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# वार्षिक प्रतिवेदन

# ANNUAL REPORT 2023


## भा.कृ.अनु.प.–केन्द्रीय कृषिवानिकी अनुसंधान संस्थान

झाँसी 284003, उत्तर प्रदेश, भारत

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झाँसी 284003, उत्तर प्रदेश, भारत

ICAR-Central Agroforestry Research Institute
Jhansi 284003, Uttar Pradesh, India

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# Preface

Agroforestry promotes environmentally friendly production and provides ecosystem services that support livelihoods and protect the environment. With a strong conservation agriculture component, agroforestry helps preserve natural resources across various agro-climatic regions. It is also the only way to increase the nation's forest cover. In a context of decreasing arable land, degraded soil and water resources, rising pollution, and threats from global warming and climate change, agroforestry interventions can meet the growing population's needs for food, fodder, fiber, firewood, and timber. To meet these demands, new farming techniques are necessary. Since its inception, CAFRI has been focused on these issues through coordinated research efforts. Recently, NABARD has recognized four of the more than 80 agroforestry models developed and documented by the Institute as bankable agroforestry models for various agro-climatic areas.

The Institute boasts the largest germplasm collection of neem and other agroforestry tree species, including Indian rosewood, cactus, Malabar neem, teak, karanj, leucena, chironji, ber, citrus, mango, aonla, bael, guava, pomegranate, and fig. It provides opportunities for exploratory research on superior germplasms. To promote tree cover, the Institute has established various gardens, such as the Rashi Vatika, Nakshatra Vatika, and Navgarh Vatika. A recent initiative under the Climate Change Program is the National Mission for Maintaining the Himalayan Environment, which includes a regional center of the National Afforestation & Eco-Development Board (NAEB). Additionally, the Institute is documenting tree numbers through the USAID project "Trees Outside Forests in India" (TOFI). The Institute has also begun work on drone-based agroforestry and is educating farmers in the Jhansi district and other parts of India. The ICAR-Central Agroforestry Research Institute (CAFRI) has been notified as the national nodal agency for the agroforestry component of Rashtriya Krishi Vikas Yojana (RKVY) to provide technical support, capacity building, setting up of nurseries, production, and certification of QPM. To cater to the demand of QPM, the institute is now focusing more on the production of Quality Planting Material (QPM) through financial support from the RKVY Project. The institute is now focusing more on strengthening community resilience by diversifying the cropping system through agroforestry interventions in Central India. Recently Institute has started large-scale screening, identification, and promotion of *Azardirachta Indica* accessions for high Azadirachtin yield. Through financial support from NABARD, the institute has successfully developed strawberry farming in Jhansi's Babina and Moth blocks and now promoting a pomegranate-based agroforestry system in the Semi-arid region of Bundelkhand. The institute is also promoting the religious, multipurpose, and medicinally important *Butea monosperma* through *in vitro* regeneration and its assessment for mass propagation of genetically uniform quality planting material.

The Annual Report contains executive summaries, achievements of different research programs, important meetings/days observed, details on various awards received by Institute scientists and other staff, research publications, participation in training, participation in workshops, webinars, meetings, and symposia, as well as a report on the implementation of different externally funded projects, inter-institutional projects, and SCSP schemes. The Institute organized farmer events such as farmer seminars, training programs, field days, and exhibitions to impart agroforestry innovations and promote quick agroforestry adoption. At the selected MGMG villages, scientists from ICAR-CAFRI, Jhansi, took part in a significant plantation campaign. Besides this the institute has launched different schemes such as “One Month One Lab (OMOL): and One Month One District (OMOD) to cater to the problem of farmers not only in Jhansi district but also in other districts of UP and M.P.

I extend my gratitude to Dr. Himanshu Pathak, Hon'ble Secretary, DARE and Director General, ICAR, New Delhi, for his steadfast support and encouragement. I am pleased to acknowledge Dr. S K Chaudhari, Deputy Director General (NRM), ICAR, New Delhi, for his continual guidance and motivation. I would like to specifically thank Dr. Rabir Singh, ADG (A, AF&CC), and the entire NRM Division team for their generous assistance. My thanks also go to my predecessors for their support in carrying out institutional activities. I commend the efforts of the PME Cell and the report's editors for their dedication to preparing and releasing the report on time.

**(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 35 वर्षों में विभिन्न कार्यक्रम के अन्तर्गत अनुसंधान कार्य किये जा रहे है। संस्थान में किये जा रहे अनुसंधान का कार्यकारी सारांश निम्नलिखित हैः

संरक्षित कृषिवानिकी परियोजना में सागौन, बेल और सागौन + बेल आधारित कृषिवानिकी मॉडल में फसल वृद्धि, उपज और मिट्टी के रासायनिक और जैविक गुणों पर डेटा लिया गया। खरीफ के दौरान, मक्का और ज्वार की फसलों को अलग–अलग जुताई और अवशेष प्रबंधन उपचारों के साथ लिया गया। यह देखा गया कि तीनों कृषिवानिकी प्रणाली में दोनों जुताई उपचार (पारंपरिक और न्यूनतम) सांख्यिकीय रूप से बराबर रहे। हालांकि, फसल अवशेषों के उपयोग से ज्वार, मक्का, अलसी एंव चना की फसलों की वृद्धि और उपज में 10–12 प्रतिशत तक की वृद्धि दर्ज हुई है। फसल अवशेषों के प्रयोग से मृदा में सूक्ष्मजैविक प्राचलों में भी काफी वृद्धि हुई।

प्रायोगिक कृषिवानिकी प्रणालियों (सागौन. फसल, मेलिया. फसल, बेर. फसल, आंवला. फसल) के साथ–साथ कृषि (एकमात्र) फसल प्रणाली पर 'प्रमुख कृषिवानिकी–आधारित भूमि उपयोग प्रणालियों में मिट्टी के जैविक और जैव रासायनिक लक्षणों का आंकलन' परियोजना में मिट्टी के विश्लेषण से पता चला कि मिट्टी के माइक्रोबियल और जैव रासायनिक गुण अंतरफसली क्षेत्र की तुलना में वृक्ष राइजोस्फीयर क्षेत्र में नाटकीय रूप से अधिक थे। माइक्रोबियल आबादी के मूल्यांकन से पता चला कि आंवला आधारित कृषि वानिकी में बैक्टीरिया (133×105 और 103×105 सीएफयू प्रति ग्राम मिट्टी) और कवक (16×104 और 11×104 सीएफयू प्रति ग्राम मिट्टी) की उच्चतम आबादी ($P < 0.05$) दर्ज की गई क्रमशः वृक्ष राइजोस्फीयर क्षेत्र की ऊपरी मिट्टी और उपमृदा दोनों पर। उच्चतम डिहाइड्रोजनेज गतिविधि मेलिया–आधारित कृषिवानिकी में ऊपरी मिट्टी (7.85 ug टीपीएफ प्रति ग्राम मिट्टी प्रति 24 घंटे) में देखी गई, लेकिन सागौन–आधारित कृषिवानिकी में वृक्ष राइजोस्फीयर क्षेत्र के उपमृदा (5.87 ug टीपीएफ प्रति ग्राम मिट्टी प्रति 24 घंटे) में देखी गई, जबकि सागौन आधारित कृषिवानिकी ने अंतरफसली क्षेत्र की ऊपरी मिट्टी (5.25 ug टीपीएफ प्रति ग्राम मिट्टी प्रति 24 घंटे) और उपमृदा (4.00 ug टीपीएफ प्रति ग्राम मिट्टी प्रति 24 घंटे) दोनों पर अपनी उच्चतम गतिविधि दर्ज की। β–ग्लूकोसिडेज और एसिड फॉस्फेट गतिविधि फिर से काफी हद तक ($P < 0.05$) थी, जो ऊपरी मिट्टी (171.18 और 117.88, और 300.44 और 437.10 ug पी–एनपी प्रति ग्राम मिट्टी प्रति घंटे) और उपमृदा (93.62 और 58.43, और 223.87 और 194.97 ug पी–एनपी प्रति ग्राम मिट्टी प्रति घंटे) दोनों पर मेलिया–आधारित कृषिवानिकी में उच्चतम थी वृक्ष राइजोस्फीयर और इंटरक्रॉप्ड जोन, क्रमशः। दूसरी ओर, सागौन आधारित कृषिवानिकी में उच्चतम यूरिया और क्षारीय फॉस्फेट गतिविधि ऊपरी मिट्टी (3.70 और 2.23 mg यूरिया प्रति ग्राम मिट्टी प्रति घंटे, और 169.67 और 152.02 ug पी–एनपी प्रति ग्राम मिट्टी प्रति घंटे) दोनों पर देखी गई और उपमृदा (1.14 और 1.35 mg यूरिया प्रति ग्राम मिट्टी प्रति घंटे, और 70.94 और 53.65 ug पी–एनपी प्रति ग्राम मिट्टी प्रति घंटे) क्रमशः वृक्ष राइजोस्फीयर और इंटरक्रॉप्ड जोन की।

एक बहुउद्देशीय वृक्ष प्रजाति, अजादिराक्टा इंडिका पर इस अध्ययन में तीन आबादी के 170 जर्मप्लाज्म नमूनों में आनुवंशिक विविधता का आकलन करने के लिए 20 नीम–विशिष्ट मार्कर्रों का उपयोग किया गया। दक्षिण–पूर्वी आबादी में सबसे अधिक आनुवंशिक विविधता प्रदर्शित हुई, जबकि उत्तर–मध्य में सबसे कम, जो अंतःप्रजनन का संकेत देता है। आणविक विश्लेषण ने आबादी के बीच 12% और भीतर 88% भिन्नता दिखाई। प्रमुख घटक, क्लस्टरिंग और संरचना विश्लेषण ने तीन अलग–अलग आबादी की पहचान की। यह शोध ए. इंडिका की आनुवंशिक क्षमता के संरक्षण और उपयोग के लिए अंतर्दृष्टि प्रदान करता है।

सिल्वीपास्टोरल परियोजना में पारिस्थितिकी तंत्र सेवाओं के मूल्यांकन में, प्रमुख पारिस्थितिकी तंत्र सेवाओं जैसे प्रावधानी और विनियमित सेवाओं का मूल्यांकन किया गया। विभिन्न उपचारों के बीच सागौन + महोगनी + चरागाह के साथ–साथ समोच्च क्रमब) खाइयों के संयोजन ने उच्चतम बायोमास उत्पादकता और मिट्टी की नमी की मात्रा प्रदर्शित की। समवर्ती :प 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 के से उच्च अपवाह और मिट्टी के कटाव का प्रदर्शन किया। इसके अलावा जब, कल वृक्षारोपण (सागौन या महोगनी) की तुलना वृक्ष–चरागाह संयोजनों से की गई तो बाद वाले में मिट्टी में बढ़ी हुई सूक्ष्मजीव गतिविधियों पायी गयी।

आईसीएआर–एनबीपीजीआर–आईआईएचआर–सीएएफआरआई और आईसीआरएएफ का यह संयुक्त पायलट प्रोजेक्ट फील्ड जीन बैंक में अजाडिराक्टा इंडिका सहित 30 बहुउद्देशीय पेड़ों की निगरानी के लिए आरएफआईडी तकनीक का उपयोग करता है। आरएफआईडी टैग एसएएमएस पोर्टल में दर्ज किए गए रूपात्मक और स्वास्थ्य स्थिति पर वास्तविक समय डेटा के साथ निष्क्रिय प्रबंधन को सक्षम करते हैं। इसके अलावा, 50 नीम के पेड़ मानव हस्तक्षेप को कम करते हुए, सहज वास्तविक समय की निगरानी के लिए चिप्स से लैस हैं।

इस वर्ष के दौरान, हमारे शोध ने एजैडाइरेक्टिन निष्कर्षण को अनुकूलित करने के लिए विभिन्न क्रोमैटोग्राफी तकनीकों की तुलना करने पर ध्यान केंद्रित किया। विशेष रूप से, हमने सॉल्वैंट्स के रूप में इथेनॉल और एसीटोनिट्राइल की तुलना की। निष्कर्षों से पता चला कि इथेनॉल की तुलना में एसीटोनिट्राइल में एजैडाइरेक्टिन की उपज अधिक है। इसके अतिरिक्त, हमने तेल की उपज और एजाडिरेक्टिन उपज के बीच आनुवंशिक सहसंबंध का पता लगाया, लेकिन परिणामों ने इन दोनों विशेषताओं के बीच कोई महत्वपूर्ण संबंध नहीं दर्शाया।

# Executive Summary

The executive summary of the research and development activities carried out at ICAR-Central Agroforestry Research Institute during 2023 is presented here:

Within the framework of the conservation agroforestry project, comprehensive data encompassing growth patterns, yield outcomes, and soil chemical and biological attributes were meticulously gathered from teak, bael, and teak+bael based agroforestry systems. Throughout the kharif and rabi seasons, a spectrum of tillage practices and residue management approaches were applied to maize and sorghum crops and linseed and chickpea crops, respectively. Remarkably, statistical analyses revealed that both conventional and minimum tillage methods yielded comparable results across all three agroforestry systems. However, the strategic incorporation of crop residue exerted a significant positive influence on the growth, yields and soil chemical and biological properties. Among the triad of agroforestry systems under scrutiny, teak-based agroforestry emerged as the frontrunner in terms of securing higher crop yields for kharif crops and teak+bael based agroforestry system for rabi crops.

