., Ramanan, S.S., and Verdiya, A. (2024) Perspective of Jainism on the Socio-Cultural and Environmental Values of Sacred Trees. *Journal of Dharma Studies*, pp.1-15.
- Kader, S., Bashir,O., Bangroo,S., Shafai,S., Shah,T., Jaufer,L., Senesi,N., Kuriqi,A., Omidvar,N., Kumar, S.N., Arunachalam, A., Michael,R., Ksibi,M., Spalevic,V., Sestras,P., Marković,S., Billi,P., Ercişli, S. and Hysa, A. (2024) Mathematical vs. machine learning models for particle size distribution in fragile soils of North-Western Himalayas. *Journal of Soils and Sediments*, DOI: 10.1007/s11368-024-03820-y.
- Kishor, A., Debnath, S., Das, B., Narayan, R., Attri, B.L., Kumar, A., Chandni, E.R., Rashmi, Prasad, R., Verma, M.K., and Arunachalam, A. (2024) Integrated nutrients management in apple-based horti-olericulture system enhances yield and improves soil health in *Kumaon* region of Himalaya, Uttarakhand. *Indian Journal of Agroforestry* (Special Issue), pp.42-49.
- Kumar, V., Prasad, R., Debnath, S., Venkatesh Y.N., Ashajyothi M., Ram, A., Kumar, S., Kumar, N., Chanda, B. and Arunachalam, A. (2024) Temporal dynamics in the abundance of soil fauna, microflora, and soil biochemical properties in different agroforestry systems of Central India. *Indian Journal of Agroforestry* 2024 (Special Issue): 11-17.
- Kumar, S., Alam, B., Arunachalam, A. and Taria, S. (2024) Mitigating greenhouse gas emissions and improving livelihood security through innovative agroforestry models. *Indian Journal of Agronomy*, 69 (Special issue), S 193- S 203.
- Kumar, D., Sinha, N.K., Mishra, R., Kumar, J., Wanjari, R.H., Prasad, R. and Nagwanshi, A. (2024) Agroforestry for Nutrient Cycling and Soil Health Improvement. *Indian Journal of Agroforestry* (Special Issue), pp.32-41.
- Kumar, S., Misra, A.K. and Venkatesan, K. (2024) Traditional fodder storage systems used in India's western hot arid zone as a drought-proofing mechanism. *Indian Journal of Traditional Knowledge,* 23(6), 594-599. https://doi: 10.56042/ijtk.v23i6.2016.
- Kumar, V., Prasad, R., Debnath, S., Venkatesh, Y.N., Ashajyothi, M., Ram, A., Kumar, S., Kumar, N., Chanda, B. and Arunachalam, A. (2024) Temporal dynamics in the abundance of soil fauna, microflora, and soil biochemical properties in different agroforestry systems of Central India. *Indian Journal of Agroforestry* (Special Issue), pp.11-17.
- Maurya, A.C., Verma, S.K., Kumar, S., Shekhar, S., Taria, S., Alam, B., Yadav, A. and Banjara, T.R. (2024) Agronomic management: irrigation scheduling, mulching and integrated nutrient management influences growth, yields, quality, and economics of summer groundnut in a subtropical condition of India. *Journal of Plant Nutrition*. 10.1080/01904167.2024.2308191.
- Meena, S.N., Sharma, S.K., Singh, P., Meena, B.P., Ram, A., Meena, R.L., Singh, D., Meena, R.B., Nogiya, M., Jain, D., Kumar, K., (2024) Comparative analysis of soil quality and enzymatic activities under different tillage based nutrient management practices in soybean–wheat cropping sequence in Vertisols. *Sci. Rep.,* 14, 1–16. https://doi.org/10.1038/s41598-024-54512-z.
- Mushineni, A., Narayanaswamy, V.Y., Yadav, A., Alexander, B., Kumar, N., Venkidusamy, K.S., Handa, A.K., Arunachalam, A. and Aundy, K. (2024) The outbreak of teak leaf blight disease caused by *Alternaria alternata* in the semi-arid Bundelkhand region of India. *Forest Pathology*, *54*, e12875. https://doi.org/10.1111/efp.12875.
- Pandey, L., Arunachalam, A. and Joshi, N. (2024) Biomass, productivity and monetary efficiency of

various cropping systems in the Almora district of the Indian Himalaya, *Geografisk Tidsskrift-Danish Journal of Geography.* https://doi.org/10.1080/00167223.2024.2354346.

- Patel, N., Sethi, T., Bhanderi, R.J., Sharma, S.A., Arunachalam, A., Ravishankar, T., Raj, A., Vagen, T.G. and Prabhu, R. (2024) Agroforestry Site Suitability for Wasteland Greening - A case study of selected districts of various agroclimatic zones. *Journal of Geomatics,* (*ISSN 0976-1330*) 18(1), 50-66.
- Prasad R., Arunachalam A., Alam B., Handa A.K., Ram A., Singh P., Shukla A., Giri S.K. (2024) Assessment of seasonal variability in gum exudation and gum yield in Palash (*Butea monosperma*) in semi-arid region of central India. *Indian Journal of Agroforestry,* 26, 69–73.
- Prasad, R., Arunachalam, A., Shukla, A., Singh, P., Newaj, A.R., Singh, R., Saroj, N.K., Tripathi V.D., Debnath, S. (2024) Horizontal and vertical variations in soil properties under different pruning regimes in *Albizia procera* based agroforestry system. *Indian Journal of Agroforestry* (Special Issue), 50-60.
- Prasad, R., Arunachalam, A. and Shukla, A. et al. (2023). Field management practices in agroforestry systems influence organic carbon and biological properties of soil. *Agroforest Systems*, 97, 1375–1390. https://doi.org/10.1007/s10457-023-00861-z.
- Priyadarsini, P., Pal, M., Pandey, R., Gopalakrishnan, S., Sehgal, V. K., Chinnusamy, V., Taria, S., Kumar, P., Padaria, J., and Lal, M. K. (2024) Photosynthesis and radiation use efficiency at anthesis in relation to biomass accumulation and yield in basmati rice (*Oryza sativa* L.). *Plant Physiology Reports,* https://doi.org/10.1007/s40502-024-00784-6.
- Rajarajan, K., Sakshi Sahu, A. K. Handa, A. Arunachalam, E. Priyadarshini, A. Bharti, A. Yuvaraja, M. Muthamilarasn, and Anuragi, H. (2024) Genetic diversity and population structure of Azadirachta indica using simple sequence repeat (SSR) markers for genetic resource conservation and utilization. *Genetic Resources and Crop Evolution*, pp.1-12. https://doi.org/10.1007/s10722-023-01841-z.
- Rajendran, A., Ayyagari, R., Sarkar, S., Agasti, S.S., Rajarajan, K., Lal, S. K., Raju, D. and Subramaniam, S. (2024) Autofluorescence– spectral imaging for rapid and invasive characterization of soybean for pre-germination anaerobic stress tolerance. *Frontiers in Plant Science*, 15; 1334909.
- Ram, A. and Arunachalam, A. (2024) Drone Application in Agriculture and Agroforestry. *International Journal on Agricultural Sciences*, 15(1); 19-24.
- Ram, A., Kumar, N., Dev, I., Handa, A.K., Yadav, A., Debnath, S., Chandra, M., Anuragi, H. and Arunachalam, A. (2024) Potential of Agroforestry for Climate Change Adaptation and Mitigation. *Indian Journal of Dryland Agricultural Research and Development*, 39(2); 60-67.
- Ramanan, S.S. and Arunachalam, A. (2024) Dashboard to facilitate *Melia* research. *Indian Journal of Agroforestry,* 26(1); 110-111.
- Ramanan, S.S., Arunachalam, A., Sahoo, U.K. and Upadhaya, K. (2024) Exploring research trends and priorities of genus Melia. *Scientifi Reporter,* 14, 6265. https://doi.org/10.1038/s41598024-53736-3.
- Ramanan, S.S, Arunachalam, A., Sahoo, U.K., Upadhyaya, K. and Rashmir R. (2024) Phytochemical properties of genus Melia: A comparative review, *Medicinal Plants,* 16(1); 58-65.
- Ramanan, S.S., Arunachalam, A. and Singh R. (2024) Horizons of medicinal and aromatic plants (MAPs) cultivation under agroforestry: Insights from India. *Medicinal Plants,* 16(1); 15-28.
- Ramanan, S.S., Verdiya, A., Arunachalam, A. and Handa, A.K. (2024) Crafting state-of-the-art agroforestry for Bundelkhand using insights from past. *Annals of Arid Zone,* 63(3); 32-39.
- Reddy, M.K., Asthana, R., Debnath, S., Ray, P., Mandal, N., Arunachalam A., Koduru, J.R. (2024) Nanofertilizers for sustainable crop production: A comprehensive review. *BioNanoScience,* 14, 1918–1939. https://doi.org/10.1007/s12668-024-01413-0
- Rizvi, J., Dhyani, S.K., Arunachalam, A., Rouge, J.C. and Singh, A.(2024) The National Agroforestry Policy in India, transforming Indian agriculture landscape and inspiring other nations: The role of ICRAF and its partners. *Indian Journal of Agroforestry,* 26(1); 1-11.
- Singh, P., Choudhary, B.B., Sharma, P., Kumar, S., Dev, I., Singh, R., Garg, K.K., Chand, K., Ram, A., Kumar, N. and Arunachalam, A. (2024) Impact of soil and water conservation measures on farm productivity and income in the semi-Arid tropics of Bundelkhand, central India. *Environmental Conservation,* https://doi.org/1017/S0376892924000146.
- Sirohi, C., Kumar, P., Dhillon, R.S., Bhardwaj, K.K., Ahlawat, K.S., Handa, A.K. and Arunachalam, A. (2024) Soil nutrient status and wheat productivity under poplar (*Populus deltoides*) boundary plantation in Haryana. *Indian Journal of Agroforestry*, Special Issue, 70-75.

- Srinivasan, G., Chinnamani, C., Chellapandian, M., Leela, V., Sathiamoorthy, T. and Arunachalam, A. (2024) Floral diversity and nutritive value of forages in Pulikulam catle breeding tract. *Range Management and Agroforestry*, 45(1), 148-154.
- Tiwari, P., Deshmukh, P.P., Dobriyal, M.J., Yadav, R.P., Kumar, R. and Kumar, N. (2024) Impact of different spatial geometries of *Gmelina arborea* on performance of lentil varieties in Bundelkhand region. *Agricultural Mechanization in Asia, Africa and Latin America*, 55 (11), 19219-19229.
- Upadhyay, S., Ram, A., Kumar, N., Dev, I., Debnath, S., Upadhyay, K., Yadav, A., Anuragi, H., and Arunachalam, A. (2024) Effect of Tree-Crop Interactions in *Melia dubia*-Wheat Agroforestry System on Light Interception, Growth and Yield of Wheat in Bundelkhand Region of Central India. *Journal of Agricultural Physics*, 24 (2), 199-208
- Venkatesh, Y. N., Ashajyothi, M., Rajarajan, K., Sahu, S., Chaturvedi, V., Prathima, P. T., Muthamilarasan, M., Handa, A. K. and Arunachalam. A. (2024) Transcriptional and physio-chemical responses of *Tectona grandis* L. triggered by teak defoliator. *Plant Stress*, 12, 100468.
- Yadav, A., Garg, S., Kumar, S., Alam, B., & Arunachalam, A. (2024) A review on genetic resources, breeding status, and strategies of dragon fruit. *Genetic Resources and Crop Evolution*, 1-21pp.
- Yadav, A., Jha, S., Garg, S., Arunachalam, A., Handa, A.K., & Alam, B. (2024) Unveiling nutraceutical, antioxidant properties, and bioactive compound profiling of Chironji gum. *Food Bioscience*, 62, 105274.
- Yadav, S.L., Debnath, S., Singh, Y., Singh, S.K., Devi, Y.B., Ghosh, A., Ram, A., Kumar, S. & Arunachalam, A. (2024) Influence of Varied Nutrient Management Strategies on Yield, Nutrient Absorption and Grain Protein Content in Chickpea (*Cicer arietinum L.*). *Indian Journal of Agricultural Research,* A-6255 [1-7]. 10.18805/IJARe.A-6255.

(B) Action Plan

- Arunachalam, A., Dey, D., Sharma, V.K., Handa, A.K. and Ramanan S.S. (2023) TEEB AgriFood Learning Landscape – Action Plan for Assam. ICAR-CAFRI, Jhansi 284003, Uttar Pradesh, India; 30 p.

(C) Policy Paper

- Arunachalam, A. (2024) Scientific Social Responsibility in Agroforestry. Policy Paper # 1, ICAR-CAFRI, Jhansi 284003, Uttar Pradesh, India; 17 p. (ISBN: 9788196525842)
- Arunachalam, A., Ramanan, S.S. and Handa, A. K. (2024) Foresighting National Agroforestry Policy for Fostering Green Development. Policy Paper # 2, ICAR-CAFRI, Jhansi; 18p.
- The success of a national agroforestry policy in India has become a model for other countries. Policy Brief (September 2024). oil.org/10.17528/cifor-icraf/009240, 8 p.
- Arunachalam, A., Ramanan S., S and Handa, A.K. (2024) Reviewing National Agroforestry Policy. ICAR-CAFRI, Jhansi 284003, Uttar Pradesh, India; 16 pages.

(D) Project Reports

- Arunachalam, A., Sharma, V.K., Handa, A.K., Ramanan, S.S, Dey, D., Kumar, Debbaruah, R., and Bordoloi, K. (2023) Synthesis Report: The Economics of Ecosystems and Biodiversity (TEEB) - AgriFood Initiative in Assam, India. ICAR-Central Agroforestry Research Institute, Jhansi 284003, Uttar Pradesh, India; 22 p.
- Arunachalam, A., Sharma, V. K., Handa, A.K., Ramanan S.S, Dey, D., Kumar, U., Debbaruah, R. and Bordoloi, K. (2023) Project Completion Report: The Economics of Ecosystems and Biodiversity (TEEB) - AgriFood Initiative in Assam, India. ICAR-Central Agroforestry Research Institute, Jhansi 284003, Uttar Pradesh, India; 223 p.

(E) IPR Registry

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- The concept and design of *CAFRI-Thorny Tree Gum Amasser* has been registered in ITMU

(F) Books / Book Chapters

Books

- ICAR-CAFRI (2023) Accreditation Protocol for Agroforestry Nurseries. ICAR-Central Agroforestry Research Institute, Jhansi, Uttar Pradesh, 29 p.
- ICAR-CAFRI, QRT Report (2018-23): 6th Quinquennial Review Team Report (2018-23) of CAFRI and AICRP on Agroforestry, ICAR, New Delhi; 68p.

- ICAR- CAFRI, Annual Report (2023) ICAR- Central Agroforestry Research Institute, Jhansi 284003, Uttar Pradesh, India, 87p.
- ICAR- CAFRI, Krishivaniki Alok 13 (2024) ICAR-Central Agroforestry Research Institute, Jhansi 284003, Uttar Pradesh, India, 166p.
- AICRP on Agroforestry, Annual Report (2024) ICAR-Central Agroforestry Research Institute, Jhansi 284003, Uttar Pradesh, India, 68p.
- Arunachalam, A., Ramanan S, S and Handa, A.K. (2023) Trainers Training Manual on Agroforestry. ICAR-Central Agroforestry Research Institute, Jhansi 284003, Uttar Pradesh, India, 112 p.
- ICAR-CAFRI, Promising Agroforestry Models for Odisha (2023) ICAR-Central Agroforestry Research Institute, Jhansi, 18p.
- ICAR-CAFRI, Promising Agroforestry Models for Maharashtra (2024). ICAR-Central Agroforestry Research Institute, Jhansi, 26 p.
- ICAR-CAFRI, Promising Agroforestry Models for Karnataka (2024). ICAR-Central Agroforestry Research Institute, Jhansi, 26 p.
- ICAR-CAFRI, Promising Agroforestry Models for Haryana (2024). ICAR-Central Agroforestry Research Institute, Jhansi, 22 p.
- ICAR-CAFRI, Promising Agroforestry Models for Assam (2024). ICAR-Central Agroforestry Research Institute, Jhansi, 22 p.
- ICAR-CAFRI, Promising Agroforestry Models for Uttar Pradesh (2024). ICAR-Central Agroforestry Research Institute, Jhansi, 26 p.
- ICAR-CAFRI, Promising Agroforestry Models for Manipur (2024). ICAR-Central Agroforestry Research Institute, Jhansi, 14 p.
- ICAR-CAFRI, Promising Agroforestry Models for Nagaland (2024). ICAR-Central Agroforestry Research Institute, Jhansi, 15 p.
- ICAR-CAFRI, Promising Agroforestry Models for Chhattisgarh (2024). ICAR-Central Agroforestry Research Institute, Jhansi, 24 p.
- ICAR-CAFRI, Promising Agroforestry Models for Tamil Nadu (2024). ICAR-Central Agroforestry Research Institute, Jhansi, 25 p.
- ICAR-CAFRI, Promising Agroforestry Models for Andhra Pradesh (2024). ICAR-Central Agroforestry Research Institute, Jhansi, 20 p.
- Dey, D., and Arunachalam, A. Sustainable and Traditional Environmental Conservation in Asia. Springer Singapore. 182 p, https://doi.org/10.1007/978-981-97-1806-1.
- Kirupa, M., Thilak, M., Sivakumar, P., Balasubramanian, A. and Arunachalam, A. (2024) `Kaanagaviyal' in Tamil (=Forestry in English), Agricultural Scientific Tamil Society (SciTSA); ISBN: 978-93-91853-52-5
- Latha, P., Thilagavathi, R and **A**. Arunachalam (2024) `Payir Noyiyeal in Tamil (=Plant Pathology in English), Agricultural Scientific Tamil Society (SciTSA); ISBN: 978-93-91853-94-5
- Prasad, R. and Arunachalam, A. (2024) *Acacia senegal* :A multipurpose gum yielding tree for agroforestry. ICAR-Central Agroforestry Research Institute, Jhansi; 100 pages (ISBN 9788196525823)
- Rameshwar, P., Handa, A.K. and Arunachalam, A. (2024) Soapnut (*Sapindus mukorossi*) Monograph, AICRP-Agroforestry Centre, CSKHPKV, Palampur (HP); 114 p.
- Singh, Priyanka, Ramanan, S., Chanda, B., Kumar, S., Handa, A.K. and Dwivedi, R.P. (2024) Souvenir-cum-Abstracts/Proceedings Book, National Conference on Agro-ecological basis of Agroforestry: Interaction, Innovation and Incubation, 18-19 June, 2024; *Indian Society of Agroforestry*, Jhansi, Uttar Pradesh, India; 156 p.
- ICAR-CAFRI (2024) Abstract-cum-Souvenir Book, National Conference on Shashwat Srishti Sanrakshan A Pledge for protecting World against Natural Hazards: Agro-biotechnological approach, 23-24 August, 2024; STE, Gurugram and CAFRI, Jhansi, Uttar Pradesh, India; 63p.
- ICAR-CAFRI (2024) Access CAFRI online (QR Codes), ICAR-Central Agroforestry Research Institute, Jhansi; 4p.

Book Chapters

- Ambati, S., Anuragi, H., Prasad, K.R., Vidhyadhar, B., Marathi, B. (2024) Botanical Description, Brief History of Browntop Millet and Its Spectacular Adaptations as a Hardy Food and Feed Crop. In Genetic improvement of Small Millets. Singapore: Springer Nature Singapore. pp 637-644. https://doi.org/10.1007/978-981-99-7232-6_31
- Arunachalam, A., Ramanan, S.S., and. Handa, A.K. (2024) Agroforestry in the context of Climate Change for Future Agriculture. In: Shelat, Kirit, Shrikant Kalamkar, A.R. Pathak and Odemari Mbuya (2024). (Eds), "Future Agriculture—'Viksit Bharat', Allied Publishers Pvt. Limited, Noida. ISBN: 978-93-89934-43-4.
- Baskar, D.C.V., Ramanan, S.S., Yadav, S.K., Gupta, A.K. (2024) Green Market perspectives on Carbon Trading, Agri-Life, 5(2), 31-33.

- Baskar, V.D.C., Kumar, V., Kumar, S., Ramanan, S.S. and Pal, S. (2024) Green Market and Its Impact on Climate Change with Special Reference to the Agroforestry Ecosystem, *In*: Agroforestry Solutions for Climate Change and Environmental Restoration. Publisher: Springer Nature Singapore, Singapore, pp. 281–300. https://doi.org/10.1007/978-981-97-5004-7_13.
- Biswakarma, N., Sharma, K., Chichghare, A.R., Harish, M.N., Naik, M.R., Ram, A. and Arunachalam, A. (2024) Innovations in agronomic management of field crops for higher productivity and sustainability. *In*: Srinivasa Rao, Ch., Dhandapani, A. and Kumar, S. (Eds.), Research and Technology Advancement in Agriculture. ICAR-National Academy of Agricultural Research Management, Hyderabad, India. 748 p
- Choudhary, B.B., Chand, P., Singh, P. and Pandey, S. (2024) Marketing of Feed and Fodder in India: Issues, Challenges and Way Forward. In: Essentials of Agricultural Science (A.K. Maurya, R.K. Rai, Y. Gautam, H. Pandey, S.K. Maurya (eds.)), Content Vibes publisher, 46-56.
- Gopamma, D., Kumar, K.S., Srinivas, N., Debnath, **S**., Ram, A., Kumar, S., Arunachalam, A. (2024) Air pollution tolerance and carbon sequestration potential of tree species to combat climate change. In: Kumar, S. *et al*. (Eds.) Agroforestry Solutions for Climate Change and Environmental Restoration, Springer Nature, Singapore, pp. 301-322
- Harika, A., Ezhumalai, S., Singh, B., Allimuthu, E., Taria, S., Raju, D., Kumar, S., Kumar, M., Das, M. and Chinnusamy, V. (2024) Accelerate Crop Breeding Utilizing Modern Genomics and Phenomics Tools. *In*: Chen, J. T. (Eds.), *Plant Speed Breeding and High-throughput Technologies*. CRC Press, Taylor & Francis group, Boca Raton, London, New York. pp. 37-52.
- Kumar, S., Yadav, A., Taria, S., Alam, B., Singh, P., Dwivedi, R.P., Arunachalam, A. (2024) Scope, importance, and limitations of precision agriculture-based practices for crop management: Indian perspective. *In*: Lamine, S., Srivastava, P. K., Kayad, A., Muñoz-Arriola, F. and Pandey, P. C. (Eds.), Earth Observation, Remote Sensing in Precision Agriculture, Academic Press. pp. 27-40. https://doi.org/10.1016/B978-0-323-91068-2.00005-9.
- Kumar, S., Taria, S., Yadav, A., Alam, B., Singh, P., Dwivedi, R.P., and Arunachalam, A. (2024) Sustainable nutrient management strategies for increased crop productivity and soil health. *In*: Kumar, P., Singh, A., Rajput, V. D., Minkina, T., and Singh, A. K. (Eds), Smart Technologies in Sustainable Agriculture: Current and Future Prospects, Apple Academic Press. pp. 187-207.
- Lata, S, Yadav, A., Kumar P and Joshi A.K. (2024). Nano-Fertilizers for Sustainable Crop Production Under Changing Climate: A Global Perspective. In book: Smart Technologies in Sustainable Agriculture Current and Future Prospects Publisher: CRC
- Meena, S., Yadav, S., Taria, S., Kumar, S. and Nagar, S. (2024) Role of brassinosteroids in abiotic stresses. *In*: Raju, D, Rajendran, R. A, Ramlal, A. and Singh, V. P. (Eds.), *Phytohormones in Abiotic Stress*. CRC Press, Taylor & Francis group, Boca Raton, London, New York. pp. 89-99.
- Madhumathi, V., Dhakar, M.K., Das, B. and Yadav, A. (2024) Genetic Diversity of *Aegle marmelos* and Sustainable Utilization. In book: Genetic Diversity of Fruits and Nuts. CRC Press ISBN: 9781003492207, 101201/9781003492207-10.
- Madhumathi, V., Dhakar, M.K., Das, B., and Yadav, A. (2024) Genetic Diversity of *Aegle marmelos* and Sustainable Utilization. In book: Genetic Diversity of Fruits and Nuts. CRC Press ISBN: 9781003492207, 10.1201/9781003492207-10.
- Rajarajan, K., Jadhav, M, C. Varsha, Sakshi Sahu, R. Ambika Rajendran, A. K. Handa, and Arunachalam, A. (2024) Peptide Hormone with Emphasis on Abiotic Stress Tolerance in Plants. *In: Phytohormones in Abiotic Stress*, pp. 151-161. CRC Press.
- Ramanan, S.S., Arunachalam, A., Singh, R., Verdiya, A. (2024) Digital Tools for Climate Change and Environmental Restoration. *In:* Agroforestry Solutions for Climate Change and Environmental Restoration. Springer Nature Singapore, Singapore, pp. 511–529.
- Ramanan, S.S., Arunachalam, A., Verdiya, A. and Handa, A.K., (2025) Agroforestry and Trees Outside Forests: Its Implications. *In: Tree Biology and Biotechnology*. Springer Nature Singapore, Singapore, pp. 183–195. https://doi.org/10.1007/978-981-96-0002-1_12
- Singh, P., Choudhary, B.B., Kumar, S., Dwivedi, R.P. and Arunachalam, A. (2024) Agroforestry: A green solution for climate resilient farming. In: Agroforestry solutions for climate change and environmental restoration (S. Kumar, B. Alam, S. Taria, P. Singh, A. Yadav and A Arunachalam (eds.)), *Springer*, pp- 245-259.