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 soil microbial and biochemical properties were dramatically higher at tree rhizosphere zone over intercropped zone. Evaluation of the microbial population revealed that amla-based agroforestry registered significantly ($P$ <0.05) highest population of bacteria ($133\times10^5$ and $103\times10^5$ CFU g soil$^{-1}$) and fungi ($16\times10^4$ and $11\times10^4$ CFU g soil$^{-1}$) at both topsoil and subsoil of tree rhizosphere zone, respectively. Highest dehydrogenase activity was noticed in melia-based agroforestry at topsoil (7.85 ug TPF g soil$^{-1}$ 24 h$^{-1}$) but teak-based agroforestry at subsoil (5.87 ug TPF g soil$^{-1}$ 24 h$^{-1}$) of tree rhizosphere zone; whereas teak-based agroforestry registered its highest activity at both topsoil (5.25 ug TPF g soil$^{-1}$ 24 h$^{-1}$) and subsoil (4.00 ug TPF g soil$^{-1}$ 24 h$^{-1}$) of intercropped zone. β-glucosidase and acid phosphatase activity was again significantly ($P$ <0.05) highest at melia-based agroforestry at both topsoil (171.18 and 117.88, and 300.44 and 437.10 ug $p$-NP g soil$^{-1}$ h$^{-1}$) and subsoil (93.62 and 58.43, and 223.87 and 194.97 ug $p$-NP g soil$^{-1}$ h$^{-1}$) of tree rhizosphere and intercropped zone, respectively. On the other side, highest urease and alkaline phosphate activity was observed at teak-based agroforestry both at topsoil (3.70 and 2.23 mg urea g soil$^{-1}$ h$^{-1}$, and 169.67 and 152.02 ug $p$-NP g soil$^{-1}$ h$^{-1}$) and subsoil (1.14 and 1.35 mg urea g soil$^{-1}$ h$^{-1}$, and 70.94 and 53.65 ug $p$-NP g soil$^{-1}$ h$^{-1}$) of tree rhizosphere and intercropped zone, respectively

This study on *Azadirachta indica*, a multipurpose tree species, used 20 neem-specific markers to assess genetic diversity in 170 germplasm samples from three populations. The south-eastern population exhibited the highest genetic variation, while the north-central showed the lowest, indicating inbreeding. Molecular analysis showed 12% variation among populations and 88% within. Principal component, clustering, and structure analyses identified three distinct populations. This research provides insights for conserving and utilizing the genetic potential of *A. indica*.

The objectives of the project are i) to study the influence of agroforestry tree species on soil properties, and ii) to establish the relationship among leaf traits to understand agro-ecosystem functioning in agroforestry. During the year mechanical separates – (sand, silt and clay) of surface soil of all 10 sites were analysed. The bulk density, available N, P, K, dehydrogenase activity (DHA) and micronutrients-Zn, Cu, Fe &Mn in soil samples collected up to depth of 100cm were estimated. Also, N content in mature and senescence leaves of all the five tree species was estimated. In general, bulk density of soil increased with increase in soil depth except few oscillations. Similarly, on an average, available N, P and K in soil decreased with increase in soil depth with few exceptions for P and K. In agroforestry systems having clay loam soil, the DHA was higher at 15-30cm depth than 0-15cm, thereafter it decreased in soil profile. Mature leaves had higher N content than senescence leaves.

Various physiological responses of clonal and seedling populations of *Pongamia pinnata* trees have been noted. Differential responses in dynamics of leaf area index (LAI) have been observed.

In the evaluation of ecosystem services within the context of a silvopastoral project, a comprehensive assessment was conducted focusing primarily on provisioning and regulating services. Notably, the integration of various elements yielded distinct outcomes. Among the different treatments, the combination of teak, mahogany, and pasture alongside contour staggered trenches exhibited the highest biomass productivity and soil moisture content. Concurrently, this configuration significantly mitigated runoff, soil erosion, and nutrient loss, boasting the highest sediment trapping efficiency. Conversely, the sole plantation of mahogany demonstrated higher runoff and soil erosion, underscoring

the importance of diverse species compositions. Moreover, when comparing sole tree plantations (teak or mahogany) to tree-pasture combinations, the latter exhibited heightened soil microbial activities.

From preliminary focused group discussion, it is revealed that the major constraint in adoption of agroforestry is stray animals (14.36%).

The watershed area has seen significant improvements in cropping patterns, with increased gross cropped area, cropping intensity, and crop rotation intensity. These interventions have also improved crop productivity, increased fodder availability, and reduced migration patterns. The land use types with the highest density were grazing land, boundary, and cropland, with the highest species diversity observed in boundaries trees. The Shannon diversity index for cropland was minimum, with an average H' of 0.93 per farm. Overall, these interventions have positively impacted the livelihood of farmers in the watershed area, enhancing their livelihoods and promoting sustainable agriculture.

During the 14$^{th}$ annual workshop of the project the coordinating unit of ICAR-NISA Ranchi after overhauling recommended two new sub-projects *viz.* i) documentation of Indigenous technical knowledge (ITKs) on harvesting, processing and value addition of NRGs in India, and ii) feasibility for inclusion of NRG plants into economically viable agroforestry models. In new subprojects some of the objectives of old subprojects were retained to maintain continuity of ongoing research relating to agroforestry models and indigenous technical knowledge. During the year two districts of Rajasthan *viz.* Jhalawar and Baran were surveyed for collecting information on ITK of gum and resins. The major gums collected in Baran and Jhalawar districts *include Anogeissus latifolia* (dhawra gum), *Acacia catechu* (khair gum), *Acacia nilotica* (babool gum) and *Butea monosperma* (palas gum). The forest produce collected by tribal are sold in the local market without any post-harvest processing except cleaning. The grading of the NTFP is done at the end of local traders. Based on the ITK information, development of a tapping tool *viz.* CAFRI: Thorny tree-gum amasser for picking and collecting naturally exuded gum-balls from high end trees particularly the thorny trees has been conceptualized and designed to enhance efficiency and reduce drudgeries of the gum collectors.

The agroforestry models based on gum yielding trees *viz.*, multi-component based agri-horti-silvicultre, rainfed agri-silviculture, silvi-herbal, biofence and block planting on rocky site as gum garden are maintained and tree growth, gum yield and intercrop production data are monitored for economic viability. In multi-component model, decline in grain yield of barley intercrop over control was 13.6, 29.5 and 22.5% in association of *A. senegal, C. limon* and *A. marmolos,* respectively. In rainfed agri-silviculture model, grain yield *E. sativa* was influenced by tree species as well as planting spacing. As planting spacing increased from 5x5 m, 10x5 m and to 10x10 m, the seed yield also increased significantly from 24.3 g $m^{-2}$, 34.5 and to 43.0 g $m^{-2}$, respectively. Total biomass of *E. sativa* was, significantly more in association of *A. senegal* than *A. nilotica*. In silvi-herbal model maximum survival, growth and biomass yield of lemon grass were recorded in tussocks planted at 100x100cm spacing. The penetrability of bio fence model against stray cattle was measured using Digitiser V 6.3.0 tool, which revealed that ~13% vertical projection of the bio-fence had opening/gap and the actual vertical area occupied by the fence was 53.15 $m^2$ out of 60.97 $m^2$. The yield of gum arabic in multi-component model, old gum garden, new gum garden and rainfed model ranged from 32.0 – 136, 1.0 – 36.0, 3.0 – 116.0 and 7.0 – 59.0 g $tree^{-1}$ with a mean value of 84.0, 7.89, 29.2 and 30.3 g $tree^{-1}$, respectively. Similarly, yield of gum from *A. nilotica* ranged from 10.0 – 54.0 g $tree^{-1}$ in silvi-harbal model and from 1.0 – 23.0 g $tree^{-1}$ in rainfed agri-silviculture model with respective mean value of 33.75 and 13.20 g $tree^{-1}$.

Feasibility of using IINRG-gum tapping blazer-75 for tapping gum in Bundelkhand was tested by conducting a trial. The initial results revealed that the incision/ cut made by blazer-75 did not show exudation of *gum-dhwara (A. latifolia)* and *gum-gatti (A. pendula),* while exudation and yield of gum-butea *(B. monosperma* ) was very less (2.0 g $cut^{-1}$). Trial to observe gum exudation in *B. monosperma* throughout the year revealed that in general, maximum gum yield was obtained in the month of December followed by January and February while in rainy season (July, August and September) the gum yield was negligible. During the current year planting materials of gum arabic (10000 seedlings and 9.5 kg seeds – multiplied to 37000 seedlings in nursery) was supplied to ICRISAT Hyderabad for planting on farmer's field in Bundelkhand.

This joint pilot project by ICAR-NBPGR-IIHR-CAFRI and ICRAF employs RFID technology to monitor 30 multipurpose trees, including Azadirachta indica, in the field gene bank. RFID tags enable passive management, with real-time data on morphological and health status entered into the SAMS portal. Furthermore, 50 neem trees are equipped with chips for effortless real-time monitoring, minimizing human intervention.

During this year, our research focused on comparing various chromatography techniques to optimize azadirachtin extraction. Specifically, we compared with ethanol and acetonitrile as solvents. The findings revealed a higher azadirachtin yield in acetonitrile compared to ethanol. Additionally, we explored the genetic correlation between oil yield and azadirachtin yield, but the results indicated no significant correlation between these two characteristics.

# 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 34 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) | 4638 |
| Periodical subscribed (Indian) | 13 |
| Bound back volumes of research journals | 2487 |
| Dissertation -M.Sc. | 122 |
| 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 and Research Farm of the Institute

The Institute Research Farm spreads over 178.029 acres, possessing dug well (05), submersible (06), 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 2023-24 are given as follows:

| ***Kharif* -2023** | | | |
|---|---|---|---|
| **Details of crop (variety)** | **Sown area (ha)** | | |
| | **Experimental** | **General** | **Total** |
| Sorghum (CSH-3) | 1.5 | - | 1.5 |
| Maize (CP-858/ Kanchan) | 1.9 | - | 1.9 |
| Paddy (Pusa basmati-1121) | 0.5 | - | 0.5 |
| Black gram (PU-35) | 0.2 | - | 0.2 |
| Moong (PDM-139) | - | 3.9 | 3.9 |
| Total | 4.1 | 3.9 | 8.0 |

| **Revenue generated from farm produce (Rs.)** | |
|---|---|
| **Particulars/products** | **Revenue generated (Rs.)** |
| Aonla fruit | 80000.00 |
| Guava fruit | 20000.00 |
| Bael fruit | 25000.00 |
| Moringa | 1000.00 |
| Total | 1,26,000.00 |

During *Rabi* season 2023-24 about 15.75 ha area (8.95 ha experimental and 6.8 ha general cultivation) was utilized for cultivation of different crops, the details are given below:

| **Details of crop (variety)** | **Sown area (ha)** | | |
|---|---|---|---|
| | **Experimental** | **General** | **Total** |
| Wheat (HD2967/HD2932) | 1.7 | - | 1.7 |
| Barley (DWRB137/Jai) | 1.1 | 2.8 | 3.9 |
| Gram (Jaki-9218) | 2.6 | - | 2.6 |
| Mustard (Giriraj) | 0.85 | 4.0 | 4.85 |
| Linseed | 1.5 | - | 1.5 |
| Taramira | 1.2 | | 1.2 |
| Total | 8.95 | 6.8 | 15.75 |

The Institute Research Farm generated revenue to the tune of Rs. 13.74 lakhs from sale of grains, fruits, firewood, straw and saplings during the reporting period. The Institute Research Farm also maintains most improved farm machineries and implements for mechanized farm operations. Moreover, there is a mini workshop equipped with welding and drills machine, grinder and other tools which are used for repairing and maintenance of available farm machineries. In addition to the above, two new submersible pumps are added as the new development in the Farm area.

### 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 2022, the institute signed MoUs with following institutions for achieving excellence in teaching & research.

| S.No. | Name of the party/ Institute entered MoU with ICAR-CAFRI | Date of Signing MoU |
|---|---|---|
| **National/ International Organization** | | |
| 1. | Environment and Social Welfare Society (ESW), Khajuraho, Madhya Pradesh | 27th January, 2023 |
| 2. | V Sivaram Research Foundation, Bengaluru | 14th April, 2023 |
| **Universities** | | |
| 1. | ITM University, Gwalior, Madhya Pradesh | 03rd January, 2023 |
| 2. | Banda University of Agriculture & Technology, Banda, Uttar Pradesh | 24th January, 2023 |
| 3. | S R College of Professional Studies (SRGI), Jhansi, Uttar Pradesh | 13th March, 2023 |
| **Others** | | |
| 1. | Multiplex Forest Factree, Bangalore, Karnataka | 05th February, 2023 |
| 2. | Network for Certification and Conservation of Forests (NCCF), New Delhi | 05th June, 2023 |

# 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 (2016-2021)
- RAC (2021-2024)
- IMC (2022-2025)

**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

# Budget (2023-24)

(₹ in Lakhs)

| S.No. | Head | Budget | Expenditure |
|---|---|---|---|
| **1.** | **ICAR-CAFRI, Jhansi** | | |
| | a. Capital (Grant for creation of Capital Assets | 32.00 | 32.00 |
| | b. Establishment Expenses (Grant in Aid-Salaries) | 777.41 | 777.41 |
| | c. Grant in Aid-General (Pension Benefits) | 194.04 | 194.03 |
| | d. Grant in Aid-General | 349.00 | 349.00 |
| | **Total** | **1352.45** | **1352.44** |
| **2.** | **Plan Schemes** | | |
| | All India Coordinated Research Project on Agroforestry (AICRP on Agroforestry) | 1237.91 | 1149.61 |
| | Harvesting processing and value addition of natural resins and gums (HPVA of NRG | 8.29 | 8.24 |
| | National Agriculture Innovation Fund (NAIF) Scheme IP&TM | 4.60 | 4.59 |
| **3.** | **Externally funded projects** | | |
| | a. Trees Outside Forests in India (TOFI) | 24.77 | 22.25 |
| | b. Task Force on Himalayan Agriculture- NMSHE (2nd Phase) | 148.41 | 146.62 |
| | c. Pilot the solutions of chip based technology for real time and RFID-passive monitoring of field gene bank and agroforestry species for scaling up | 3.19 | 1.95 |
| | d. "Agri-Drone Project" | 7.04 | 0.12 |
| | e. Evaluation the performance of Sea weed Extract, Humid acid, Protein Hydrolysates Biochemical, and Botanical Extracts | 40.96 | 40.00 |
| | f. Development and Evaluation of Pomegranate based agroforestry system in Bundelkhand region for higher productivity and economic returns in farmers field | 11.28 | 8.10 |
| | g. *In vitro* regeneration of multipurpose & medicinally important *Butea monosperma* Lam. and its assessment for mass propagation of genetically uniform quality planting material | 9.00 | 7.81 |
| | h. Strengthening community resilience by diversifying cropping system through agroforestry interventions in Central India | 28.24 | 1.58 |
| | I. Tissue-specific physiological, molecular, and metabolomics analysis of green gram (*Vigna radiata*) for shade adaptive traits in the context of agroforestry | 4.87 | 4.86 |
| | j. The Economics of Ecosystems and Biodiversity (TEEB) for Agriculture and Food Initiative in India | 137.17 | 137.17 |
| | k. Large scale screening, Identification and Promotion of *Azadirachta indica* accessions for high Azadirachtin yield | 7.35 | 7.35 |
| | l. Laboratory bio-assay of newer fumigant molecules against storage insects | 3.13 | 3.13 |
| | m. RKVY-Quality Planting Material (QPM) | 28.56 | 22.93 |
| **4.** | **Resource Generation** | **Target** | **Achievement** |
| | 2023-24 | -- | 157.89 |
| **5.** | **SCSP Fund** | | |
| | Capital | 50.00 | 19.99 |
| | General | | 30.00 |
| | Total | 50.00 | 49.99 |

# 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 conservation agroforestry assessment project commenced in 2021, focusing on three distinct systems: Teak-based agroforestry, Bael-based agroforestry, and a combined Teak and Bael based agroforestry system established in 2014. Trees were uniformly planted at a spacing of 9m x 4m across all systems. In the Teak and Bael combination, a pattern of alternating Teak and Bael was adopted within rows, with a spacing of 4 m. Two cropping systems, namely Sorghum-Chickpea and Maize-Linseed, were selected for investigation, each implemented with and without residue and employing both minimum and conventional tillage methods. This resulted in a total of eight treatments: T1 to T8, representing various combinations of cropping systems, tillage methods, and residue management, with three replications within each agroforestry system. Crop yield analysis revealed comparable performance between conventional and minimum tillage methods. However, the application of residue significantly enhanced crop yields (10-12%) across all treatments, regardless of tillage method. Furthermore, the introduction of residue, particularly from chickpea, positively impacted soil microbial properties, particularly under minimum tillage conditions. Comparatively, higher levels of soil microbial activity were observed following the application of chickpea residue in the succeeding sorghum crop, outperforming the effects of linseed residue.

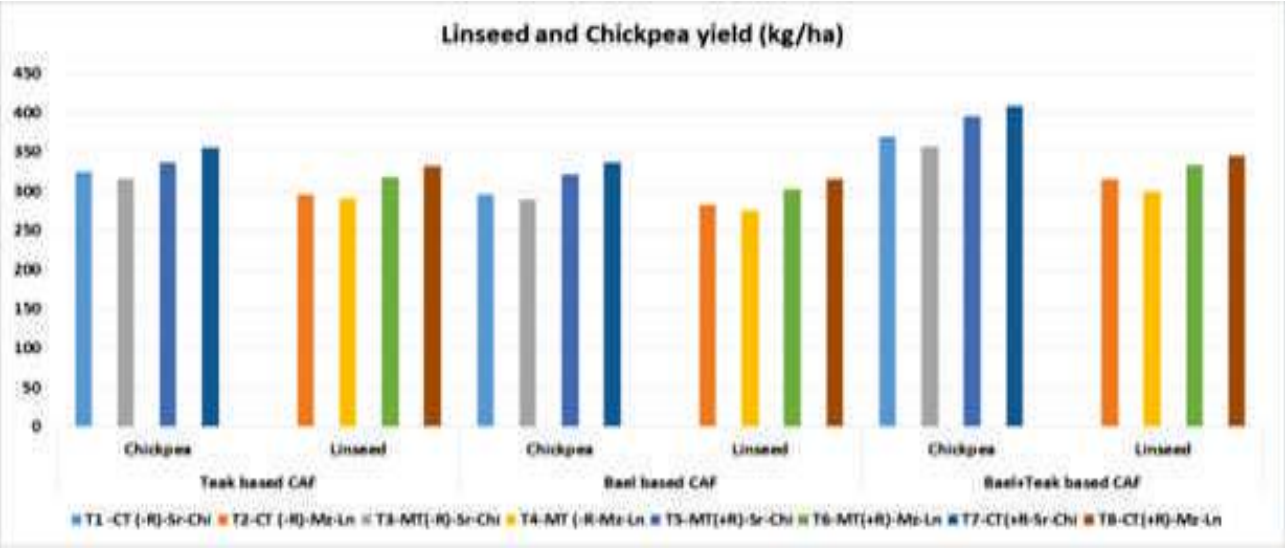
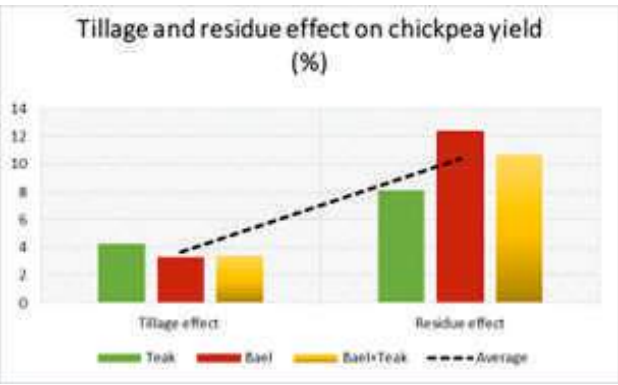



**Figure: Chickpea and linseed yield as influenced by conservation agriculture practices in teak, bael and teak + bael based agroforestry system.**



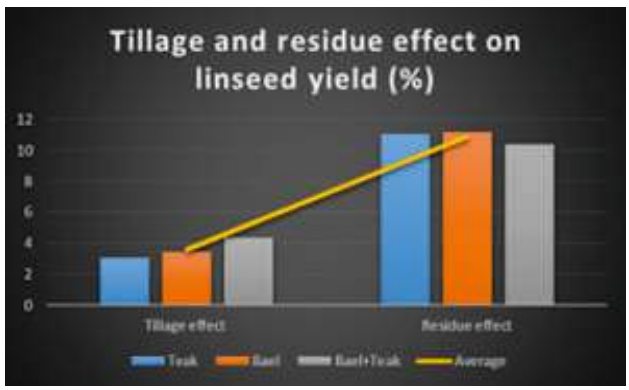




**Figure: Effect of residue application on chickpea and linseed yields in conservation agroforestry systems**

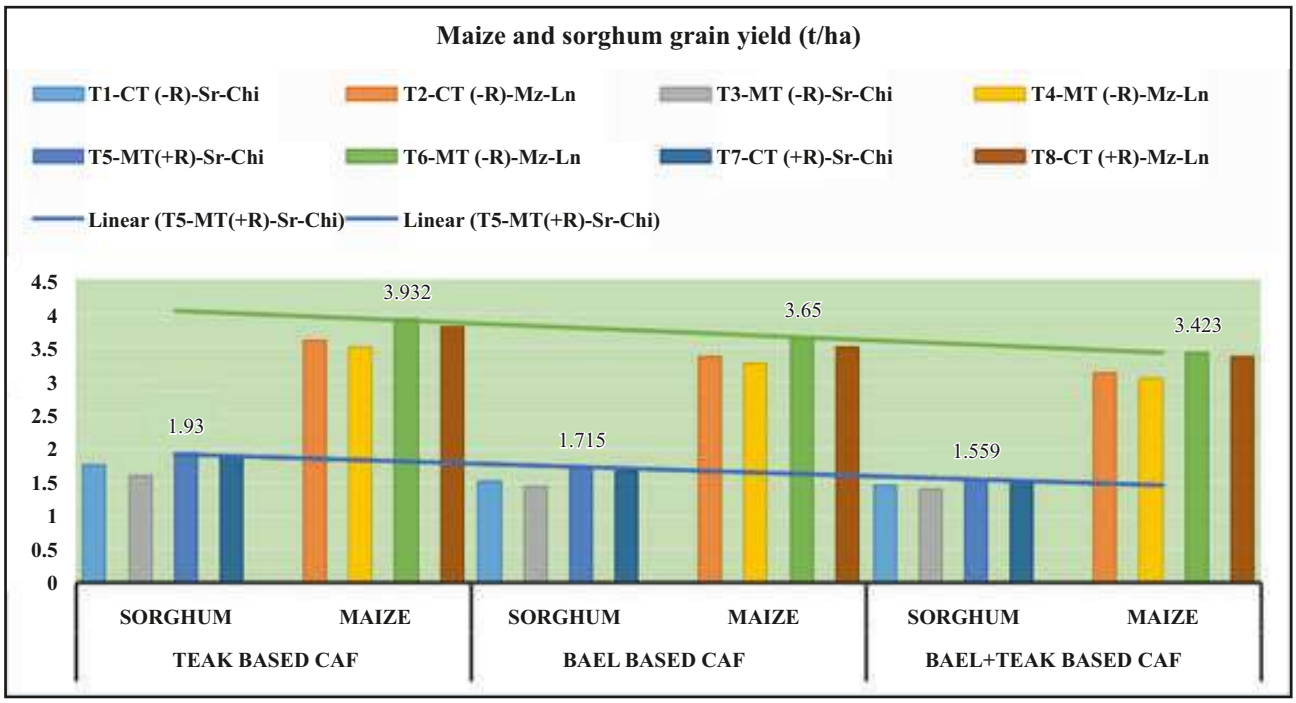



**Figure: Maize and sorghum yield as influenced by conservation agricultural practices in teak based agroforestry system**

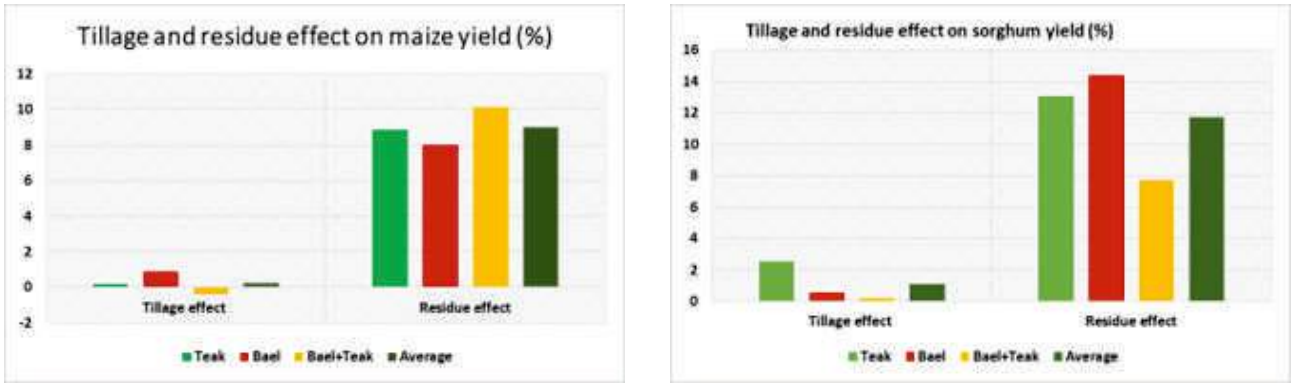



**Figure: Effect of residue application on grain yields of chickpea and maize in conservation agroforestry systems**

## 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 in the IRC meeting – 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 the plantation of *Melia dubia* was carried out in the year 2022 at a spacing of 7 x 3 m in the Experimental Farm of the Institute. The total number of the treatments are seven *viz.*, 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* with three replications under RBD.

Intercrops grown during different seasons are: *Kharif* Season: 1. Finger millet, 2. Barnyard millet and 3. Bajra; and Rabi season: 1.Mustard 2.Chickpea and 3.Barley. To study the growth performance *Melia dubia,* its plantation was also carried out at some farmers' fields. Additionally, *Melia dubia* planted on road sides, field bunds/boundaries etc. in the Institute were also studied for their growth performance.

The observations on height, collar diameter and clean bole of *M. dubia* were recorded. Height of *Melia dubia* ranged from 2.57 to 4.30 m in the Experimental Farm of the Institute. Similarly, the collar diameter ranged from 3.94 to 7.48 cm and clean bole from 2.15 to 3.72 m. Almost same growth trend of *Melia dubia* was observed on the famer's field. The plant height ranged from 2.50 to 4.16 m, collar

diameter from 3.86 to 7.46 cm and clean bole 2.10 to 3.63 m. Since, canopy is not fully developed at this stage, hence, there was no significant effect on the intercrops yield. Leaf fodder quality of *Melia dubia* is also being assessed.

***Melia dubia* at ICAR-CAFRI, Jhansi**

***Melia dubia* at farmer's field**

***Melia dubia* at Farmer's field**

**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 time to time in different parts of India for collection of plants, suitable for multifunctional agroforestry system, traditional food forest, bee forest and fruit forest.

**Traditional food forest:** Till now through different surveys several crops were identified and collected and propagated. The crop whose seedlings were successfully propagated were later on planted in the traditional food forest. The different categories of plants such as fruit crops, (banana, passion fruit, giant passion fruit, phalsa, betel vine, grape, papaya, litchi, pineapple, and pomegranate), vegetables (tree spinach, colocasia, sweet potato), spices (ginger and turmeric), medicinal plants (ajwain, bryophyllum, mint and tulsi).

**Bee forest:** The several surveys under this activity had resulted in identification of 85 crops which has nectifereous and pollineferrous value. These species were identified based on the bee activities of *Apis dorsata, Apis indica* and stingless bee. Out of these crops, 45 crops species planting material raised successfully and planted in the bee forest. These 45 species are being testing for the *Apis mellifera*.

**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, Amla + 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. In general, soil microbial and biochemical properties were dramatically higher at tree rhizosphere zone over intercropped zone.