Edited Book authored

- Kumar, S., Alam, B., Taria, S., Singh, P., Yadav, A., and Arunachalam, A. Agroforestry Solutions for Climate Change and Environmental Restoration. Publisher: *Springer Singapore; Edition 1*, 529 p.

Book Review

- Syamili, M.S., Arunachalam, A., and Ramanan, S.S. (2024) Book Review: Research and Technology Advancements in Agriculture. *Indian Journal of Agroforestry*, *26*(2), 150-152.
- Ramanan, S.S., Arunachalam, A., Singh, R., Verdiya, A. (2025) Tropical almond (*Terminalia catappa*): A holistic review. Heliyon 11, e41115.

(G) Popular Article

- Alam, B., Taria, S., Kumari, M., Kumar, S., Arunachalam, A. (2024) Pedon ke madhyam se bhari dhatuyon ka phytoremediation: krishivaniki pariprekshay. *Krishivaniki Alok* 13, ICAR-CAFRI, pp.59-63.
- Anuragi, H., Jain, S., Deepak, Ram, A., Kumar, N., Handa, A.K., Arunachalam, A. (2024) Krishivaniki Me Ucch Gunnvatta Wale Paudho Ke Liye Padap Uttak Sanvardhan Ka Mahatav. *Krishivaniki Alok* 13, ICAR-CAFRI, pp.137-141.
- Chandra, M., Kumar, N., Ram, A., Ghangoriya, S., Maurya, S., Singh, A., Handa, A.K., Arunachalam, A. and Diwedi, R.P. (2024) Lachali or Tikau Krishi Ka Bhavisy. *Krishivaniki Alok* 13, ICAR-CAFRI, pp. 109-112.
- Debnath, S., Ram, A., Kumar, S., Yadav, A., Taria, S., Alam, B., Kumar, N., Prasad, R., Arunachalam, A. (2024) Krishi Me Plastic Ke Upyog Ka Mrida Evam Pryavran Par Prabhav. *Krishivaniki Alok* 13, ICAR-CAFRI, pp.105-108.
- Debnath, S., Yadav, K.L., Ram, A., Kumar, S. and Arunchalam, A. (2024) Poshan se bharpoor Kechua khad. *Kheti*, June, pp. 20-22.
- Gautam, K., Thakur, S., Ram, A., Kumar, N. and Thakur, U. (2024) Ban Oak-An important fodder tree of temperate western Himalaya facing survival threat. *Van Sangyan* 11(2):1-5
- Jain, A., Singh Priyanka, Arunachalam, A., Handa, A.K., Singh, A., Singh, R., Verdiya, A. and Ramanan, S.S (2024) Krishivaniki ko badhava dene mein udyogo ki bhumika. *Krishivaniki Alok* 13, pp. 40-44.
- Jain, A., Singh, P., Arunachalam, A., Handa, A.K., Singh, A., Singh, R., Verdiya, A. and Ramanan, S.S (2024) Bahari van – manav swastha aur prakriti ke lie vardaan. *Krishivaniki Alok* 13, pp. 45-48.
- Kumar, A., Yadav, A., Alam, B., Ram, A., Singh, P., Kumar, N., Anuragi, H., Alam, B. and Arunachalam, A. (2024) Rabi Evam Zaid Ritu Me Dalhani Phasalo Ka Adhikadhik Utpadan Bdhane Ke Vaigyanik Taknik. *Krishivaniki Alok* 13(01): 146-150
- Kumar, S., Taria, S., Alam, B., Singh, P., Debnath, S., Dwivedi, R.P., Arunachalam, A. (2024) Krishivaniki harit aavran badane ka ek uchit evam prabhavshali madhyam. *Krishivaniki Alok* 13, ICAR-CAFRI, pp.121-123.
- Lata, S., Yadav, A., and Bandana (2024) Nutritional and medicinal properties of underutilized fruit: citron (*Citrus medica* Linn.). *Agri Journal-World* 4 (5):16-19.
- Maurya, R., Singh, A., Maurya, S., Kumar, N., Ram, A., Yadav, A., Debnath, S., Anuragi, H., Handa, A.K. and Arunachalam, A. (2024) Poshan Aur Suraksha Ke Liye Amrud Aadharit Krishivaniki. *Krishivaniki Alok* 13 (01), 142-145.
- Maurya, S., Singh, A., Samadhiya, A., Chandra, M., Ghangoriya, S., Maurya, R., Kumar, N., Ram, A., Anuragi, H. and Arunachalam, A. (2024) Sahjan Ki Kheti Harit Sona, Sehat Ka Khajana. *Krishivaniki Alok* 13, 113-116.
- Meena, S., Bansal, R., Das, M., Taria, S. and Sangwan, S. (2024) Seaweed: An Environmental Superhero Driving Sustainable Development. *Global Agriculture*, 1(10), 48-49.
- Meena, S., Bansal, R., Das, M., Taria, S. and Yadav, S. (2024) The Role of Auxin in Root System Architecture and Nitrogen Acquisition. Published in training manual on "Phenotyping on nitrogen use efficiency and stress tolerance: Dissection of component traits using physiological and phenomic approaches held during 5th August-14th August, 2024 at Division of Plant Physiology, ICAR- IARI, New Delhi-110012. pp. 239-245.
- Meena, S., Yadav, S., Bansal, R. and Taria S. (2024) SPEED BREEDING: Revolutionizing Plant Breeding for Global Food Security and Sustainable Agriculture. *Dream* 2047, pp 14-16.
- Prasad, R., Arunachalam, A., Alam, B., Debnath, S. and Singh, P. (2024) Jalvayu parivartan ke parivesh mein carbon credit ka bajaar: Parichaya evam krishi se sambandhit cunautiyan. *Krshivaniki Alok* 13, ICAR-CAFRI Jhansi, pp 96-102.
- Prasad, R., Singh, P., Alam, B. and Handa, A.K. (2024) Plash vruksh se gond ke risav va dohan par mah evam ritu ka prabhav. *Krshivaniki Alok* 13, ICAR-CAFRI, Jhansi.pp 103-104.
- Ramanan, S.S and Arunachalam, A. (2024) Exploring Palmyrah for Agroforestry. NESA Newsletter, 27(6): 14-15.
- Singh P., Jain, A., Dwivedi, R.P., Kumar, S., Chanda, B. and Arunachalam, A. (2024) Khadya Suraksha evam shudh jalvayu lakshya ke lie krishivaniki samadhan. *Krishivaniki Alok* (13), 49-52.

- Singh P., Yadav, A., Dwivedi, R.P., Kumar, S., Jain, A., Chanda, B. and Arunachalam, A. (2024) Aardh sushk ushna katibandhiya kshetron mein aanar ki kheti ka aarthik aur vitiya vishleshan. *Krishivaniki Alok* 13, 53-58.
- Samadhiya, A., Maurya, S., Singh, A., Chandra, M., Ghandgoriya, S., Kumar, A., Ram, A. and Arunachalam, A. (2024) Aadhunik Madhumakhi Palan. *Krishivaniki Alok* 13, 118-120.
- Yadav, A., Garg, A., Alam, B. and Arunachalam, A. (2024) Status and Prospects of Stingless Bee in Jhansi District of Bundelkhand Region. NESA Newsletter. Eversion, pp 3-4.
- Yadav, A., Kumar, R., Sonwalkar, P., Garg, S., Meena, H., Singh, P., Dwivedi, R.P., Alam, B. and Arunachalam, A. (2024) Bharatiya Makkhan Vriksh (Mahua): Bundelkhand Kshetra ke liye ek mahatavpurna aajeevika vriskh. *Krishivaniki Alok* 13 (01): 68-74.
- Yadav, A., Sonwalkar, P., Singh, P., Garg, S., Meena, H., Kumar, A., Alam, B. and Arunachalam, A. (2024) Chironji ke vibhinn bhago ka mahatav evam upyog. *Krishivaniki Alok* 13 (01): 64-67.

(H) Technical Bulletines / Technical Folder

Technical Bulletines

- Rajarajan, R., Handa, A.K. and Arunachalam, A. (2024) Neem Field Gene Bank – Provisioning Opportunities for Conservation and Utilization. Technical Bulletin CAFRI/2024/01. ICAR-Central Agroforestry Research Institute, Jhansi 284003, Uttar Pradesh, India, 31p.
- Dwivedi, R.P. and Arunachalam, A. (2024) Krishivaniki Sarthi. Technical Bulletin CAFRI/2024/02. ICAR-Central Agroforestry Research Institute, Jhansi 284003, Uttar Pradesh, India, 56p. (Hindi).
- Singh, P., Arunachalam, A., Handa, A.K., Dwivedi, R.P., Kumar, S. and Ramanan, S (2024) Agroforestry Success Stories (transforming livelihood and ecosystem restoration). Technical bulletin CAFRI/2024/03. ICAR-Central Agroforestry Research Institute, Jhansi 284003, Uttar Pradesh, India, 31p.
- Rajarajan, K., Arunachalam, A., Handa, A.K., Anuragi, H., Ramanan, S. S and Singh, P. (2024) Technology for Neem Production in Rainfed Area. Technical Bulletin CAFRI/2024/04. ICAR-Central Agroforestry Research Institute, Jhansi 284003, Uttar Pradesh, India, 20p.
- Ramanan, S. S, Arunachalam, A. and Verdiya, A. (2024) Spiritual Plantations (Spiritually connecting Science with Society). Technical Bulletin CAFRI/2024/05. ICAR-Central Agroforestry Research Institute, Jhansi 284003, Uttar Pradesh, India, 35p.
- Arunachalam, A., Suresh Ramanan S, Handa, A.K., Dwivedi, R.P., Singh P. and Chanda, B. (2024) Krishakon Ki Disha aur Dasha Badalne Hetu Krishivaniki. Technical Bulletin CAFRI/2024/06. ICAR-Central Agroforestry Research Institute, Jhansi 284003, Uttar Pradesh, India, 21p. (Hindi).

Technical Folder

- Arunachalam, A., Ramanan, S, S. and Handa, A. K. (2024) Reviewing National Agroforestry Policy. CAFRI Discussion Paper # 01/ 2024, ICAR-Central Agroforestry Research Institute, Jhansi 284003, Uttar Pradesh, India; 16 pages.
- Arunachalam, A., Handa, A.K., Kumar, N., Ram, A. and Dogra, A. (2024) Livelihood diversification through agroforestry interventions – Teak-based agroforestry system. Deutsche Gesellschaft fur Internationale (GIZ) GmbH; 20 p.
- Arunachalam, A., Handa, A.K., Ram, A., Kumar, N. and Dogra, A. (2024) Livelihood diversification through agroforestry interventions – Aonla-based agroforestry system. Deutsche Gesellschaft fur Internationale (GIZ) GmbH; 21 p.
- Handa, A.K., Arunachalam, A., Kumar, N., Ram, A. and Dogra, A. (2024) Livelihood diversification through agroforestry interventions – Bamboo-based agroforestry system. Deutsche Gesellschaft fur Internationale (GIZ) GmbH; 17 p.
- Kumar, N., Ram, A., Handa, A.K., Arunachalam, A. and Dogra, A. (2024) Livelihood diversification through agroforestry interventions – Mango-based agroforestry system. Deutsche Gesellschaft fur Internationale (GIZ) GmbH; 18 p.
- Kumar, N., Handa, A.K., Ram, A., Arunachalam, A. and Dogra, A. (2024) Livelihood diversification through agroforestry interventions – Ber-based agroforestry system. Deutsche Gesellschaft fur Internationale (GIZ) GmbH; 20 p.
- Ram, A., Handa, A.K., Kumar, N., Arunachalam, A. and Dogra, A. (2024) Livelihood diversification through agroforestry interventions – Citrus (acid lime)-based agroforestry system. Deutsche Gesellschaft fur Internationale (GIZ) GmbH; 18 p.
- Ram, A., Kumar, N., Handa, A.K., Arunachalam, A. and Dogra, A. (2024) Livelihood diversification through agroforestry interventions – Guava-based agroforestry system. Deutsche Gesellschaft fur Internationale (GIZ) GmbH; 20 p.