Evaluation of the microbial population revealed that amla-based agroforestry registered significantly ($P$ <0.05) highest population of bacteria ($133\times10^5$ and $103\times10^5$ CFU g soil$^{-1}$) and fungi ($16\times10^4$ and $11\times10^4$ CFU g soil$^{-1}$) at both topsoil and subsoil of tree rhizosphere zone, respectively. At intercropped zone, amla-based agroforestry again showed highest population of bacteria ($87\times10^5$ CFU g soil$^{-1}$) at topsoil but fungi ($4\times10^4$ CFU g soil$^{-1}$) at subsoil. Ber-based agroforestry registered highest population of actinobacteria in both tree rhizosphere ($162\times10^3$ and $125\times10^3$ CFU g soil$^{-1}$) and intercropped zone ($115\times10^3$ and $73\times10^3$ CFU g soil$^{-1}$) at topsoil and subsoil, respectively. There was a high heterogeneity in concentration of tested soil enzymes. For example, highest dehydrogenase activity was noticed in melia-based agroforestry at topsoil (7.85 ug TPF g soil$^{-1}$ 24 h$^{-1}$) but teak-based agroforestry at subsoil (5.87 ug TPF g soil$^{-1}$ 24 h$^{-1}$) of tree rhizosphere zone; whereas teak-based agroforestry registered its highest activity at both topsoil (5.25 ug TPF g soil$^{-1}$ 24 h$^{-1}$) and subsoil (4.00 ug TPF g soil$^{-1}$ 24 h$^{-1}$) of intercropped zone. β-glucosidase and acid phosphatase activity was again significantly ($P$ <0.05) highest at melia-based agroforestry at both topsoil (171.18 and 117.88, and 300.44 and 437.10 ug $p$-NP g soil$^{-1}$ h$^{-1}$) and subsoil (93.62 and 58.43, and 223.87 and 194.97 ug $p$-NP g soil$^{-1}$ h$^{-1}$) of tree rhizosphere and intercropped zone, respectively. On the other side, highest urease and alkaline phosphate activity was observed at teak-based agroforestry both at topsoil (3.70 and 2.23 mg urea g soil$^{-1}$ h$^{-1}$, and 169.67 and 152.02 ug $p$-NP g soil$^{-1}$ h$^{-1}$) and subsoil (1.14 and 1.35 mg urea g soil$^{-1}$ h$^{-1}$, and 70.94 and 53.65 ug $p$-NP g soil$^{-1}$ h$^{-1}$) of tree rhizosphere and intercropped zone, respectively.

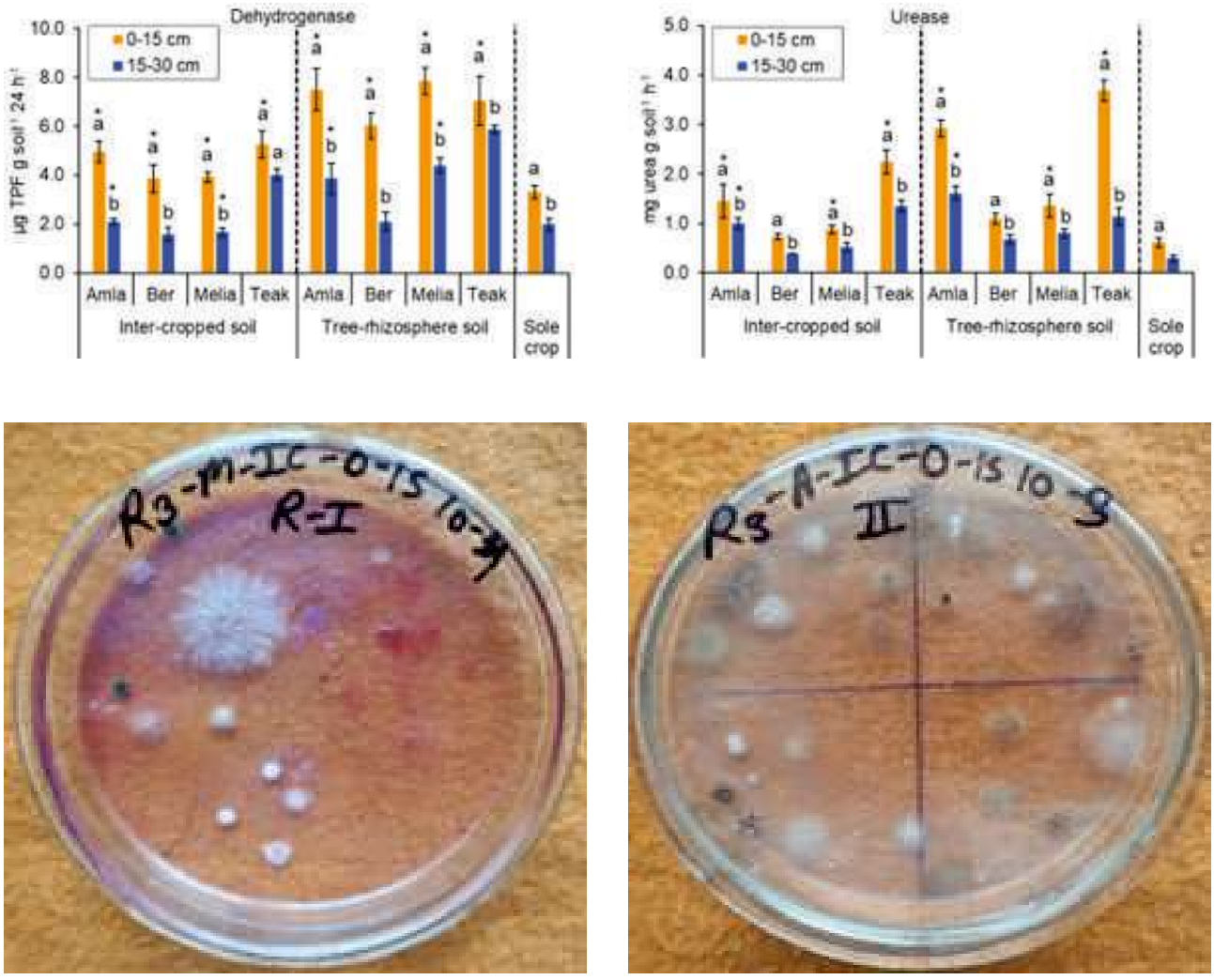



**Fig. 1. Dehydrogenase and urease enzyme activity and colony forming unit of fungi and actinobacteria of the experimental agroforestry systems. Vertical bars on columns represent standard error ($n$ = 3). Bars followed by letter in uncommon differ significantly ($P$ <0.05).**

# 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 was initiated to understand the growth performance of different clones of *Melia dubia* in semi-arid region central India. The performance of 15 clones of *Melia dubia* developed by ICFRE along with MTP2 clone developed by FCRI, Mattupalayam and one clone of WIMCO were planted in the research farm of the institute. The initial growth performance of different clones is presented in Table 1.

**Table1 : 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 | 146.75 | 19.75 |
| 2. | 2026 | 128.91 | 14.93 |
| 3. | 2087 | 225.16 | 40.52 |
| 4. | 261 | 198.75 | 31.33 |
| 5. | 260 | 187.33 | 29.15 |
| 6. | 75 | 186.00 | 30.57 |
| 7. | 2028 | 207.25 | 30.29 |
| 8. | 2056 | 176.66 | 26.12 |
| 9. | WIMCO | 170.41 | 14.35 |
| 10. | 2099 | 208.83 | 30.25 |
| 11. | 2068 | 166.91 | 24.71 |
| 12. | 2059 | 166.90 | 24.71 |
| 13. | 2061 | 231.91 | 26.47 |
| 14. | 2094 | 258.83 | 41.37 |
| 15. | 2035 | 259.35 | 43.93 |
| 16. | 2037 | 183.00 | 19.31 |
| 17. | 2021 | 181.41 | 19.10 |

The initial results showed that Melia clone FRI/MD/20235 performance is better than other clones.

### NRMA/CAFRI/SIL/2021/008/00132:

### Genetic characterization of neem germplasm for high azadirachtin yield

*(K Rajarajan and H Anuragi)*

During the year, we have compared different chromatography techniques for optimization of azadirachtin. In which, we optimized the azadirachtin extraction with ethanol and acetonitrile. The results showed that azadirachtin yield was higher in acetonitrileas compared with ethanol. Also, we have attempted the genetic correlation of oil yield with azadirachtin yield. The results showed that there is no significant correlation between these two characters.

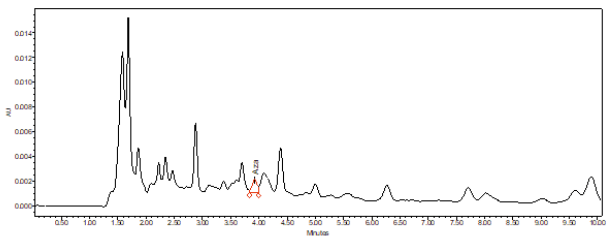


**Figure :Azadirachtin estimation from neem sample using HPLC chromatography**

### 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)*

*Moringa oleifera* Lam., has been considered as a "Superfood," or "Wonder tree," or "Tree of life" due to its exceptionally high nutritional and therapeutic properties capable of curing above 300 human diseases. Further, its fast-growing nature and drought tolerance behavior make it a very suitable and climate-smart species for agroforestry that ensures not only the nutritional and livelihood security but also encourage farmland ecosystem restoration and biodiversity conservation even under tough environmental conditions. The current study focuses on capturing the available genetic variation in Moringa from a nearby region and assessing its potential for year-round fruiting and increased tolerance to dry and hot Bundelkhand region of central India. In this context, a total of thirty moringa germplasm with morphological variations have been collected and maintained at ICAR-CAFRI, Jhansi as field gene bank. The morphological studies identified CMC-5, CMC-8, CMC-12 and CMC-24 with annual and prolonged

flowering and fruiting behavior along with higher climatic adaptability. Physio-chemical analysis revealed higher malondialdehyde, phenol content, proline content, antioxidant activity relative water content, cell membrane stability index, etc., in these germplasm. Further, the molecular diversity analysis using 46 microsatellite /simple sequence repeats (SSRs) markers were performed to understand the actual genetic variation.

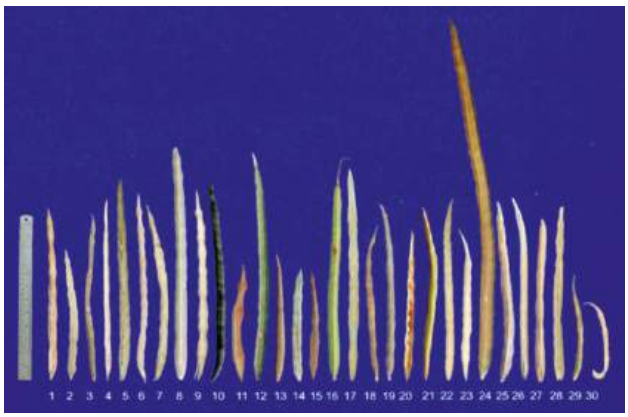


**Figure 1. Genetic variations in the pods of 30 *Moringa oleifera* germplasm conserved at ICAR-CAFRI, Jhansi**

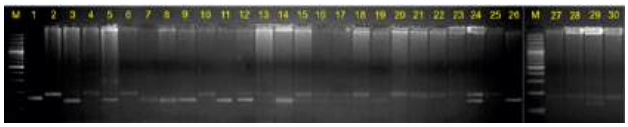


**Figure 2. PCR profile of 30 *Moringa oleifera* germplasm using SSR marker MO58**

## 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*)**

Pearl millet phyllosphere associated *Bacillus subtilis* PBs12 was screened against malabar neem vascular wilt disease inciting agent *Fusarium solani*. The *B. subtilis* PBs12 shown a significant inhibitory affect against *Fusarium solani* in both invitro assays *i.e.*, direct metabolite mediated assay (70%) and volatile mediated assay (45%). Further, the available whole genome of *B. subtilis* PBs12 was analyzed *in silico* for understanding its antimicrobial potential. The whole genome sequence analysis was performed to unveil the genetic potential of PBs12 for plant protection. The complete genome of PBs12 consists of a single circular chromosome with a size of 4.02 Mb and 4171 genes, with a G+C content of 43.68. Comparative Average Nucleotide Identity (ANI) analysis revealed close similarity of PBs12 with other beneficial strains of *B. subtilis* and found distant from *B. altitudinis, B. amyloliquefaciens, B. thuringenisis*. Functional annotation revealed a majority of pathway classes of PBs12 (30) involved in biosynthesis of secondary metabolites, polyketides and non-ribosomal peptides, followed by xenobiotics biodegradation and metabolism (21). Furthermore, 14 genomic regions of PBs12 associated with the synthesis of RiPP (Ribosomally synthesized and post-translationally modified Peptides), terpenes, cyclic dipeptides (CDPs), type III polyketide synthases (T3PKSs), sactipeptide, lanthipeptides, siderophore and NRPS (Non-Ribosomal Peptide Synthetase), NRP-metallophore etc., These regions found to comprise 25458 secondary metabolite-coding MiBiG clusters, which encode a diverse range of products including various antibiotics. The PCR based screening for the presence of Antimicrobial Peptide (cyclic lipopeptide) genes, in PBs 12 further confirmed broad-spectrum antifungal potential with the presence of *spoVG, bacA, srfAA* AMP genes which encode antimicrobial compounds such as subtilin, bacylisin and surfactin.

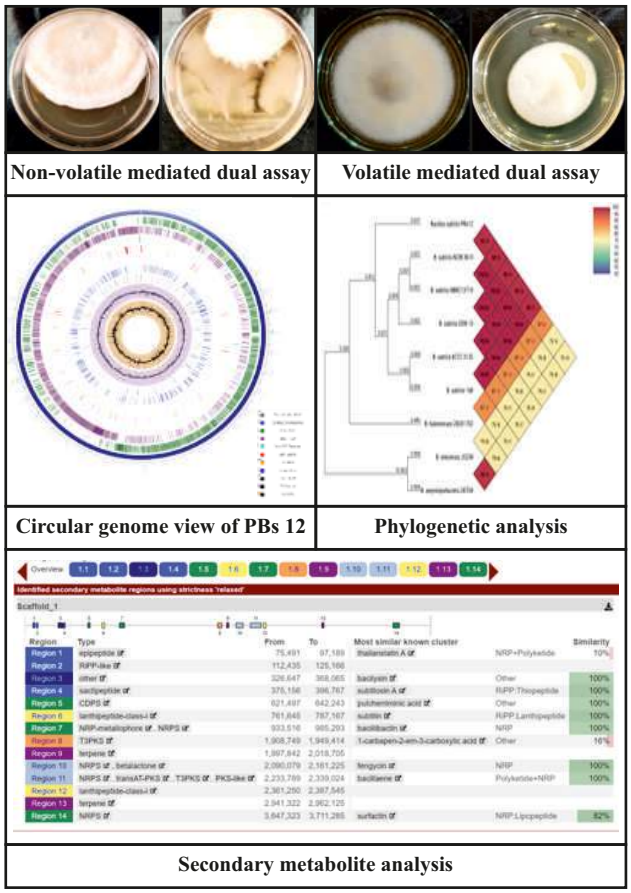



**Figure: Studies on genetic potential of *Bacillus subtilis* PBs 12**

# 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)*

Mechanical separates were estimated in surface soil samples and determined textural class (Table 1). The bulk density estimated from soil core generally increased with increase in soil depth (Figure 1).

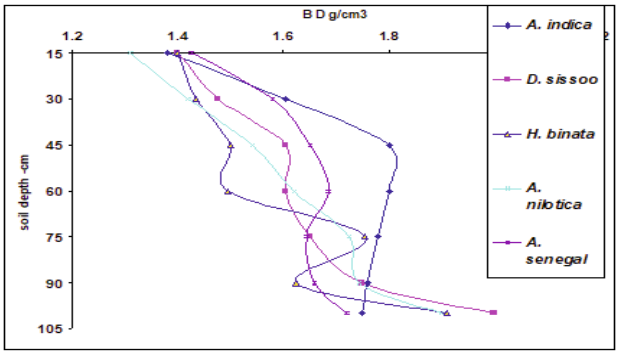
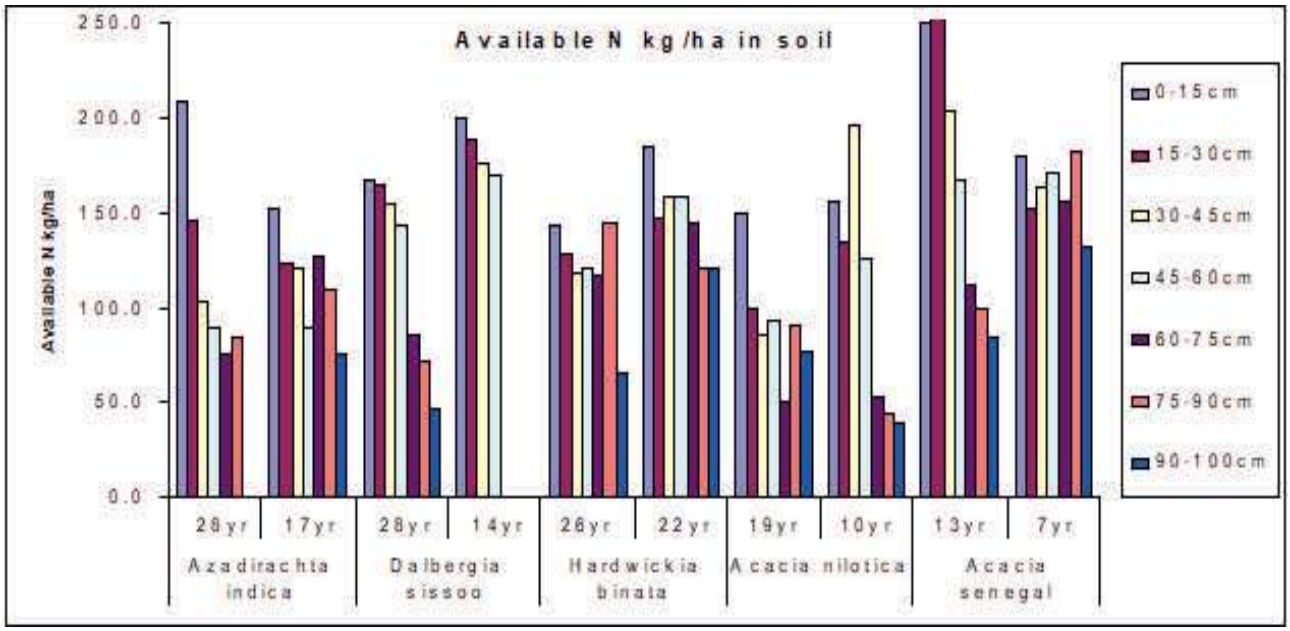



**Fig1. Bulk density of soil profile in different agroforestry system**

**Table 1. Soil texture of selected agroforestry systems**

| Plant species | Age of trees (yrs) | % sand | % silt | % clay | Soil texture class |
|---|---|---|---|---|---|
| *Azadirachta indica* | 28 | 45.1 | 26.6 | 28.3 | Sandy clay loam |
| | 17 | 41.1 | 26.6 | 32.3 | clay loam |
| *Dalbergia sissoo* | 28 | 44.1 | 32.6 | 23.3 | Loam |
| | 14 | 44.1 | 30.6 | 25.3 | Loam |
| *Hardwickia binata* | 26 | 36.1 | 33.6 | 30.3 | clay loam |
| | 22 | 43.1 | 34.6 | 22.3 | loam |
| *Acacia nilotica* | 19 | 45.1 | 30.6 | 24.3 | Loam |
| | 10 | 40.8 | 34.5 | 24.8 | Loam |
| *Acacia senegal* | 13 | 37.1 | 32.6 | 30.3 | clay loam |
| | 7 | 35.1 | 37.6 | 27.3 | Loam |

Soil samples of different depths from all the systems were processed in lab and available N, P and K was determined. In general, available N, P and K in soil decreased with increase in soil depth with few exceptions for P and K (Fig 2).



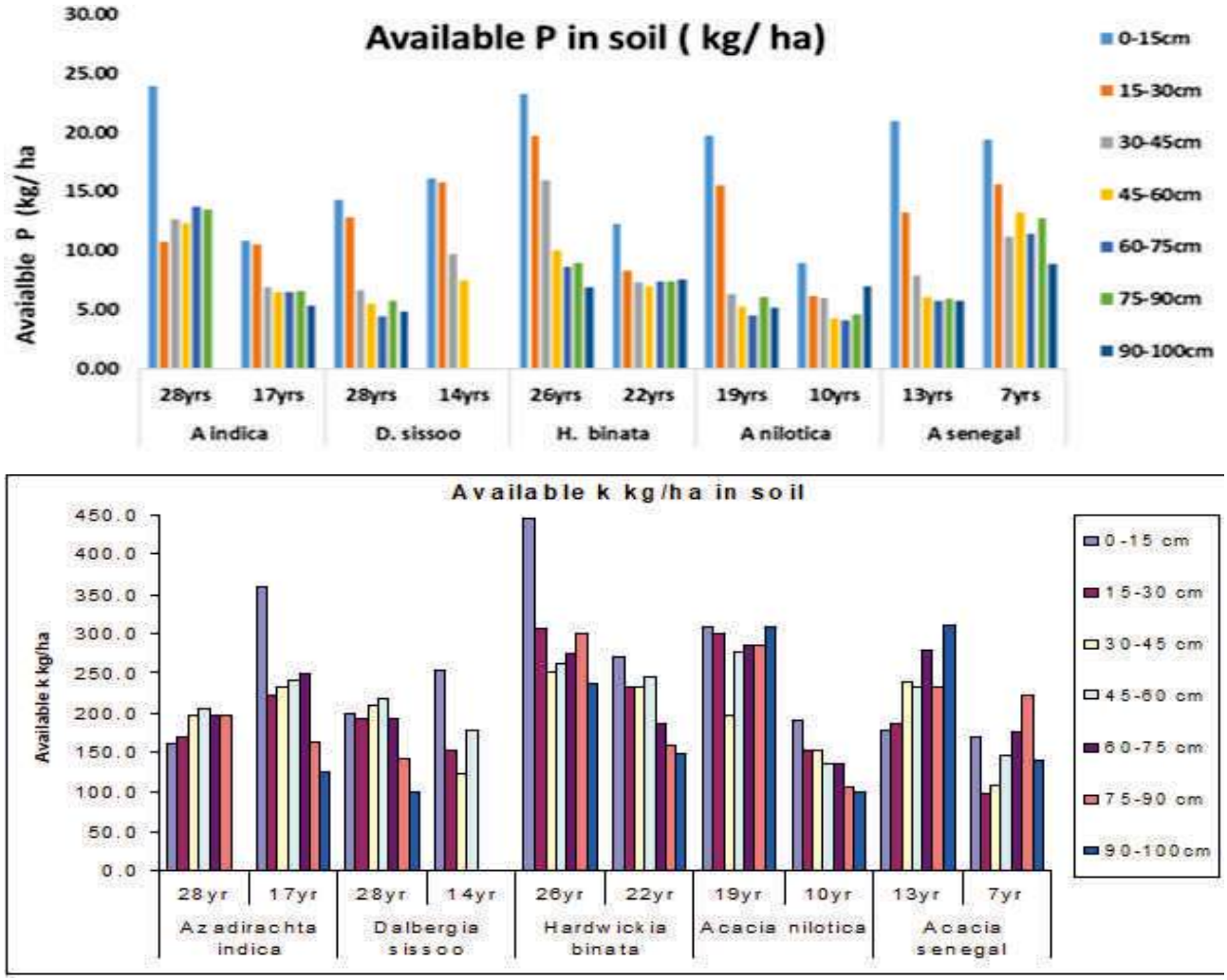



**Fig. 2 Available N, P and K in soil profile of different agroforestry systems.**

The estimates of soil biological activity (dehydrogenase) revealed that in agroforestry systems having clay loam soil, the dehydrogenase activity was higher at 15-30cm depth than 0-15cm, and thereafter, it decreased in soil profile to minimum value at 90-100cm depth (Fig 3).

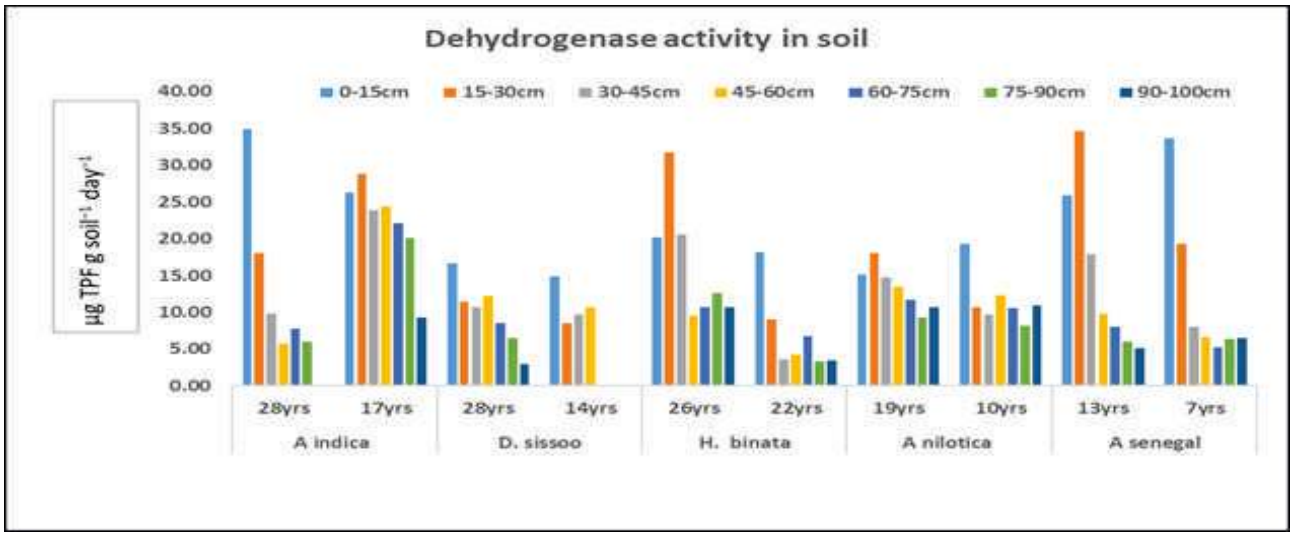



**Fig.3. Dehydrogenase activity at various depth in soil profile of agroforestry systemsFig.3. Dehydrogenase activity at various depth in soil profile of agroforestry systems**

The DTPA extracted available micronutrients- Zn, Cu, Fe & Mn were estimated with the help of atomic absorption spectrophotometer (AAS). In general, all the micronutrients declined with increase in depth of soil with some exceptions. Total nitrogen content was estimated in mature and senescence leaves of all the agroforestry trees and the data revealed that mature leaves had higher N content than senescence leaves (Fig 4). Further, age of trees appears to influence N content in leaves. On an average, in all the species the older trees had higher N content than young tree.

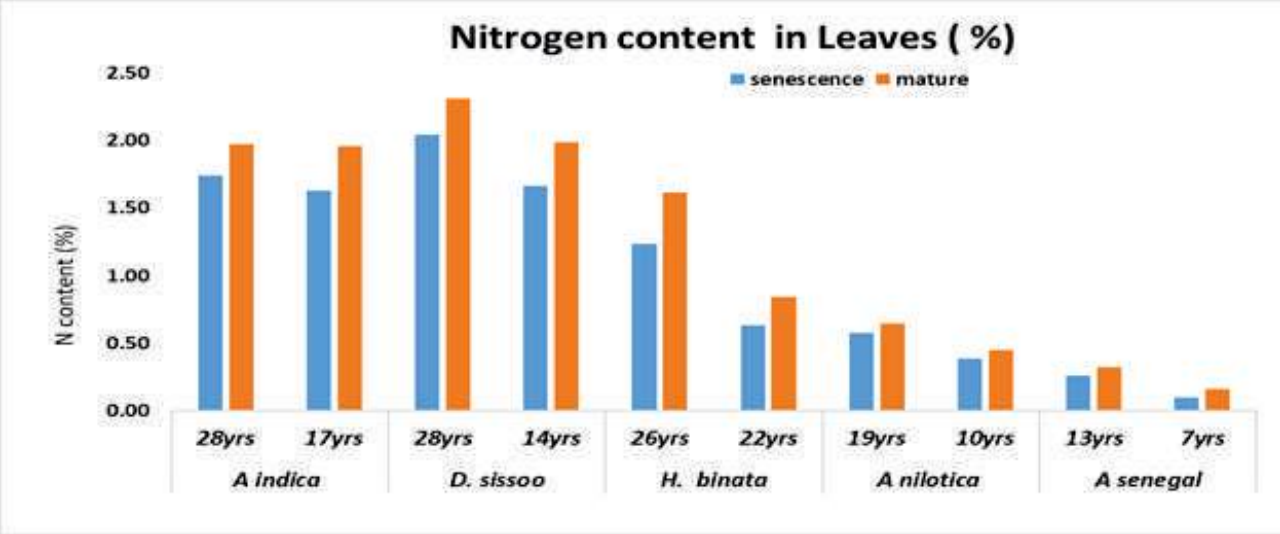



**Fig 4. Total nitrogen content in leaves of agroforestry trees**

**NRMA/CAFRI/SIL/2021/011/00135:**

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

***(Badre Alam and Rajendra Prasad)***

Differential responses of various ecophysiological traits have been studied in the clonal and seedling populations of the tree. Extremely dry harsh summer climate has imparted downregulation in photosynthetic carbon acquisition functioning of the plants. The physiological determinants of such downregulation in photosynthetic carbon assimilation which were aggravated by dry harsh summer climate are being investigated to get differential mechanistic insights. The insights on such underlying critical stress responses will have immense impact on understanding the hot summer-induced physiological constraints for the tree species. Various functional parameters related to ecophysiological dynamics of carbon gain are also being studied in the tree populations. Observational data on phenology and growth are being simultaneously monitored which will be required for relating physiological data and carbon gain in the inter-annual scale. Collection of pod and leaf samples have been continued for further analysis relating to physio-biochemical purposes relating to differential ecophysiological responses in the clonal and seedling populations. Dynamics of CCI (Chlorophyll content index), LAI (Leaf area index) and CTD (Canopy temperature depression analysis) in association with other variables have also been studied in the clonal and seedling populations. Differential responses in the LAI dynamics in the tree population have been noted (Fig.1). Data collection and analysis are progressing.