(I) Symposia/ Seminar/ Workshops (Abstracts/ Full Paper)

- Alam, B., Taria, S., Kumar, S., Prasad, R. and Arunachalam, A. (2024) Potential of microclimate modulation of a multipurpose tree species *Pongamia pinnata* towards climate resilience for agroforestry perspectives. *In*: National Conference on Agro-ecological Basis of Agroforestry: Interaction, Innovation and Incubation held at ICAR-CAFRI, Jhansi, Uttar Pradesh, June 18-19, 2024.
- Alam, B., Taria, S., Kumar, S., Prasad, R. and Arunachalam, A. (2024) Perspectives of Pongamia pinnata as a tree resource towards ecosystem services and saving the environment from degradation. *In*: National Conference on SHASHWAT SRISHTI SANRAKSHAN "A Pledge for Protecting World against Natural Hazards: Agro-Biotechnological Approach" held at ICAR-CAFRI, Jhansi, Uttar Pradesh, August 23-24, 2024.
- Anuragi, H., Gora, M., Jain, S., Handa, A.K., Arunachalam, A. (2024) Investigating the impact of salinity stress on above-ground morphological, below-ground root and physicochemical properties of young Mahua (*Madhuca longifolia*) seedlings using hydroponics and pot culture. *In*: Souvenir-cum-Abstracts of the National Conference on Shashwat Srishti Sanrakshan 'A Pledge for Protecting World against Natural Hazards: Agro-Biotechnological Approach' organized by STE, CAFRI, ISAF and SSCE societies at ICAR-CAFRI, Jhansi during August 23-24, 2024, pp33.
- Anuragi, H., Handa, A.K., Arunachalam, A. (2024) Effects of shade-stress on root system architecture of green gram (*Vigna radiata* L.) under agroforestry. *In*: Souvenir-cum-Abstracts of the National Conference on Agro-ecological Basis of Agroforestry: Interaction, Innovation and Incubation organized by ISAF and CAFRI at ICAR-CAFRI, Jhansi during June 18-19, 2024, pp148.
- Anuragi, H., Handa, A.K., Arunachalam, A. (2024) Understanding the shade-stress tolerance in *Vigna radiata* L. Wilczek, under agroforestry systems for higher adaptation and seed production. *In*: Souvenir-cum-Abstracts of the International conference on Advancements in Basic Science, Environmental Studies and Traditional Medicine for Translational Drug Discovery and Development (TMT3D-2024) on 21-23 November, 2024 held at New Delhi, pp 95.
- Anuragi, H., Jain, S., Handa, A.K., Arunachalam, A. (2024) Investigating the physio-chemical responses of green gram (*Vigna radiata* L.) under different shade stress regimes for agroforestry interventions. *In*: Souvenir-cum-Abstracts of the National Conference on Shashwat Srishti Sanrakshan 'A Pledge for Protecting World against Natural Hazards: Agro-Biotechnological Approach' organized by STE, CAFRI, ISAF and SSCE societies at ICAR-CAFRI, Jhansi during August 23-24, 2024, pp 34.
- Anuragi, H., Jain, S., Handa, A.K., Arunachalam, A. (2024) Advances in tissue culture applications for perennial trees genetic improvement. *In*: Souvenir-cum-Abstracts of the National Conference on Shashwat Srishti Sanrakshan 'A Pledge for Protecting World against Natural Hazards: Agro-Biotechnological Approach" organized by STE, CAFRI, ISAF and SSCE societies at ICAR-CAFRI, Jhansi during August 23-24, 2024, pp 35.
- Anuragi, H., Jain, S., Singh, H., Ram, A., Kumar, N., Rajarajan, K., Handa, A.K., Arunachalam, A. (2024) A rapid *in-vitro* shoot regeneration protocol from the nodal explants for conservation and mass multiplication of *Butea monosperma* Lam. *In*: Souvenir-cum-Abstracts of the National Conference on Agro-ecological Basis of Agroforestry: Interaction, Innovation and Incubation organized by ISAF and CAFRI at ICAR-CAFRI, Jhansi during June18-19, 2024, pp 141.
- Arunachalam, A., Dwivedi, R.P. and Yadav, A. presented the poster on PAPA: Promoting Agroforestry for Plantation in Agricultural-Lands in the national conference on shaswat Shristi Sanrakshan: A pledge for protecting world against the natural hazards: Agri-Biotechnological Approaches jointly organised by STE, ICAR-CAFRI Jhansi, ISAF, SSCCE, SKSS and Bundelkhand University Jhansi (August 23-24, 2024).
- Arunachalam, A., Yadav, A. and Dwivedi, R.P. presented the poster on "AMMA: Agroforestry for Mitigating Malnutrition and Adaptation" in the national conference on shaswat Shristi Sanrakshan: A Pledge for Protecting World against the natural hazards: Agri-Biotechnological Approaches jointly organized by STE, ICAR-CAFRI Jhansi, ISAF, SSCCE, SKSS and Bundelkhand University Jhansi (August 23-24, 2024).
- Bharti, Debnath, S., Ram, A., Ghosh, A., Singh, S.K., Prasad, R. and Arunachalam, A. (2024) Effects of conservation agroforestry practices on soil aggregation and its indices in Bundelkhand region. *In:* National Conference on "Agro-ecological Basis of Agroforestry: Interaction, Innovation and Incubation" held during June 18-19, 2024; organized by Indian Society of Agroforestry & ICAR-CAFRI, Jhansi-284003, Uttar Pradesh, India, pp 78.

- Chandra, M., Kumar, N., Ram, A., Maurya, S., Singh, A., Ganghoria, S., Handa, A.K. Dwivedi, R.P. and Arunachalam, A. (2024) Embracing the future: The role of circular bioeconomy in sustainable Development. Souvenir cum Abstract/Proceeding book, National Conference on Agro-ecological Basis of Agroforestry: Interaction, Innovation and Incubation held during June18-19, 2024; organized by Indian Society of Agroforestry & ICAR-CAFRI, Jhansi-284003, Uttar Pradesh, India, pp123.
- Chanda, B., Singh, P., Dwivedi, R.P., Kumar, S., Venkatesh, Y.N. and Arunachalam, A. (2024) Reviewing methodologies for valuation of ecosystem services. Souvenir cum Abstract/Proceeding book, National Conference on Agro-ecological Basis of Agroforestry: Interaction, Innovation and Incubation, June18-19, 2024, pp 115.
- Debnath, S., Bharti, Ram, A., Prasad, R. and Arunachalam, A. (2024) Conservation agroforestry exaggerates the benefits of agroforestry on soil fertility enhancement in *Bundelkhand* region. *In:* Abstract-cum-Souvenir Book, *National Conference on Shashwat Srishti Sanrakshan: A Pledge for Protecting World against Natural Hazards: Agro-Biotechnological Approach (August*23-24, 2024); Kolkata/Gurugram, India, pp 63.
- Debnath, S., Ramanan S.S., Ram, A., Prasad, R. and ArunachalamA. (2024) Tree-crop interaction in agroforestry influences active and recalcitrant fractions of soil organic C, and improves soil enzyme activity and phytoavailability of N and P. In: National Conference on "Agro-ecological Basis of Agroforestry: Interaction, Innovation and Incubation" held during June 18-19, 2024 and organized by Indian Society of Agroforestry & ICAR-Central Agroforestry Research Institute, Jhansi-284003, Uttar Pradesh, India, pp18
- Debnath, S., Thori, B., Ghosh, A., Ram, A., Singh, S.K., Prasad, R., and Arunachalam, A. (2024) Spectroscopic Investigation of Soil Organic Matter Composition for Contrasting Teak (*Tectona Grandis*) based Agroforestry Systems of Central India. *In:* Global Soils Conference 2024 on Caring Soils Beyond Food Security: Climate Change Mitigation & Ecosystem Services (November 19-22, 2024), held at NASC Complex, New Delhi, pp 466.
- Dwivedi, R.P., Arunachalam, A., Handa, A.K., Singh, P., Chanda, B., Syamili, M.S., Rajarajan, K. and Yadav, A. (2024) Market-based Policy Initiatives for Promotion of Agroforestry in India, International Conference on Biodiversity, Agroforestry, Non-Wood Forest Products and Sustainable Livelihoods (October18-19, 2024); held at Kota Kinabalu, Sabah State, Malaysia.
- Ghangoriya, S., Kumar, N., Ram, A., Maurya, S., Singh, A., Chandra, M., Singh, P. and Arunachalam, A. (2024) E-commerce in agroforestry: Opportunities and challenges. In: National Conference on "Agro-ecological Basis of Agroforestry: Interaction, Innovation and Incubation" held during June 18-19, 2024 and organized by Indian Society of Agroforestry & ICAR-CAFRI, Jhansi-284003, Uttar Pradesh, India, pp 131.
- Kumar, N., Ram, A., Gautam, K., Singh, R.K., Samadhiya, A., Maurya, S., Handa, A.K. and Arunachalam, A. (2024) Potential industrial agroforestry tree species for Bundelkhand region of central India. In: National Conference on "Agro-ecological Basis of Agroforestry: Interaction, Innovation and Incubation" held during June18-19, 2024; organized by Indian Society of Agroforestry & ICAR-CAFRI, Jhansi-284003, Uttar Pradesh, India, pp 136.
- Kumar, S., Singh, P., Taria, S., Alam, B., Dwivedi, R.P., Arunachalam, A. (2024) Resource Management and Livelihood Improvement through Engineering and Agroforestry Measures in the Bundelkhand Region. In: National Conference on Agro-ecological Basis of Agroforestry: Interaction, Innovation and Incubation held at ICAR-CAFRI, Jhansi, Uttar Pradesh (June 18-19, 2024).
- Kumar, S., Taria, S., Alam, B., Singh, P., Dwivedi, R. P., Arunachalam, A. (2024) Agroforestry Innovations and Technologies: A Pragmatic Approach for Sustainable Production in Changed Scenarios. *In:* National Conference on Shashwat Srishti Sanrakshan 'A Pledge for Protecting World against Natural Hazards: Agro-Biotechnological Approach' held at ICAR-CAFRI, Jhansi, Uttar Pradesh (August 23-24, 2024).
- Maurya, S., Ram, A., Kumar, N., Chandra, M., Ghangoria, S., Singh, A. and Arunachalam, A. (2024) Scope and strategies of millet cultivation in Bundelkhand region *In:* National Conference on "Agro-ecological Basis of Agroforestry: Interaction, Innovation and Incubation" held during June 18-19, 2024; organized by Indian Society of Agroforestry & ICAR-CAFRI Jhansi-284003, Uttar Pradesh, India, pp 130.
- Prasad, R., Alam, B., Arunachalam, A., Debnath, S. and Singh, P. (2024) Distribution of Soil Organic Carbon and Major Nutrients (NPK) in Soil Profile of Different Multipurpose Tree based Agroforestry Systems in Semi-Arid Region, India. *In abstracts*:

Global Soils Conference 2024 "Caring Soils Beyond Food Security - Climate Change Mitigation & Ecosystem Services" held (November 19-24, 2024); at NASC New Delhi, organized by the Indian Society of Soil Science Under the aegis of International Union of Soil Sciences in collaboration with Indian Council of Agricultural Research and National Academy of Agricultural Sciences, pp 472-473.