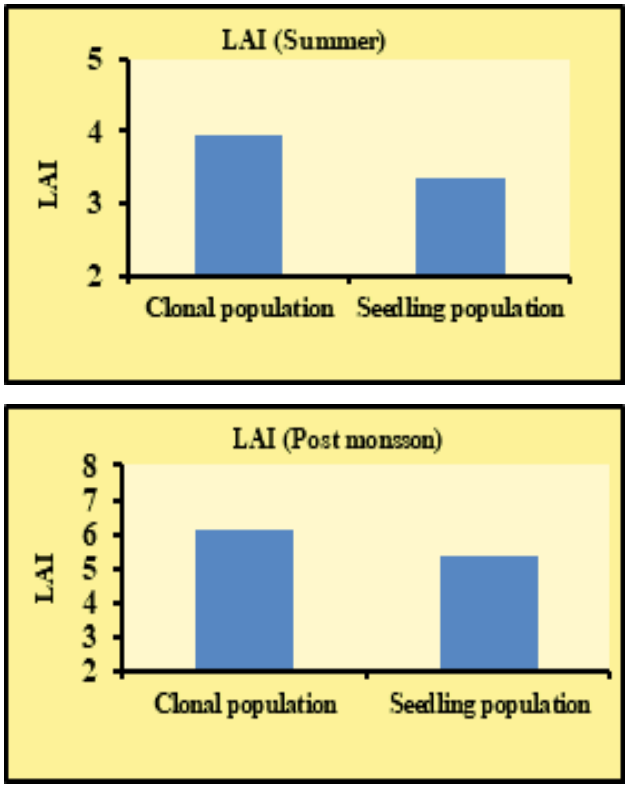



**Fig.1 Dynamics of LAI (Leaf Area Index) in the contrasting tree population of *Pongamia pinnata*.**

## NRMA/CAFRI/SIL/2021/012/00136:

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

*(Asha Ram and Inder Dev)*

In 2021, a pioneering project was initiated to evaluate ecosystem services within silvipastoral systems under semi-arid conditions. Focused on a silvipastoral system established in 2016 with teak and mahogany as primary tree species, alongside *Cenchrus ciliaris* and *Stylosanthes seabrana* as grass companions, this study aimed to elucidate the intricate dynamics of ecosystem functions and services. The planting configuration was meticulously planned, with a 1:1 row pattern for grasses at 50 cm intervals and trees strategically spaced at 5 m x 5 m. 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.

Provisioning services, particularly biomass productivity, were meticulously measured, with T7 exhibiting the highest productivity, closely followed by T6 (Figure 1). Among regulating services, soil moisture dynamics were monitored bi-weekly, revealing superior moisture retention in treatments incorporating soil conservation measures, notably in T7. In contrast, sole mahogany plots exhibited the lowest soil moisture levels due to poor water holding capacity.

In 2023, 07 rainfall events were meticulously recorded, with runoff analysis revealing significant differences among treatments. Notably, sole mahogany plots generated the highest runoff, while T7 recorded the lowest, underscoring the efficacy of contour staggered trenches in runoff mitigation. 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. Although soil stabilization measures reduced runoff-induced soil loss, contour staggered trenches exhibited unparalleled sediment trapping efficiency compared to HMB and vegetative hedge configurations. Soil biological properties were also recorded higher in the treatment having tree+grass combination with soil and moisture conservation measures (Figure 2).

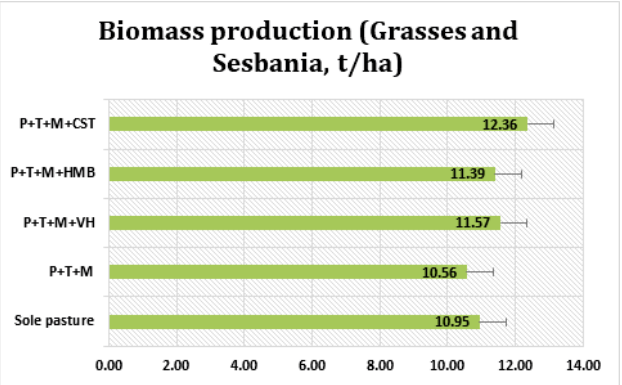



**Figure 1: Biomass production of grasses and sesbania**

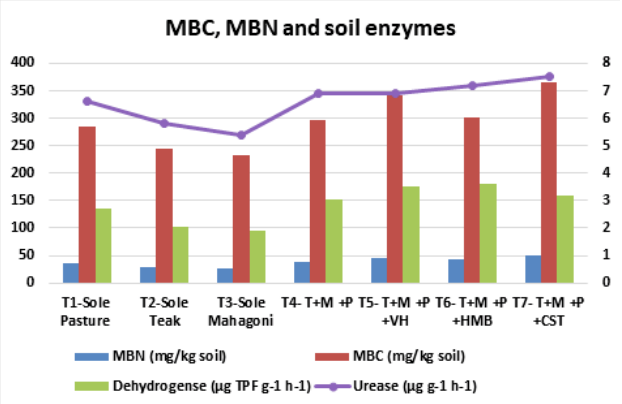



**Figure 2: Soil biological properties in silvopastoral system**

**Fig.: Different vegetation in CST due to high moisture availability**

## 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 brining 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?

**Data collection:**

Species occurrence data on *Melia dubia* was compiled from various sources across India, including field surveys, online databases, and published literature.

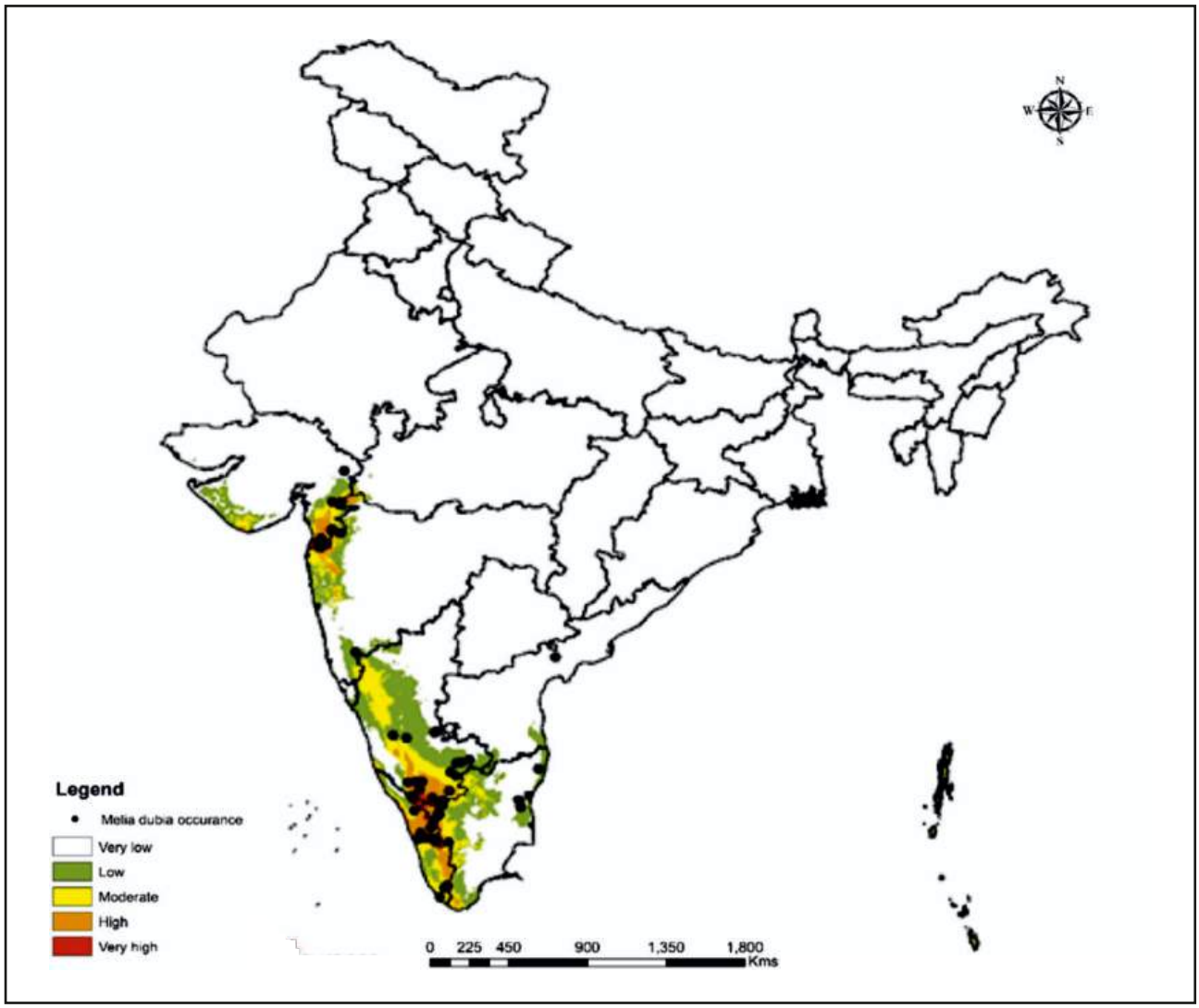
Climate data encompassing annual temperature and precipitation trends was collected. This data included factors like seasonality, temperature extremes, and precipitation extremes.

**Modeling:**

MaxEnt software was used to analyze the data and create a model predicting the climatic niche of *Melia dubia* in India.

**Results:**

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. Further research could involve field trials in these identified areas to confirm suitability and optimize cultivation practices for *Melia dubia* in India.



# 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 village Rajapur, block-Babina, in Jhansi district. From preliminary focused group discussion, it is revealed that the major constraint in adoption of agroforestry is stray animals (14.36%). The data collection 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)*

A thorough survey of the project villages in the watershed area was conducted to collect data. Data on different aspects, namely demographic details, types of interventions, land and soil characteristics, source of irrigation and drinking water, land holding size, availability of water in ponds or dug wells, migration patterns, cropping systems, input use, crop productivity, market access, and livestock information, were recorded using participatory rural appraisal (PRA) techniques, key informants (KI), formal and informal surveys, and case studies. The recorded data indicated that interventions (engineering measures and agroforestry) have enhanced the availability of water in the watershed area, which has further influenced agriculture and allied enterprises. The watershed area witnessed changes in cropping patterns that have increased gross cropped area (75%), cropping intensity (175) and crop rotation intensity (300%) as well. Moreover, the interventions have also improved the productivity of all types of crops in the range of 20-50%, increased the availability of fodder, and reduced migration patterns. The land use types with the highest density were grazing land (around 10 trees per acre), followed by boundary (around 7 trees per acre) and cropland (around 4 trees per acre). A converse trend was observed for species diversity, being highest for trees planted in boundaries (H' = 2.24), compared to other land use types. Shannon diversity index for the cropland was minimum, with an average H' of 0.93 per farm. Agroforestry proves to be a drought-proofing mechanism during drought periods and an additional source of income during normal periods. Based on the obtained results, it is concluded that interventions have positively impacted the livelihood of farmers in the watershed area.

**NRMA/CAFRI/SIL/2021/016/00140**

### Economic impact of ICAF-CAFRI interventions in Parasai-Sindh Watershed

*(Priyanka Singh and R P Dwivedi)*

**Adoption pattern of different natural resource management (NRM) practices**

The probability distribution of the individual or joint adoption probabilities of NRM practices is depicted in Fig 1. The first twelve combinations which involve adopting agroforestry account for 56% of all the households, of which around 2% adopted all the NRM practices while 12% adopted agroforestry only.

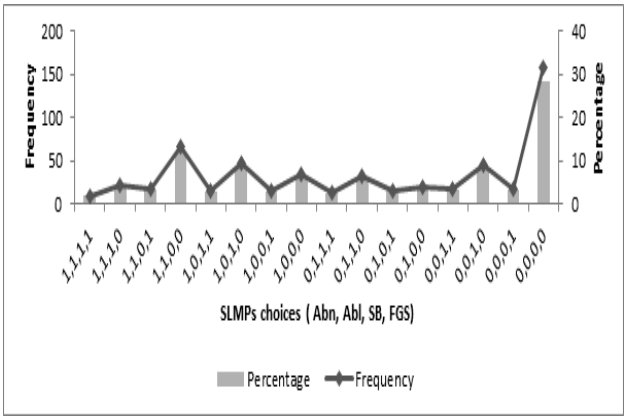



**Figure 1: Probability distribution for joint/individual adoption of NRM practices among farmers in the study area**

*Note: Abn: Agroforestry bund plantation, Abl: Agroforestry block plantation, SB: Soil bunding, FGS: Forage grass stripping*

Joint adoption of practises (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.