- Prasad, R., Alam, B., Handa, A. K. and Singh, P. (2024) Seasonal variability in gum exudation and gum yield in Palash (Butea monosperma L.). In souvenir cum Abstract proceeding book, National Conference on Agro-ecological Basis of Agroforestry: Interaction, Innovation and Incubation, June 18-19, 2024; Indian Society of Agroforestry Jhansi, pp 93.
- Prasad, R., Debnath, S., Ram, A., Arunachalam, A. and Chaudhari, S.K. (2024) Agroforestry for Nurturing Soil Health Beyond the Goals of Food Security and Resilience against Climate Change. *In:* Global Soils Conference 2024 "Caring Soils Beyond Food Security: Climate Change Mitigation & Ecosystem Services" held (November 19-22, 2024); at NASC Complex, New Delhi, pp 468.
- Ram, A. participated and presented paper (oral) entitled "Light interception, growth and yield of wheat in *Melia dubia*-wheat agroforestry system in semi-arid conditions" in "National Conference on Shashwat Shrishti Sanrakshan- A Pledge for protecting world against Natural Hazards: Agro-Biotechnological Approach" during August 23-24, 2024; held at ICAR-CAFRI, Jhansi.
- Ram, A., Choure, S., Dev, I., Kumar, N., Kumar, D., Debnath, S., Ramanan SS., Dwivedi A., Maurya S., and Arunachalam, A. (2024) Fine Root Distribution Pattern and Nutrient Dynamics in *Tectona Grandis* L.-based Agri-Silviculture System in Semi-Arid Conditions of Central India. *In:* Global Soils Conference 2024 "Caring Soils Beyond Food Security: Climate Change Mitigation & Ecosystem Services" held November 19-22, 2024; at NASC Complex, New Delhi, pp 187-188.
- Ram, A., Kumar, N., Dev, I., Debnath, S., Anuragi, H., Dwivedi, R.P., Yadav, A. Singh, P., Handa, A.K. and Arunachalam, A. (2024) Drone application in agriculture and agroforestry. 2024. In: National Conference on Agro-ecological Basis of Agroforestry: Interaction, Innovation and Incubation held during June18-19, 2024; organized by Indian Society of Agroforestry & ICAR-Central Agroforestry Research Institute, Jhansi-284003, Uttar Pradesh, India, pp 105.
- Ramanan, S.S., Arunachalam, A. and Rashmi, R. (2024) Intellectual property in agroforestry research: A case study on the patents. In Abstracts: National Conference on Agro-ecological basis of Agroforestry: Interaction, Innovation and Incubation; organized by the Indian Society of Agroforestry in association with ICAR-Central Agroforestry Research Institute, Jhansi, Uttar Pradesh w.e.f. June 18-19, 2024, pp 138.
- Ramanan, S.S., Arunachalam, A., Sahoo, U.K. and Upadhaya, K. (2024) Inter-species response variability to climate change: A case study from genus Melia. In Abstracts: Compendium for International Conference on Climate Change on Biodiversity- A global perspective at TANUVAS, Chennai on July 11-13, 2024, pp 153-154.
- Ramanan, S.S., Arunachalam, A., Singh, R., Handa, A.K. and Verdiya, A. (2024) Examining the felling and transit legislations for upscaling agroforestry and TOF. In Abstracts: National Conference on Agro-ecological basis of Agroforestry: Interaction, Innovation and Incubation; organized by the Indian Society of Agroforestry in association with ICAR-CAFRI, Jhansi, Uttar Pradesh w.e.f. June 18-19, 2024, pp 129.
- Ramanan, S., Arunachalam, A. and Handa, A.K. (2024) Role of accreditation protocol in agroforestry nurseries for quality planting material production. In Abstracts: National Conference on Agro-ecological basis of Agroforestry: Interaction, Innovation and Incubation; organized by the Indian Society of Agroforestry in association with ICAR-CAFRI, Jhansi, Uttar Pradesh w.e.f. June 18-19, 2024, pp 155.
- Samadhiya, A., Chandra, M., Maurya, S., Singh, A., Ghanghoriya, S., Kumar, N., Ram, A., Handa, A.K. and Arunachalam, A. (2024) Mahua: A multipurpose tree for livelihood security in Bundelkhand region of India. *In*: National Conference on Agro-ecological Basis of Agroforestry: Interaction, Innovation and Incubation held during June18-19, 2024; organized by Indian Society of Agroforestry & ICAR-Central Agroforestry Research Institute, Jhansi-284003, Uttar Pradesh, India, pp 24.
- Singh, A., Ram, A., Kumar, N., Kumar, S. and Arunachalam, A. (2024). Agroforestry as climate resilient production system: Carbon sequestration potential of major agroforestry systems. *In*: National Conference on Agro-ecological Basis of Agroforestry: Interaction, Innovation and Incubation held during June18-19, 2024; organized by Indian Society of Agroforestry & ICAR-Central Agroforestry Research Institute, Jhansi-284003, Uttar Pradesh, India, pp 76.

- Singh, A., Maurya, S., Gangoriya, S., Chandra, M., Ram, A., Kumar, N., Dwivedi, R.P. Handa, A.K. and Arunachalam, A. (2024) Role of women in agroforestry. In: National Conference on Agro-ecological Basis of Agroforestry: Interaction, Innovation and Incubation held during June18-19, 2024; organized by Indian Society of Agroforestry & ICAR-Central Agroforestry Research Institute, Jhansi-284003, Uttar Pradesh, India, pp 113.
- Singh, P., Choudhary, B.B., Dwivedi, R.P., Kumar, S. and Arunachalam, A. (2024) Determinants of adoption of sustainable land management practices in Bundelkhand, the semi-arid tropics. Souvenir cum Abstract/Proceeding book; In: National Conference on "Agro-ecological Basis of Agroforestry: Interaction, Innovation and Incubation" June 18-19, 2024, pp 126.
- Singh, P., Prasad, R., Alam, B., Handa, A.K., Ramanan, S.S. and Arunachalam, A. (2024) Performance of *Acacia senegal* based bio-fence models to protect field crops from *Anna-pratha* in semi-arid Bundelkhand Region. In: National Conference on Shashwat Srishti Sanrakshan "A Pledge for Protecting World against Natural Hazards: Agro-Biotechnological Approach" held during August 23-24, 2024; at ICAR-Central Agroforestry Research Institute Jhansi, Uttar Pradesh. *Abstract-cum-Souvenir*, pp 48.
- Singh, P., Ramanan, S.S., Chanda, B., Kumar, S., Handa, A.K. and Dwivedi, R.P. (2024) Sovenir-cum-Abstracts/Proceedings Book, National Conference on Agro-ecological basis of Agroforestry: Interaction, Innovation and Incubation, June 18-19, 2024; Indian Society of Agroforestry, Jhansi, Uttar Pradesh, India, pp 156.
- Sonwalkar, P.M., Yadav, A. Alam, B., Deshmukh, P. and Garg, S. presented the poster on "Chironji- A multipurpose tree" at a national conference on Agro-ecological Basis of Agroforestry: Interaction, Innovation, and Incubation from June 18-19, 2024; held at ICAR-CAFRI Jhansi, U.P.
- Taria, S., Alam, B., Kumar, S. and Arunachalam, A. (2024) Regulation of Shade Responses in Crops- An Agroforestry Standpoint. *In*: National Conference on Shashwat Srishti Sanrakshan "A Pledge for Protecting World against Natural Hazards: Agro-Biotechnological Approach" held at ICAR-CAFRI, Jhansi, Uttar Pradesh (August 23-24, 2024).
- Taria, S., Alam, B., Kumar, S., Kumar, M., Rane, J. and Arunachalam, A. (2024) Prospective of Mango Tree for Food and Nutritional Security Through Agroforestry Systems. *In*: National Conference on Agro-ecological Basis of Agroforestry: Interaction, Innovation and Incubation held at ICAR-CAFRI, Jhansi, Uttar Pradesh (June 18-19, 2024).
- Taria, S., Arora, A., Krishna, H., Kumar, S., Manjunath, K.K., Singh, B., Meena, S., Malakondaiah, A. C., Kousalya, S., Padaria, J.C., Singh, P.K., Alam, B., Kumar, S. and Arunachalam, A. (2024) Genetic analysis of stem reserve mobilisation from component parts of the main culm to grains in wheat (*Triticum aestivum* L.) under combined heat and drought stress. *In*: International Conference on Nature, Science and Modern life Style: Issues and Perspectives held at Lucknow, Uttar Pradesh (December 28-29, 2024).
- Verdiya, A., Ramanan, S.S., Arunachalam, A. and R. Singh (2024) Scope of Terminalia catappa as a nut yielding tree grown in India. In Abstracts : Souvenir-cum-Abstracts/Proceedings Book of the National Conference on Agro-ecological basis of Agroforestry: Interaction, Innovation and Incubation; organized by the Indian Society of Agroforestry in association with ICAR-CAFRI, Jhansi, Uttar Pradesh, June 18-19, 2024, pp 25.
- Yadav, A., Garg, S., Ram, A., Alam, B. and Arunachalam, A. presented an oral presentation on "Effect of humic acid, fulvic acid, and their derivatives-based biostimulants on the vegetative, fruit, and yield traits of strawberry at national conference on Agro-ecological Basis of Agroforestry: Interaction, Innovation and incubation on June 18-19, 2024; held at ICAR-CAFRI Jhansi, U.P.
- Yadav, A., Garg, S., Kumar, R., Handa, A.K., Alam B., and Arunachalam, A. delivered the oral presentation on "Neglected and Underutilized Horticultural Crops of Bundelkhand Region: Status, Importance, Conservation, and Their Traditional Knowledge" in the national conference on Shaswat Shristi Sanrakshan: A pledge for protecting the world against the natural hazards: Agri-Biotechnological Approaches jointly organized by STE, ICAR-CAFRI Jhansi, ISAF, SSCCE, SKSS and Bundelkhand University Jhansi from August 23-24, 2024.

Lecture delivered

- Asha Ram delivered lecture on "Quantification of ecosystem services in agroforestry system" in the Training workshop on carbon farming and assessment of ecosystem services during November 25-27, 2024
- Ashok Yadav delivered the lecture on "Horticultural crops and value addition" on 1st March 2024 in the Farmers Training School organized by "The Farmer Improve Technology Council, Haryana in collaboration with ICAR-Central Agroforestry Research Institute Jhansi, U.P. from March 1-2, 2024.
- Ashok Yadav delivered the lecture on "Fruit crops in agroforestry" in the three days training program i.e. Training of Trainers on Agroforestry Assessment and Accreditation" on June 7, 2024 organized by ICAR-CAFRI Jhansi from June 6-8, 2024.
- Ashok Yadav delivered the lecture on "Crop diversification through agri-horti-system" in the two days training program *i.e.* Training of Trainers on

Agroforestry Assessment and Accreditation" organized by ICAR-CAFRI Jhansi from 10-11th June 2024 (Date: 11.06.2024)

- Ashok Yadav delivered the lecture on "Crop Diversification through Agri-Horti-System" in the two-day training program, *i.e.* Training of Trainers on Agroforestry Assessment and Accreditation, organized by ICAR-CAFRI Jhansi from 13-14th June 2024 (Date: 14.06.2024).
- Ashok Yadav delivered the lecture on "Crop diversification through agri-horti-system" in the two days training program *i.e.* Training of Trainers on Agroforestry Assessment and Accreditation" organized by ICAR-CAFRI Jhansi from June 10-11, 2024.
- Ashok Yadav delivered the lecture on "Crop Diversification through Agri-Horti-System" in the two-day training program, *i.e.* Training of Trainers on Agroforestry Assessment and Accreditation, organized by ICAR-CAFRI Jhansi from June 13-14, 2024
- Ashok Yadav delivered the lecture on "Fruit and vegetable crops suitable for apiculture" in training on beekeeping organized by RLBCAU, Jhansi, U. P. from May 1-3, 2024.
- Ashok Yadav delivered the lecture on "Latest technologies for quality honey production" in the awareness workshop on the promotion of horticulture crops Organized by the State Horticultural Co-operative Marketing Federation (HOFED) in auditorium Jhansi, U.P. on September 24, 2024
- Ashok Yadav delivered a radio talk on potential fruit crops for the Bundelkhand region under the Kissanvani Programme on Special Sangosthi on National Farmers Day on Kissan Ki Pragati: Desh Ki Unnati on December 19, 2024 at Akashvani Jhansi.
- Ashok Yadav delivered a tutorial on "Quantification of ecosystem service in agroforestry system" in three days training workshop on carbon farming and assessment of ecosystem services from November 25-27, 2024
- Naresh Kumar delivered a lecture on the topic "Fodder tree leaves feeding in goat" in EDP Training cum Workshop On "Commercial Goat Production: Potential for Entrepreneurship 18-23 Sep. 2024" organized by ICAR-IGFRI, Jhansi
- Priyanka Singh delivered lecture on government schemes and policies for farmers' welfare on June 14, 2024 during two days farmers training on Improved Agricultural Practices (June 13-14, 2024).
- Priyanka Singh delivered lecture on government schemes and policies for farmers' welfare on June 24, 2024 during two days farmers training on Improved Agricultural Practices (June 24-25, 2024).
- Priyanka Singh delivered lecture to students of College of Agriculture & Research Station, Gariaband, IGKV, Raipur, CG (online) during Deekshaarambh on September 26, 2024.
- Priyanka Singh delivered lecture to farmers on "Government schemes and policies for farmers' welfare" during two days farmers training on "Best management practices for prominent agroforestry models of Bundelkhand region" (September 27-28, 2024).
- Sukumar Taria delivered lecture on June 13, 2024 on "Heat stress management and judicious uses of growth regulators in agricultural crops" during two days farmers training on "Improved Agricultural Practices", Sponsored by NABARD supported village watershed committee, Magarwara (PIA-Haritika), organised by Indian Society of Agroforestry (ISAF), Jhansi, Uttar Pradesh.
- Suresh Ramanan S delivered a lecture on the basic design and development of agroforestry systems specific to the Indian subcontinent at the Kumaraguru Institute of Agriculture in Tamil Nadu. Nearby 86 participants attended the program on July 9, 2024