**Multivariate probit model estimates**

Table 1 presents the results of the marginal effect of NRM practices adoption. The marginal effect shows that agroforestry bund plantation, soil bunding, and forage grass stripping are more likely to be adopted by older farmers. More educated farmers are around 9% more likely to adopt agroforestry and 7 percent more likely to use soil bunding, indicating that these NRM practices are knowledge intensive. Additionally, households with more family members are more likely to adopt agroforestry bund plantation and soil bunding. This can be attributed to the labour-intensive nature of practices related to conserving and managing natural resources, which are more feasible for households with sufficient labour resources. However, it is noteworthy that the probability of planting trees in the main field (block) decreases with family size. In larger households, there is often competition between food production and off-farm activities, leading farmers to be hesitant to sacrifice crop field areas for agroforestry.

**Table 1: Marginal effect of adoption of NRM practices**

| Variables | Agroforestry bund plantation (dY/dX) | Agroforestry block plantation (dY/dX) | Soil bund (dY/dX) | Fodder grass stripping (dY/dX) |
|---|---|---|---|---|
| Age | 0.027*(0.006) | 0.067(2.09) ** | 0.046(1.78) *** | 0.041(2.11)** |
| Farming experience | 0.02(0.09) | 0.028(0.19) | 0.027(2.20)** | 0.023(1.89)* |
| Education | 0.091(0.041)** | 0.087(2.54)** | 0.072 (0.022)** | 0.083(0.92) |
| HH_Size | 0.061(2.39)** | ? 0.043(1.71) * | 0.037*(0.011) | 0.068(1.1) |
| Land degradation awareness | 0.073(1.8)*** | 0.076(1.89)*** | 0.105(2.81) * | 0.054(3.79)* |
| NRM and agroforestry practices awareness | 0.089(2.29)* | 0.112(2.24) ** | 0.078(2.33) ** | 0.08(0.31) |
| Dependency Ratio | -0.038(0.048) | -0.078(0.03)** | -0.033(0.01)** | -0.021(0.058) |
| Plot | 0.017(1.03) | 0.041(0.013)** | 0.015(0.12) | 0.018 (0.33) |
| Farm_Size | 0.033(2.31)** | 0.041(2.43)** | 0.027(2.29)** | 0.063(0.049) |
| ALU | -0.002(0.008) | 0.008(0.95) | 0.007(1.51) | 0.034** (2.71) |
| Off-farm | 0.056(1.23) | 0.048(0.81) | 0.053(0.43) | 0.047(1.53) |
| Soil_Type | 0.051(1.08) | 0.043(1.18) | 0.071(0.07) | 0.081(0.89) |
| Slope | 0.045(1.95)*** | 0.052(1.81) *** | 0.122(0.048)* | 0.057(3.6) * |
| Tenure security | 0.043(2.59) * | 0.103(0.047)** | 0.041(2.11) ** | 0.037(1.93)*** |
| Training | 0.033(2.23) ** | 0.037(2.10) ** | 0.046 (2.40) ** | 0.031(2.37) ** |
| Extension service | 0.041(1.61)*** | 0.053(1.67)*** | 0.043 (1.78)*** | 0.043(1.66) *** |
| Credit | 0.039(0.09) | 0.044(1.48) | 0.038 (0.21) | 0.057(0.47) |
| Distance to market | 0.042(0.26) | 0.048(0.06) | 0.039 (0.88) | 0.057(1.27) |
| Log likelihood | 2243 | | | |
| Wald X2 (72) | 567.81; Prob> X2 = 0.0000 | | | |

*,**,and *** indicate statistical significance at 99%, 95% and 90% confidence level, respectively.

Farmers who are aware of land degradation problems are 7% more likely to adopt tree based farming practises, 10% more like to adopt soil bunding and 5% more like to use forage stripping. Likewise, NRM practices awareness also accentuate the likelihood of adoption of boundary plantation of tree, block plantation of trees and soil bunding by around 9, 11 and 8%, respectively. According to the estimates, perception and awareness of technology-specific characteristics of NRM practices increase the likelihood of adoption. Hence, formal education, more awareness about land degradation and its management issues, and the ability of NRM practices to reduce the impact of land degradation related risks have significantly increased the likelihood of adoption of NRM practices. As expected, the dependency ratio, which indicates economically inactive household members, has a negative association with the adoption of NRM practices. This implies that households with a higher dependency ratio are less likely to adopt such practices.

Farmers with a large number of plots are 4.1% more likely than farmers with a small number of plots to take up tree cultivation in field blocks. Farm size has a significant positive effect on the probability of adopting all types of NRM practices, except for forage stripping, where the effect of farm size is insignificant. Additionally, households with larger livestock herds are more inclined to adopt grass strips. This can be attributed to the need for grass as feed for the animals, particularly during extended dry seasons. Farm's slope is significantly and positively associated with the probability of adopting all NRM practices. The likelihood of adoption of all the land management practices ranges from around 4 to 10% with strong tenure security. Land ownership ensures future use of the land, providing farmers with additional incentives to adopt measures for sustainable land uses. Among institutional factors considered in this study, training and extension services, have a clear positive effect on the probability adoption of all the NRM practices. Training and demonstrations enhance farmers' confidence in new technologies and mitigate the negative impact of limited formal education on adoption decisions.

**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 involving two tillage practices (conventional and zero tillage) in main plots and five nitrogen management practices (100% RDN, GM, GM + 40% RDN, GM + 60% RDN, GM + 80% RDN) in subplots is established at the Institute experimental farm in a split-plot design with three replicates. Visuals of the experiment are shown in (Figure 1 and 2).

**Figure: View of the experiment field**

### Mera Gaon–Mera Gaurav (MGMG) 2023

ICAR-CAFRI is implementing MGMG scheme with the main objective to improve the socio-economic conditions of the farmers and other stake holders at village level. The team comprises of all the Scientists & Technical staff of the Institute under the Guidance and Supervision of the Director, ICAR-CAFRI, Jhansi.

During the year 2023 there were 55 visits were organized by MGMG team members to 16 adopted MGMG villages and 1845 farmers, farm women and rural youths were benefitted by the MGMG of ICAR-CAFRI, Jhansi. The activities like, distribution of seedlings of different tree species (Sandal wood, custard apple, Guava, Aonla, Lemon, Jackfruit, Karonda, Teak, Neem, etc), Kisan gosthi, Awarness programme, Farmers-Scientist interface meetings, Exposure visit to Institute's experimental research farm, ATIC, Exhibition Hall, Vermi-compost unit, Livestock unit, KVKs, NGOs, FPOs and line departments were organized.

**Table 1: Institute Summary**

| Year | Total No. of Groups/team formed | No. of Scientists Involved | No. of villages covered |
|---|---|---|---|
| 2023 | 5 | 14 Scientists | 17 |
| | | 10 Technical Staff | |

**Table 2: Activities organised under MGMG during 2023**

| S.No. | Name of activity | No. of activities conducted/provided | No. of farmers participated & benefitted |
|---|---|---|---|
| 1. | Visit to village by all teams | 45 | 688 |
| 2. | Interface meeting/ Goshthies | 28 | 388 |
| 3. | Training organized | 06 | 122 |
| 4. | Demonstrations conducted | 15 | 218 |
| 5. | Mobile based advisories | 06 | 71 |
| 6. | Literature support provided | 05 | 36 |
| 7. | Awareness programmes | 24 | 685 |
| | Total | 129 | 2208 |

# 2. Research Achievements

## 2.5: Externally Funded Projects

*ICAR Network Project*

**NRMA/CAFRI/SOP/2008/001/00077:**

**Harvesting, Processing and Value Addition of Natural Resins and Gums**

*(Rajendra Prasad, A K Handa and Badre Alam)*

During the 14th annual workshop the coordinating unit of ICAR-NISA, Ranchi has recommended to conclude all the five ongoing sub-projects. Hence, five sub-projects *viz*., i) productivity of gum yielding tree-based agroforestry models; ii) demonstration and development of gum yielding tree-based agroforestry models on farmer's fields; iii) indigenous technical knowledge (ITK) on gum and resin's tapping, applications and post-harvest value addition; iv) standardization of gum tapping techniques; and v) studies on root distribution pattern and aboveground and belowground biomass in *Acacia senegal* were concluded. Also, the existing post of one research associate and one senior research fellow were abolished and one post of young professional-II was sanctioned for future. The mandate for ICAR-CAFRI center of HPVANRG was revised and two sub projects were approved. In new sub-projects some of the objectives of old sub-projects were retained to maintain continuity of ongoing research relating to agroforestry models and indigenous technical knowledge on natural gums and resins. The approved sub projects along with objectives are given below.

**Sub-project 1**: Documentation of Indigenous technical knowledge (ITKs) on harvesting, processing and value addition of NRGs in India.

**Duration:** April 2023- March 2026

**Objective:** To collect information on ITK on gum and resin's tapping, applications and post-harvest value addition in respect of all major gums/resins.

**Sub-project 2:** Feasibility for inclusion of NRG plants into economically viable agroforestry models.

**Duration:** April 2023- March 2026

**Objectives:**

- To evaluate promising gum yielding trees for economic viability in agroforestry.
- To evaluate gum-tapping tools/techniques for feasibility of adoption in agroforestry.
- Demonstration and development of gum yielding tree based agroforestry models on farmers' fields.

The progress made during the year is discussed below.

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

Two districts of Rajasthan *viz.* Jhalawar and Baran were surveyed for collecting information. For survey a questionnaire has been developed to collect information from the respondent in respect to family details, occupation, indigenous tapping techniques and tool applied, and the use of gum and resins in the daily life. Survey of tribal dominant villages was conducted with the help and cooperation of divisional forest officers of the district concerned (Plate 1). The details of villages surveyed in Jhalawar and Baran districts and the occupation of tribal communities are given in Table1 and Table 2.

**Plate 1. Indigenous technical knowledge (ITKs) survey in Jhalawar and Baran districts of Rajasthan**

**Table 1. Details of tribal villages surveyed in Jhalawar and Baran districts of Rajasthan**

| Districts | Forest range | Beed | Village | Total families | No. of respondents | GPS coordinate Latitude | Longitude |
|---|---|---|---|---|---|---|---|
| Jhalawar | Khanpur | Heenchar | Heenchar | 160 | 6 | 24º43'43.9" | 76º07'52.1" |
| | Khanpur | Bagher | Bagher | 500 | 10 | 24º36'28.0" | 76º16'37.8" |
| Baran | Shahabad | Chaura Khari | Chaura Khari | 250 | 17 | 25º22'42.3" | 77º16'26.4" |
| | Shahabad | Beel khera | Harinagar | 250 | 25 | 25º23'44.1" | 77º13'17.5" |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Shahabad | Beel khera | Kuda kotra | 100 | 23 | 25°25'27.9" | 77°17'24.7" |
| | Shahabad | Beel khera | Beel khera daang | 150 | 14 | 25°23'1.6" | 77°18'41.4" |
| | Shahabad | Matia khara | Matia khara | 70 | 17 | 25°19'59.6" | 77°16'31.8" |
| | Shahabad | | Pathari colony | 150 | 11 | 25°20'23.9" | 77°18'43.8" |
| | Shahabad | | Sandhri colony | 145 | 20 | 25°19'15.3" | 77°19'37.5" |
| | Shahabad | | Madhi sabhar singha | 40 | 19 | 25°17'56.2" | 77°19'52.9" |

The main occupation of tribal in Baran district was collection of NTFP coupled with farming, while in Jhalawar district farming remained primary source of sustenance. In both the districts, the tribal are small and marginal farmers and cultivate crops like wheat, chickpea, mustard in winter season. In summer season, the crops like till, black gram, soybean and millet are grown. Some farmers in Jhalawar grow coriander and garlic as cash crop. Livestock production, migration for wages and collection of NTFPs remain secondary source of livelihood in both the districts.

**Table 2. Occupation of tribal communities of villages in Jhalawar and Baran districts of Rajasthan**

| Districts | Main occupation | Secondary occupation |
|---|---|---|
| Jhalawar | Small and marginal farmers; cultivates agricultural crops (wheat, chickpea, Mustard, Coriander, Garlic, soybean, till, black gram etc.) | Livestock cultivation, collects gum dhawra and khair; and seasonal migration to Shivpuri, Surat and Gujarat for agricultural wages |
| Baran | Collection of NTFPs and Small and marginal farmers; cultivates agricultural crops (maize, Millet, till, wheat, chickpea, Mustard, etc.) | Livestock cultivation, collects gum dhawra, khair and babul; and migrates to U.P., Gujarat, and M.P. as agricultural labourers. |

The forest produce collected by tribal are sold in the local market without any post-harvest processing except cleaning. The prices are decided by the traders on which tribal have no control and are compelled to sell the produce. The grading of the NTFP is done at the end of local traders who sell their stock to the secondary market at high price. The main natural gums collected in the area are dhawra, khair, babool, palas, and their selling prices varies in both the districts and also from season to season (Table 3 and 4).