Invited Talk

- A. Arunachalam gave a Keynote Address on Agroforestry for Human Wellbeing on 22 April, 2024 in Gautam Buddha University, Greater Noida on the eve of the Earth Day.
- A. Arunachalam gave a Lead Lecture on Agroforestry-Tree based solutions to environmental and livelihood securities on 22 June, 2024 in National Conference on Living with Nature: Soil, water and society in ecosystem conservation (LNSWSEC-2024) organized by Indian Association of Soil and Water Conservationists (IASWC), Dehradun in collaboration with ICAR-IISWC, Dehradun.
- Ashok Yadav delivered a radio talk on potential fruit crops for the Bundelkhand region under the Kissanvani Programme on Special Sangosthi on National Farmers Day on Kissan Ki Pragati: Desh Ki Unnati on 19th December, 2024 at Akashvani Jhansi.
- Bijoy Chanda delivered an Invited talk in Ninth international webinar, "Recent Trends in Statistical Theory and Applications (WSTA 2024)", organized by the joint collaboration of the Indian Society for Probability and Statistics (ISPS) and the Kerala Statistical Association (KSA) held from 29th June to 2nd July, 2024.
- Bijoy Chanda delivered an Invited Talk during the session on "Computational Statistics: Theory and Application" at the Tenth International Conference on Statistics for the Twenty-First Century (ICSTC-2024), organized by the Department of Statistics, University of Kerala, held from December 13 to 16, 2024.

9. Trainings and Capacity Building

A. Participation in Trainings

Event	Duration	Organizer	Participants
Winter School on Application of Weather Information for climate resilient farming	23rd January - 12th February, 2024	ICAR-CRIDA-AICRPM, Hyderabad	Dr. Ashok Yadav
Winter School on From Genes to Proteins: Addressing Molecular Complexity of Agriculturally Important Traits in Crops	19th February–10th March, 2024	RLBCAU, Jhansi	Dr. Hirdayesh Anuragi
Training on Basic Statistical Tools in Agroforestry, Soil and Water Conservation Research	8th-10th April, 2024	ICAR-CAFRI, Jhansi	Dr. Badre Alam & Dr. Sovan Debnath
IP awareness week programme (Online)	12th-19th June, 2024	ICAR (IPTM Unit), New Delhi & IISWC (IPTM Unit), Dehradun	All Scientific Staff of ICAR-CAFRI, Jhansi

B. Training organized for Employees and other stakeholders

Event	Duration	Venue	Participants	Coordinaters
Hands-On Training in Plant Biotechnology and Biochemistry Techniques	February 01-03, 2024	ICAR-CAFRI, Jhansi	18	Dr. K Rajarajan, Dr. Badre Alam & Dr. A Arunachalam
Training on Basic Statistical Tools in Agroforestry, Soil and Water Conservation Research	April 08-10, 2024	ICAR-CAFRI, Jhansi	25 (Staff & Yps)	Dr. Bijoy Chanda
Kisan Gosthi	May 08, 2024	ICAR-CAFRI, Jhansi	60	Dr. Priyanka Singh Dr. R.P. Dwivedi
Training of Trainers on Agroforestry Nursery assessment and accreditation for Maharashtra & Karnataka	June 06-08, 2024	ICAR-CAFRI, Jhansi	35	Dr. A. Arunachalam Dr. A.K. Handa & Mr. Suresh Ramanan S
Farmers' training program on "Improved Agricultural Practices"	June 10-11, 2024	ISAF at ICAR-CAFRI, Jhansi	25	Dr. Asha Ram Dr. Naresh Kumar
Farmers' Training on Ber pruning	June 12-14, 2024	Shivarampur-Ubaura village (Niwari district)	22	Dr. R.P. Dwivedi Dr. Suhil Kumar Dr. Ashok Yadav Dr. Priyanka Singh
IP Awareness Week "The program centered on the theme of Copyright within the context of intellectual property."	June 12-19, 2024	ICAR-CAFRI Jhansi	20	Mr. Suresh Ramanan S,
Kissan Goshti on Fruit-based agroforestry system in Bundelkhand	June 07, 2024	Village: Magarwara, Block: Bangra	35	Dr. Ashok Yadav
Farmers training on Improved Agricultural Practices	June 13-14, 2024	ISAF at ICAR-CAFRI, Jhansi	25	Dr. Naresh Kumar Dr. Asha Ram
Farmers' training program on "Improved Agricultural Practices"	June 24-25, 2024	ISAF at ICAR-CAFRI, Jhansi	25	Dr. Naresh Kumar Dr. Asha Ram
Training program on "Kissano ki Aajivika Surkasha Hetu Krishivaniki Taknikiya"	June 26-30, 2024	ICAR-CAFRI, Jhansi	30	Dr. Naresh Kumar, Dr. Asha Ram & Dr. Ashok Yadav

Farmers' Training on Ber budding	July 16-18, 2024	Shivrampur-Ubaura village (Niwari district), M.P.	22	Dr. R. P. Dwivedi Dr. Sushil Kumar Dr. Ashok Yadav Dr. Priyanka Singh & Sh. Rajesh Srivastava
A virtual training program for state officials from Nagaland and Manipur focused on agroforestry nursery accreditation	July 23, 2024	Virtual Mode	30	Dr. A.K. Handa & Mr. Suresh Ramanan S
Krishak Gosthi to create awareness about various tangible and intangible benefits of tree-based farming practices	July 24, 2024	Kharag village of Datia district, Madhya Pradesh	35	Dr. Priyanka Singh Dr. Bijoy Chanda
Krishak Gosthi on the importance of agroforestry practices among the farmers	July 25, 2024	ICAR-CAFRI, Jhansi	15	Dr. RP Dwivedi, Dr. AK Handa, Dr. Priyanka Singh Dr. Bijoy Chanda
Entrepreneurship Development Program via hybrid session titled "Developing Business Opportunities in Agroforestry: Learning from the Consortium of Industrial Agroforestry Success Story from Tamil Nadu	July 30, 2024	ICAR-CAFRI Jhansi	52	Mr. Suresh Ramanan S
Capsule Course on Agroforestry R&D Methodologies	August 16 – September 4, 2024	ICAR-CAFRI, Jhansi	19 (Project Staff)	Mr. Suresh Ramanan S,
Farmers' training program on "Best Management Practices for prominent agroforestry models of Bundelkhand region"	August 21-22, 2024	ICAR-CAFRI, Jhansi	30	Dr Naresh Kumar Dr. Asha Ram
Training of Trainers (ToTs) on Agroforestry Nursery Assessment and accreditation for Uttar Pradesh	August 27-29, 2024	ICAR-CAFRI, Jhansi	23 (Forest officials, Uttar Pradesh)	Dr. A. Arunachalam Dr. A. K. Handa & Mr. Suresh Ramanan S
Training session on Ecological Niche Modelling which was conducted under the DST-National Mission for Sustaining the Himalayan Ecosystem (NMSHE) project	August 29, 2024	ICAR-CAFRI, Jhansi	18	Dr. A. Arunachalam, Dr. A.K. Handa & Mr. Suresh Ramanan S
Training of Trainers program on Nursery Assessment and Accreditation in Assam	September 26-28, 2024	ICAR-CAFRI, Jhansi	29	Dr. A. Arunachalam Dr. A.K. Handa & Mr. Suresh Ramanan S
Farmers' training program on "Best Management Practices for prominent agroforestry models of Bundelkhand region"	September 27-28, 2024	ICAR-CAFRI, Jhansi	30	Dr Naresh Kumar Dr. Asha Ram
Accreditation Protocol for Agroforestry Nurseries in Mizoram state. The program was attended by 16 officials from the Directorate of Agriculture	September 30, 2024	Department of Agriculture, Mizoram	16	Mr. Suresh Ramanan S

Training on Promotion and adoption of agroforestry and related interventions for the farmers of project villages under SCRDCS Project	October 1, 2024	ICAR-CAFRI, Jhansi	20	Dr Naresh Kumar Dr. Asha Ram
Training on Promotion and adoption of agroforestry and related interventions for the farmers of project villages under SCRDCS Project	October 3, 2024	ICAR-CAFRI, Jhansi	20	Dr Naresh Kumar Dr. Asha Ram
Training of Trainers program on Nursery Assessment and Accreditation	October 6- 8, 2024	Jaipur, Rajasthan	20	Dr. A.K. Handa
Hands-on training on basic plant tissue culture techniques.	October 22-24, 2024	ICAR-CAFRI, Jhansi	30	Dr. Hirdayesh Anuragi, Dr. A. Arunachalam & Dr. A. K. Handa
Training Workshop on Carbon Farming and Assessment of Ecosystem Services	November 25-27, 2024	ICAR-CAFRI, Jhansi	25 (Project Staff)	Dr. Rajendra Prasad Dr. Badre Alam
Training of Trainers program on the Accreditation of Agroforestry Nurseries	December 11 -12, 2024	Rajahmundry, Andhra Pradesh	15	Mr. Suresh Ramanan S
Kisan Gosthi on the Role of agroforestry in enhancing farmers' income	December 18, 2024	ICAR-CAFRI, Jhansi	15	Dr. R.P. Dwivedi, Dr. A.K. Handa Dr. Priyanka Singh Dr. Bijoy Chanda Mrs. Syamili MS

10. Scheduled Caste Sub Plan (SCSP) Programme

For training and empowerment of marginalized farming community, ICAR-CAFRI is implementing SC-SP scheme with the main objective to improve the socio-economic conditions of the SC farmers' community. Under this scheme, various training/capacity building programmes were organized for scheduled caste farmer, farm women, widows and handicap people. The scheme includes the enhancement of incomes of the target group for the development of assets such as those related to agricultural sector. During this period forty programmes were organized in which different SC-SP welfare materials like equipment/tools were distributed to the farmers/farm women. Forty trainings and Agroforestry Awareness programmes were organized for the benefit of SC community.

The institute has organized 40 training programmes, in every training programme about 35-50 farmers/ farmwomen have participated from Bundelkhand villages.

Table. Details of the training cum distribution camps organized during 2024 under SC-SP at ICAR-CAFRI, Jhansi

Sr. No.	Total No. of villages	Beneficiaries of SC farmers		Distributed items in 2023
		Male	Female	
1	23	729	481	1210
				Spray Machine ,Mixer Grinder, Vermi-bag Water Camphor .

11. Distinguished Visitors

- Shri Prabhat Pandey, RTO, Jhansi visited the CAFRI premises on 1st January, 2024 and appreciated the efforts of the Institute for putting up eco-friendly measures of CAFRI for enabling a carbon-neutral campus.
- Shri G.P. Sharma, Joint Secretary (Finance), ICAR (HQ) visited ICAR-CAFRI, Jhansi on 22nd January 2024 and discussed various finance and accounts related matters.
- A GIZ Team led by Dr. Sanjay Tomar visited ICAR-CAFRI on 25th January 2024, and discussed various HRD options for the agroforestry sector.
- Dr. J.M.S. Tomar, Head (Plant Sciences), ICAR-IISWC, Dehradun visited and addressed the employees of ICAR-CAFRI on 14th February, 2024. He appraised the role of agroforestry and raised research opportunities for Institutional Collaboration.
- Sh. Arun Kumar, IFS & Secretary, ICFRE visited for Training Program on Agroforestry and QPM for the FPS of Uttar Pradesh on 1st March 2024.
- Dr. C.L. Acharya, the veteran Agricultural Scientist visited ICAR-CAFRI, Jhansi on 08th April, 2024 and discussed research opportunities with the CAFRI Scientists.
- Prof. N.P. Melkania, Dean (Academics), Gautam Buddha University visited on 27th April, 2024
- Dr. S.K. Chaudhari, DDG (NRM), ICAR, New Delhi; Dr. A.K. Singh, VC, RLBCAU, Jhansi and Dr. K. Ramasamy, Former Vice Chancellor, TNAU, Coimbatore (TN) graced 37th Foundation Day of Institute on 8th May 2024.
- The Quinquennial Review Team Chaired by Dr. K. Ramasamy, Former Vice Chancellor, TNAU, Coimbatore, Tamilnadu visited the Institute during 7th - 9th May, 2024 and reviewed for the period of 2018-2023.
- Sh. K.K. Singh, IFS & Chief Conservator of Forests, Jhansi Region visited on 6th June, 2024.
- Dr. U.S. Gautam, DDG (Extension), ICAR visited ICAR-CAFRI Jhansi on 18th June, 2024.
- Dr. Prabhat Pandey, RTO, Jhansi visited on 25th July, 2024. He gave a Rajbhasa address during the Vichar Manch organized by ICAR-CAFRI, Jhansi in the Institute. Dr. Pandey gave an account of Traffic Rules and Regulations benefitting the participants
- Prof. A.K. Shukla, VC, RVSKVV, Gwalior; Dr. W. Selvamurthy, President, ASTIF; Dr. Kshipra Mishra, STE, Kolkata/Gurugram and Dr. Madhu Vats, SKSS, Meerut visited ICAR-CAFRI on the eve of a two days National Conference on "Shashwat Srishti Sanrakshan" is being organized on August 23-24, 2024 at ICAR-CAFRI, Jhansi.
- Prof. Senthil Vinayagam, former Director, NIRD & former Director MANAGE, and Programme cooridnator, NAARM Hyderabad visited ICAR-CAFRI Jhansi to discuss opportunities in Agroforestry Research Management on 5th Setpember 2024.
- Dr. A.K. Patra, Former Director of ICAR-IISS, Bhopal as Chairman, Dr. Jitendra Kumar, ADG (NASF) from ICAR, Dr. A.R. Sharma, Former Director, ICAR-DWR, Jabalpur (M.P.) & Former, Director Research, RLBCAU, Jhansi (U.P.) visited ICAR-CAFRI Jhansi on 9th September, 2024 and reviewed the progress of NASF funded project.
- The Chief Development Officer of Jhansi, Mr. Junaid Ahmed, IAS, visited ICAR-Central Agroforestry Research Institute, Jhansi on 25th September, 2024 and held discussions with Director, CAFRI on the agroforestry opportunities, nursery management practices, *etc.*
- Dr N. P. Bhatt, Principal Scientist,NRM Division, ICAR New Delhi, graced the IRC(II) meeting of the ICAR-CAFRI as an expert member on 4th December 2024.
- Dr. Nishi Rai, Chairperson, ICC visited ICAR-CAFRI on 10th December, 2024.

12. Digital Reforms

ICAR-CAFRI has improved it official website https://cafri.icar.gov.in/ as per latest guidelines and is available in English, Hindi and Tamil languages. All the social media platforms *viz.*, Facebook, YouTube, Twitter, Instagram and LinkedIn and mobiles apps are linked to the website for easier availability to the users. Institute is promoting online payments through digital payment gateway using bank details and UPI. The compatibility features to especially abled viewers and mobile users are also enabled on the website. Mobile applications of the institute have been updated and also are in the process for their iOS versions for apple phone users for wider utility and outreach. Institute has enhanced its outreach through all of its social media platforms. Institute has implemented various digital platforms like e-office, ERP, e-HRMS, ARMS, KRISHI, SPARROW, PIMS, PFMS, *etc.* for all of its routine official works.

Mobile *apps* & e-Learning platforms

1. FarmTree

CAFRI's first mobile application developed for guiding package of practices of 25 promising agroforestry tree species. It has around 10,000 downloads and 4.7google rating.

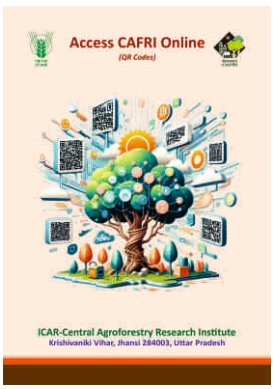
2. Learn Agroforestry

CAFRI's initiative for promoting e-learning among students through capsule course on agroforestry. It has achieved 1000 downloads and 3.5 google rating.

ABIC e-learning module

Trees outside Forests (TOF) is being promoted across India through external driving factor. This is typically the Top-Down Approach. The top-down approach may have limitations, such as the potential for overlooking important details or the risk of developing problems after the remove of the external force. To mitigate it, the top-down approach needs to be combined with a bottom-up approach. Thus, there is a need to develop bottom-up approach as well as market-centric approach. This will enable the formation of perpetual driving force promoting and upscaling TOF. The first step in this regard will be Capacity building and Training on the entrepreneurship opportunity of TOF. Conventional physical handholding has limited reach and we need to tap in the digital tools like MOOCs, Online Class Rooms. The module has been developed to establish a roadmap for the students and other stakeholders and it gives an idea about the foundation for business incubation in wood-based products.

Quick and easier access through QR codes



FAO's self-paced e-Learning courses, designed for professionals working to implement the SDGs on the ground and enhance their ability to champion the 2030 Agenda in their locality. Likewise, this e-learning module is also a self-pace course for all the entrepreneurship cantered around TOF.E-learning is flexible, convenient, cost effective, easily accessible, wide reach and personalized learning which makes it to reach many audiences. It is developed under the umbrella of ToF. The courses tell about opportunities for small and medium enterprises and farmers to help diversify income sources through success stories of various stakeholders. The course delivers where entrepreneurs can set ventures for business of tree based products and ways to allocate the resources. The course can be accessed free of cost at https://cafri.icar.gov.in/e-learning-module/

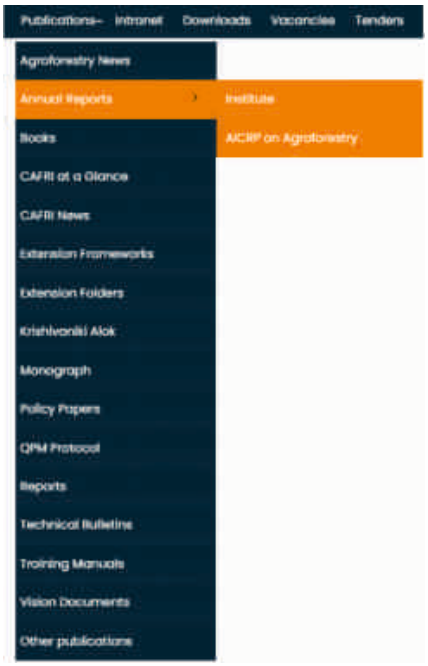
Tree species dashboard

Melia dashboard

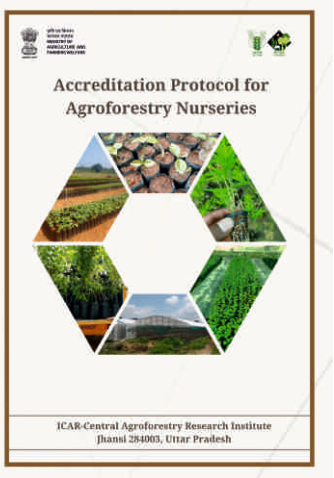
The ICAR-CAFRI Melia Initiative Dashboard is a platform offering resources and tools for researchers, scientists, farmers, and stakeholders to optimize Melia dubia cultivation, enhance timber production, and contribute to sustainable agroforestry practices, ensuring economic and environmental benefits.

Publications are digitally available

All publications after 2020 have been digitized and furbished electronically for easier and quick access to all. Similarly, Identity cards of all institute employees have been upgraded using QR code as per Brand ICAR Document and linked to the institute website for better authenticity.



The agroforestry nursery accreditation certificate are also QR coded.



13. Personnel Information

Dr. A. Arunachalam, Director
Scientific
1. Dr. Rajendra Prasad, Principal Scientist (Soil Science)
2. Dr. A. K. Handa, Principal Scientist (Forestry/ Agroforestry)
3. Dr. R. P. Dwivedi, Principal Scientist (Agriculture Extension)
4. Dr. Badre Alam, Principal Scientist (Plant Physiology)
5. Dr. Naresh Kumar, Principal Scientist (Agroforestry)
6. Dr. K. Rajarajan, Senior Scientist (Genetics & Plant Breeding)
7. Dr. Sushil Kumar, Senior Scientist (Agronomy)
8. Dr. Asha Ram, Senior Scientist (Agronomy)
9. Dr. Sovan Debnath, Senior Scientist (Soil Science)
10. Dr. Ashok Yadav, Scientist, Senior Scale (Fruit Science)
11. Dr. Hirdayesh Anuragi, Scientist, Senior Scale (Genetics & Plant Breeding)
12. Dr. Sukumar Taria, Scientist (Plant Physiology)
13. Dr. M. Ashajyothi, Scientist (Plant Pathology)
14. Dr. Y. N. Venkatesh, Scientist (Agricultural Entomology)
15. Dr. Priyanka Singh, Scientist (Agricultural Economics)
16. Dr.. Suresh Ramanan S, Scientist (Agroforestry)
17. Dr. Bijoy Chanda, Scientist (Agricultural Statistics)
18. Mrs. Syamili MS, Scientist (Agroforestry)
Technical
1. Sh. Rajesh Srivastava, Chief Technical Officer (Art & Photo)
2. Sh. Rajesh Kumar Singh, Assistant Chief Technical Officer
3. Sh. S. P. Singh Yadav, Assistant Chief Technical Officer
4. Dr. Ajay Kumar Pandey, Senior Technical Officer
5. Dr. Pradyuaman Singh, Senior Technical Officer
6. Mrs. Shelja Tamrakar, Technical Officer (Library)
7. Sh. Het Ram, Technical Officer (Driver)
8. Sh. Kashi Ram, Technical Officer (Driver)
9. Sh. Anil Kumar, Senior Technical Assistant
10. Sh. Gulshan Kumar, Technician
Administration
1. Sh. Gautam Saxena, AO
2. Sh. Pavan Kumar Panday, F&AO
3. Sh. Birendra Singh, AAO
4. Sh. Mahendra Kumar, AAO
5. Sh. Hoob Lal, Private Secretary
6. Sh. Ajay Kumar Gaur, Private Secretary
7. Sh. Deepak Vij, Personal Assistant

8.	Sh. Tridev Chaturvedi, Personal Assistant	
9.	Sh. Jai Janardan Singh, Assistant	
10.	Sh. Rahul Kumar Suraj, Assistant	
11.	Sh. Vaibhav Butola, Assistant	
12.	Mrs. Kaushalya Devi, Sr. Clerk	
Skilled Supporting Staff		
1.	Sh. Ram Din	
2.	Sh. Pramod Kumar	
New Staff		
1.	Dr. Bijoy Chanda, Scientist (Agricultural Statistics)	Joined on 01.02.2024
2.	Mrs. Syamili M.S., Scientist (Agroforestry)	Joined on 19.08.2024
3.	Sh. Anil Kumar, Senior Technical Assistant	Joined on 01.08.2024
4.	Sh. Rahul Kumar Suraj, Assistant	Joined on 01.10.2024
5.	Sh. Vaibhav Butola, Assistant	Joined on 04.11.2024
6.	Sh. Gulshan Kumar, Technician	Joined on 07.05.2024
Transfer		
1.	Dr. Priti Tigga, Scientist (Agricultural Physics) has been relieved on 23.02.2024 to ICAR-IARI, Hazaribagh, J.H.	
2.	Dr. Alka Bharati, Scientist (Agricultural Biotechnology) has been relieved on 06.12.2024 to ICAR-NEH, Umiam.	
Promotion		
1.	Dr. Sovan Debnath, Senior Scientist (Soil Science)	w.e.f. 01.01.2023
2.	Mrs. Shelja Tamrakar, Technical Officer (Library)	w.e.f. 24.11.2022
Retirement		
1.	Sh. Jagdish Singh, Skilled Supporting Staff (SSS) on 29.02.2024	
2.	Sh. Ram Bahadur, Assit. Chief Technical Officer on 30.06.2024	
3.	Sh. Om Prakash, Private Secretary on 30.06.2024	
4.	Sh. Munna Lal, Skilled Supporting Staff (SSS) on 31.07.2024	

Annexure-I

Research Advisory Committee (RAC) (2021-2024)

Dr. P. Kaushal (Chairman) Vice Chancellor Uttarakhand university of Horticulture& Forestry, Uttarakhand	**Dr. N.B. Singh** Vice Chancellor, B.N. University, Udaipur, Rajasthan
Dr. K.T. Parthiban Dean, Forest College and Research Institute, TNAU, Mettupalayam	**Dr. K. Sammi Reddy** Director, ICAR-NIASM, Baramati
Dr. A .K. Shukla Vice Chancellor RVSKVV, Gwalior, Madhya Pradesh	**Dr. N. Narasimha** Former Head (Extension), UASB,Bangalore (KA)
Dr. Rajbir Singh Assistant Director General (Agron./AF & CC) NRM Division, ICAR, Krishi Anushandhan Bhawan-II, New Delhi- 110 012	**Dr. A.K. Handa** Pr. Scientist & Member Secretary, ICAR- CAFRI, Jhansi (U.P.)

Annexure-II

Institute Management Committee (IMC)
(2022-2025)

Dr. A. Arunachalam Director ICAR-CAFRI, Jhansi (U.P.)	**Dr. F. Murli Gopal** Principal Scientist, ICAR-CPCRI, Kasargod, Kerala
Dr. V.K. Yadav Principal Scientist, ICAR-IGFRI, Jhansi	**Dr. R.S. Yadav** Principal Scientist, ICAR- HQ, New Delhi
The Assistant Director General (ADG) (AAF & CC) NRM, Division Indian Council of Agricultural Research, Krishi Anushandhan Bhavan-II New Delhi-110012	**Dr. A.K. Handa** Principal Scientist, ICAR-CAFRI, Jhansi
Director Agriculture Govt. of UP, Lucknow (U.P.)	**Dr. Suneel Pandey** ITC Limited, Bhadra Chalam (Telangana)
Director - Research, RLBCAU, Jhansi	**Sr F & AO** ICAR-IIPR, Kanpur (U.P.)
Director - Extension, RVSKVV, Gwalior (M.P.)	**Sh. Gautam Saxena** Administrative Officer & Member Secretary, ICAR-CAFRI, Jhansi
F&AO ICAR-CAFRI, Jhansi	
Non- official Members	
Sh. Surendra Kumar Tiwari Panchampura, Badagaon, Jhansi	**Sh. Rajendra Singh Brijesh** Kasava, Sangrampur, Anwal Bazar, Gorakhpur (U.P.)

Annexure-III

Institute Joint Staff Council (IJSC)
(2022-2025)

Chairman : Dr. A. Arunachalam, Director				
Category	**Staff Side**		**Office Side**	
Administration	**Sh. Birendra Singh** AAO	**Member, CJSC**	**Dr. A.K. Handa** Pr. Scientist	Member
	Sh. Jai Janardan Singh Assistant	**Secretary, IJSC**	**Dr. K. Rajarajan** Pr. Scientist	Member
Technical	**Smt. Shelja Tamrakar** Technical Officer	Member	**Dr. Ajay Kumar Panday** Sr. Technical Officer	Member
	Sh. Kashi Ram Tech. Officer (Driver)	Member	**Sh. P.K. Panday** F & AO	Member
Skilled Supporting Staff	**Sh. Pramod Kumar** SSS	Member	**A.O. / H.O.**	**Member Secretary**
	Sh. Munna Lal SSS	Member		

Annexure-IV

राजभाषा कार्यान्वयन समिति

डॉ. ए. अरुणाचलम	निदेशक	अध्यक्ष
डॉ. ए.के. हाण्डा	प्रधान वैज्ञानिक	सदस्य
डॉ. आर.पी. द्विवेदी	प्रधान वैज्ञानिक	सदस्य
डॉ. के. राजराजन	वरिष्ठ वैज्ञानिक	सदस्य
श्री गौतम सक्सेना	प्रशासनिक अधिकारी	सदस्य
श्री पी.के. पाण्डे	वित्त एवं लेखाधिकारी	सदस्य
श्री बिरेन्द्र सिंह	सहायक प्रशासनिक अधिकारी	सदस्य
श्री हूबलाल	निजी सचिव	सदस्य
श्री कौशल्या देवी	वरिष्ठ लिपिक	सदस्य
श्रीमती शैलजा ताम्रकार	तकनीकी अधिकारी	प्रभारी अधिकारी (राजभाषा) एवं सदस्य सचिव

Annexure-V

Internal Complaint Committee (ICC)

Dr. Nishi Rai	Incharge, KVK, Jhansi	Chairperson
Dr. Neeti Shastri	NGO Member	Member
Dr. Priyanka Singh	Scientist, ICAR-CAFRI, Jhansi	Member
Smt. Shelja Tamarkar	Tech. Officer, ICAR-CAFRI, Jhansi	Member
Smt. Kaushalaya Dev	Sr. Clerk, ICAR-CAFRI, Jhans	Member
A.O./H.O.	ICAR-CAFRI, Jhansi	Member Secretary

Annexure-VI

Farm Calendar-2024

S.No.	Month	Activity
1.	January	1. Farm management committee meeting (first week)
		2. Need-based cultural operations in *rabi* season crops/germplasm blocks/seed orchards
		3. Preparation of tentative list of input requirements
		4. Preparation of tentative list of farm produce with periodicity
		5. Price fixation of farm produce (tentative)
		6. Interaction meeting with scientists and stakeholders
		7. Proposal for purchase of needed tools/implements/solar lights
		8. Tree counting in sub blocks
		9. Updating tree register
2.	February	1. Farm management committee meeting (first week)
		2. Need-based cultural operations in *rabi* season crops
		3. Deepening of existing water resources/dugout ponds
		4. Observing open day on Basant Panchami
		5. Whitewash of avenue trees
		6. Maintenance of implements/tools
3.	March	1. Farm management committee meeting (first week)
		2. Need-based work in *rabi* season crops
		3. Preparations for harvesting
		4. Identification of new site for composting /disposing crops residue
4.	April	1. Farm management committee meeting (first week)
		2. Harvesting/threshing/winnowing operations of *rabi* season crops
		3. Interaction meeting with scientists and stakeholders
		4. Maintenance of biological units such as organic manure unit/vermicompost/FYM *etc.*
		5. Observing open day on Baishakh
5.	May	1. Farm management committee meeting (first week)
		2. Storage/price-fixing /sale of *rabi* season crops
		3. Pruning operations in tree plants/ber
		4. Need-based irrigation in established plants/germplasm blocks/seed orchards
		5. Monitoring and maintenance of farm implements for *kharif* sowing
		6. Visit by dignitaries and farmers including Foundation Day arrangements
		7. Interaction meets with farm incharges of neighboring institutes.
		8. Disiltaion of ponds/channels
		9. Insurance renewal of motorcycle (UP 93 V7891)
6.	June	1. Farm management committee meeting (first week)
		2. Need-based irrigation in established plants/germplasm blocks/seed orchards
		3. Field day on prominent AFS
		4. Maintenance of drainage channels

		5.	Maintenance of implements/tools
		6.	Preparations for *kharif* sowing
7.	July	1.	Farm management committee meeting (first week)
		2.	Interaction meeting with scientists and stakeholder
		3.	Plantation drive in farm area
		4.	Sowing of *kharif* crops
8.	August	1.	Farm management committee meeting (first week)
		2.	Need-based cultural operations in fields
		3.	Inputs purchasing for *rabi* season crops
		4.	Monitoring of water source and water bodies for water storage capacity
9.	September	1.	Farm management committee meeting (first week)
		2.	Land preparation and sowing of *rabi* season crops (rapeseed & mustard)
		3.	Monitoring and maintenance of farm implements for *rabi* season sowing
		4.	Repairing of GI pipeline system and motors
		5.	Preparations for *kharif* harvesting
10.	October	1.	Farm management committee meeting (first week)
		2.	Kharif crop harvesting
		3.	Storage/price fixation/sale of *kharif* season crops
		4.	Land preparation and sowing of *rabi* season crop (gram)
		5.	Interaction meeting with scientists and stakeholder
		6.	Insurance renewal of Tractors (UP 93 AG0342; UP 93 AG 0336)
		7.	Pre and post preparatory operations for *rabi* season crops
11.	November	1.	Farm management committee meeting (first week)
		2.	Field day *rabi* season
		3.	Sowing of *rabi* season crops
		4.	Pruning of MPTs
		5.	Need based operations in *rabi* season crops
12.	December	1.	Need-based cultural operations in *rabi* season crops
		2.	Annual store verification
		3.	Field activities on world soil day and farmers' day

*Preparation of consolidated statement of labours indent and administrative approval (last week of every month) * Processing of labour bills for payment (First week of every month) * POL purchase as per need * Servicing and repair of implements (need-based) *Monthly store stock check and verification*Monthly dry run of motors and machines *Quarterly meetings with PL, estate and other relevant sections * Six monthly workshops on: (a) Farm management and (b) Nursery management* Auction of farm produce yearly twice* Sale of farm produce through sale counter on all working days from 4.30 to 5.30

Annexure-VII

Important Days/Events Calendar-2024

S.No.	Month	Event	Date	Coordinators
1.	January	Republic Day	26.01.2024	AO, Chairman, FMC, Sh. Ajay K. Gaur, Sh. Om Prakash
2.	February	National Science Day	28.02.2024	PL, ASR, Dr. Priti Tigga, Sh. Ajay Pandey
3.	March	International Women Day	08.03.2024	Dr. Ashajothi M., Dr Priyanka Singh Smt. Shelja Tamrakar, Smt. Kaushalya Devi
		World Water Day	22.03.2024	Dr Sushil Kumar, Dr Asha Ram, Sh. Praduymman Singh
4.	April	Earth Day	22.04.2024	PL, CCCR, Dr Sovan Debnath, Sh. Ram Bahadur
5.	May	Agroforestry Day	08.05.2024	Incharge, PME; Incharge, ITMU Sh. Hoob Lal
		International Day for Biological Diversity	22.05.2024	Dr K Rajarajan, Dr Hirdayesh Anuragi, Sh. S.P. Yadav
6.	June	World Environment Day	05.06.2024	PL, AER, Mr Suresh Ramanan S, Sh. Pradyuman Singh
7.	July	Van Mahotsav	1.07.2024 to 7.07.2024	Chairman, FMC; OIC (Farm) Sh. S.P. Yadav, Sh. Praduymman Singh
8.	August	National Honeybee Day	21.08.2024	Dr. Venkatesh, Y.N., Dr Ashok Yadav, Dr Ashajyothi M, Sh. R.K. Singh
9.	September	Hindi Divas	14.09.2024	Chairman, Library; Librarian; AAO (Establishment); Smt. Kaushalya Devi

10	October	World Food Day	16.10.2024	PL, TIR, Dr. Asha Ram, Dr Sukumar Taria, Sh. R.K. Singh
		Mahila Kisan Divas	15.10.2024	Dr Priyanka Singh, Dr Priti Tigga, Sh. Rajesh Srivastava
11.	November	Constitution Day	26.11.2024	AO, I/c PME, FAO, AAO (Store)
		Agriculture Education Day	3.12.2024	Chairman (HE), Dr. Hirdayesh Anuragi, Sh. Deepak Vij
12.	December	World Soil Day	05.12.2024	PL, CCCR, Dr Sovan Debnath, Sh. J.J. Singh
		National Farmers Day	23.12.2024	Incharge, ATIC, Sh. Rajesh Srivastava, Sh. Tridev Chaturvedi

Swachh Bharat Abhiyan

स्वच्छ भारत

एक कदम स्वच्छता की ओर

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CENTRAL AGROFORESTRY RESEARCH INSTITUTE

"AGROFORESTRY PATHWAY FOR RESTORATION OF DEGRADED LANDS"

भा.कृ.अनु.प.–केन्द्रीय कृषिवानिकी अनुसंधान संस्थान
झाँसी 284003, उत्तर प्रदेश

ICAR-Central Agroforestry Research Institute
Jhansi 284003, Uttar Pradesh