**Table 3. List of gums, resins and other non-timber forest produces (NTFPs) collected by tribal**

| Districts | Trees tapped for gum | Other NTFPs |
|---|---|---|
| Jhalawar | *Anogeissus latifolia* (dhawra gum), *Acacia catechu* (khair gum), *Acacia nilotica* (babool gum), *Butea monosperma* (palas gum) | *Asparagus racemosus* (Satawar), *Justicia adhatoda* (Adusa), Konkadbela, Nav, *Aristolochia indica* (Gorisal), Bevasa leaf, *A. marmelos* (bael fruit's pulp), |
| Baran | *Anogeissus latifolia* (dhawra gum), *Acacia catechu* (khair gum), *Acacia nilotica* (babool gum) | Umar, Gunisar root, Lengad leaf, sajai leaf, Karipana root, Sakooli, Harjuri, *Asparagus racemosus* (Satawar), *Emblica officinalis* (aonla), *Aegle marmelos* (bael), *Diospyros melanoxylon* (tendu: leaves and fruit), *Phyllanthus niruri* (bhumi aonla) |

**Table 4. Selling price of different natural gums and other NTFPs in local market**

| Forest produce | Price (Rs. $kg^{-1}$) | |
|---|---|---|
| | Jhalawar | Baran |
| Dhawra gum | 120 to 200 | 200 to 300 |
| Khair gum | 100 to 150 | 130 to 150 |
| Babool gum | 100 to 150 | 120 to 150 |
| Palas gum | 80 to 100 | 80 to 150 |

| | | |
|---|---|---|
| Bael fruit's pulp | 20 to 25 | - |
| Bael fruit shell | 4 to 5 | - |
| Aonla pulp | 120 | 100 |
| Aonla seed | 5 | 5 to 10 |
| Satawar roots | 80 to 150 | 100 to 150 |
| Tendu patta | 250 per 100 bundles of 50 leaves | 250 per 100 bundles of 50 leaves |

**Concept for development of CAFRI-Thorny Tree Gum Amasser**

In Central region of India, the tribals tap and collect gum exudes from different trees existing in and around forest. Broadly, tapping and collection methods of gum-exudes can be classified in two categories viz. collection of exuded gum-tears or gum-balls after making cuts/ incisions on the tree-stem and collection of gum-tears exuded naturally without any man-made cuts or incisions on tree-stem. The first method is used for trees like *Sterculia urens,* Roxb. (gum karaya), *Anogeissus latifolia* Roxb. (gum dhawara), *Butea monosperma* (Lam.) (gum-butea or Kamarkas) etc while, for thorny trees like *Acacia nilotica* (L.) (gum acacia), *Acacia senegal* L. (Willd.) (gum arabic) *Acacia catechu* etc., the second method is used. Collection of naturally exuded gum-balls or gum-tears from the thorny trees which grow up to the height of 7-12m is very difficult, tedious and risky. Traditionally, gum collectors (only tribal men) climb on the trees and manually pluck gum-tears attached at high end stem and branches with their fingers. In the process the men's hand, legs, foot and whole body remains vulnerable for being pierced with the thorn of the tree. Because of these difficulties, tribe women do not dare to collect these gum ball or gum-tears on high end trees. During survey for indigenous technical knowledge on tapping and application of natural gums in some of the district of M.P. and Rajasthan, the gum-collectors narrated their difficulties in collecting gum-tears from the thorny trees. Some tribal men were using stick to detach gum-ball from the thorny tree and its branches; and collecting it from the ground once fallen down. The above narration compelled the investigators to think creatively and conceptualize development of a tool *viz.* CAFRI: Thorny tree-gum amasser, for picking and collecting naturally exuded gum-balls from high end trees particularly the thorny trees on which climbing is difficult.

The concept of CAFRI: Thorny tree-gum amasser is centered on removing the vagaries in collecting gum-tears from high end trees particularly the thorny trees. Secondly the women can also easily collect gum tears attached at height of 3-4m in such trees. The CAFRI: Thorny tree gum amasser consists of three components *viz.* I) Gum Amasser, ii) Push handle cum extension rod support and iii) Extension rod (Accessory). Based on the concept, a computer aided design (CAD) developed and two samples (prototype) of CAFRI-Thorny Tree-Gum Amasser have been developed. During forthcoming season, this tool will be used on farm and its feasibility will be tested. Use of this tool is likely to increase the efficiency of gum collectors and reduce the drudgeries particularly of tribal women. Besides, use of this tool will increase total quantity of collected gums from the trees as significant part of gum-exudes from thorny trees remain ingathered.

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

**I) Promising gum yielding trees for economic viability in agroforestry**

In past ICAR-CAFRI has developed different types of agroforestry models viz., multi-component based agri-horti-silvicultre, rainfed agri-silviculture, silvi-herbal, biofence and block planting on rocky site as gum garden based on *Acacia senegal* (gum Arabic) and *Acacia nilotica* (Babool). All these models are maintained on the farm and tree growth, gum yield and intercrop production data are monitored for economic viability.

In *A. senegal* based multi-component agri-horti-silviculture model (Plate 2), maximum GBH and height was observed in *A. marmelos* followed by *A. senegal* and *C. limon* while the minimum in *C. carandas* (Table 5). In summer season the field was green manured with dhaincha (*Sesbania aculeata*) by which green biomass of 6.24 t $ha^{-1}$ was added.

In winter season barley was grown as intercrop and data were recorded for different parameters for assessing tree-crop interaction. Presence of trees as well as distance from tree trunk has shown variable effects on growth and yield characters of barley grown as intercrop (Table 6).

The grain yield was significantly higher in association of *A. senegal* than the other two woody fruit plants. Similarly, the distance from the tree trunk has significantly affected the grain yield with maximum at 4.5m and minimum at 1.0m distance. In comparison to control, maximum reduction in grain yield was observed near the tree at distance of 1.0m and in association of *C. limon*. For most of the plant attributes, interactions between woody species and distance from tree trunk were non-significant except for straw and grain yield; and maximum straw and grain yield was recorded in association of *A. senegal* at distance of 4.5m while the least was in association of *C. limon* at distance of

**Table 5. Growth of woody perennials in *A. senegal* based multi-component model (14 years old)**

| Woody plants | GBH (cm) | Height (m) | Canopy spread ($m^2$) | Pruned biomass (kg $tree^{-1}$) |
|---|---|---|---|---|
| *A. senegal* based multi-component model (agri-horti-silviculture) | | | | |
| *A. senegal* | 47.4 ± 4.47 | 5.9 ± 0.29 | 24.3 ± 4.38 | 3.9 ± 0.38 |
| *C. limon* | 25.8 ± 2.11 | 4.4 ± 0.21 | 18.3 ± 2.80 | 5.7 ± 0.55 |
| *A. marmelos* | 58.9 ± 2.30 | 6.1 ± 0.15 | 38.2 ± 3.21 | 4.4 ± 0.45 |
| *C. carandas* | 4.5 ± 0.34 (CD) | 2.1 ± 0.11 | 2.6 ± 0.32 | -- |

1.0 m. In comparison to control, irrespective of distance from tree trunk, decline in grain yield was 13.6, 29.5 and 22.5% in association of *A. senegal, C. limon* and *A. marmelos,* respectively. Similarly, irrespective of woody species, grain yield reduced to the tune of 41.2, 17.6 and 16.8% at distance of 1.0 m, 2.5 m and 4.5 m, respectively over control. Similar trend was noticed in the straw yield. During the year, 200 kg lemon, 250 kg karonda 1500 kg of bael fruits were produced from the fruit yielding components of the model.

**Plate 2. *A. senegal* based multi-component agri-horti-silviculture model**

**Table 6. Effect of woody perennial on yield of intercrop (Barley) in *A. senegal* based multi-component model**

| Plant Character / woody species | Distance from tree trunk | | | Mean | Control |
|---|---|---|---|---|---|
| | 1m | 2.5m | 4.5m | | |
| **Plant population (Plants $m^{-2}$)** | | | | | |
| *A. Senegal* | 29.00 | 32.30 | 34.30 | 31.89 | |
| *C. limon* | 24.67 | 29.00 | 34.00 | 29.20 | 41.50 |
| *A. marmelos* | 26.30 | 32.30 | 36.00 | 31.60 | |
| Mean | 26.70 | 31.20 | 34.80 | | |
| CD for trees: 2.057; CD for distance: 2.057; CD for Trees x distance: NS | | | | | |
| **Tillers $plant^{-1}$** | | | | | |
| *A. senegal* | 5.60 | 8.20 | 8.06 | 7.28 | |
| C. limon | 5.13 | 8.30 | 8.43 | 7.29 | 9.00 |
| *A. marmelos* | 4.67 | 8.03 | 8.47 | 7.06 | |
| Mean | 5.13 | 8.20 | 8.32 | | |
| CD for trees: NS; CD for distance: 0.413; CD for Trees x distance: NS | | | | | |
| **Plant height (cm)** | | | | | |
| *A. senegal* | 68.00 | 71.50 | 74.17 | 71.22 | |
| *C. limon* | 71.67 | 77.67 | 78.17 | 75.83 | 81.50 |
| *A. marmelos* | 72.17 | 76.33 | 80.50 | 76.33 | |
| Mean | 70.61 | 75.20 | 77.61 | | |
| CD for trees: 2.023; CD for distance: 2.023; CD for Trees x distance: NS | | | | | |
| **Barley Ear length (cm)** | | | | | |
| *A. senegal* | 8.37 | 8.70 | 8.53 | 8.53 | |
| *C. limon* | 8.90 | 8.27 | 8.37 | 8.51 | 9.25 |
| *A. marmelos* | 9.10 | 8.67 | 8.53 | 8.77 | |
| Mean | 8.79 | 8.50 | 8.48 | | |
| CD for trees: NS; CD for distance: NS; CD for Trees x distance: NS | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| **Barley Straw yield (g m$^{-2}$)** | | | | | |
| *A. senegal* | 175.67 | 241.30 | 260.33 | 225.78 | |
| *C. limon* | 133.00 | 213.50 | 230.50 | 192.33 | 270.75 |
| *A. marmelos* | 149.67 | 228.50 | 271.00 | 216.38 | |
| Mean | 152.78 | 227.80 | 253.94 | | |
| CD for trees: 6.80; CD for distance: 6.80; CD for Trees x distance: 11.78 | | | | | |
| **Barley Grain yield (g m$^{-2}$)** | | | | | |
| *A. senegal* | 108.00 | 150.3 | 168 | 142.11 (13.6)* | |
| *C. limon* | 88.67 | 98.17 | 161.16 | 116.00 (29.5) | 164.50 |
| *A. marmelos* | 93.67 | 158.2 | 130.67 | 127.50 (22.5) | |
| Mean | 96.78 (41.0)* | 135.6 (17.6) | 153.28 (6.8) | | |
| CD for trees: 8.13; CD for distance: 8.13; CD for Trees x distance: 14.08 | | | | | |

*Figures in parentheses are percentage reduction in comparison to control.

In rainfed agri-silviculture model, both the tree species *viz. A. nilotica* and *A. senegal* attained more height and GBH at 10x10m spacing than the plantation at 10x5 and 5x5m (Table 7). However, the canopy spread was maximum at 10x10m in *A. nilotica* and at 5x5m in *A. senegal*. In general *A. nilotica* attained better growth than *A. senegal.* In winter season, *E. sativa was* grown as an intercrop (Plate 3). The crop attributes were influenced by tree species as well as planting spacing (Table 8). Tree species significantly influenced seed yield of *E. sativa* while other traits remained unaffected. The planting spacing had significant influence on plant population, pods plant$^{-1}$, seed yield and total biomass. In all cases, the interaction effects of trees and spacing was non-significant. As planting spacing increased from 5x5 m, 10x5 m and to 10x10 m, the seed yield also increased significantly from 24.3 g m$^{-2}$, 34.5 and to 43.0 g m$^{-2}$, respectively. Total biomass of *E. sativa* was, significantly more in association of *A. senegal* than *A. nilotica*. Maximum biomass was recorded in 10x10 m planting spacing and minimum in 5x5 m spacing. In general, total biomass production increased with increase in planting spacing.

**Plate 3. *Acacia senegal* + *Acacia nilotica* based rainfed agri-silviculture model**

**Table 7. 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 | 44.2 ± 5.07 | 4.9 ± 0.42 | 15.5 ± 3.12 | 3.6 ± 0.42 |
| 10 m × 5 m | 35.5 ± 2.74 | 4.7 ± 0.23 | 13.1 ± 1.80 | 3.5 ± 0.33 |
| 5 m × 5 m | 38.9 ± 1.31 | 5.5 ± 0.11 | 17.7 ± 0.96 | 3.0 ± 0.31 |
| ***A. nilotica*** | | | | |
| 10 m × 10 m | 56.1 ± 5.63 | 6.1 ± 0.41 | 17.8 ± 3.71 | 3.4 ± 0.38 |
| 10 m × 5 m | 44.3 ± 3.18 | 5.3 ± 0.24 | 15.4 ± 2.10 | 3.7 ± 0.43 |
| 5 m × 5 m | 41.4 ± 1.50 | 5.5 ± 0.13 | 17.2 ± 0.88 | 2.8 ± 0.29 |

**Table 8. Effect of tree species and planting spacing on yield of *E. sativa* in rainfed agri-silviculture model**

| Tree species / crop's characters | Planting spacing | | | Mean |
|---|---|---|---|---|
| | 5x5m | 10x5m | 10x10m | |
| Plant population (Plants m$^{-2}$) | | | | |
| *A. senegal* | 5.33 | 7 | 8 | 6.78 |
| *A. nilotica* | 5 | 6.67 | 8.33 | 6.67 |
| Mean | 5.17 | 6.83 | 8.17 | |
| CD for trees: NS; CD for Spacing: 1.107; CD for Trees x Spacing: NS | | | | |

| | | | | |
|---|---|---|---|---|
| Pods plant$^{-1}$ | | | | |
| *A. senegal* | 77.07 | 108.4 | 134.75 | 106.74 |
| *A. nilotica* | 74.47 | 107.33 | 133.2 | 105 |
| Mean | 75.77 | 107.87 | 133.98 | |
| CD for trees: NS; CD for Spacing: 8.89; CD for Trees x Spacing: NS | | | | |
| *E. Sativa* Plant height (cm) | | | | |
| *A. senegal* | 59.13 | 56.27 | 53.53 | 56.31 |
| *A. nilotica* | 59.8 | 59.33 | 56.47 | 58.53 |
| Mean | 59.47 | 57.8 | 55 | |
| CD for trees: NS; CD for Spacing: NS; CD for Trees x Spacing: NS | | | | |
| *E. Sativa* Seed yield (g m$^{-2}$) | | | | |
| *A. senegal* | 25.33 | 36 | 43.67 | 35 |
| *A. nilotica* | 23.33 | 33 | 42.33 | 32.89 |
| Mean | 24.33 | 34.5 | 43 | |
| CD for trees: NS; CD for Spacing: 3.276; CD for Trees x Spacing: NS | | | | |
| *E. Sativa* Total biomass (g m$^{-2}$) | | | | |
| *A. senegal* | 112 | 131 | 143 | 128.67 |
| *A. nilotica* | 106 | 126.33 | 135 | 122.44 |
| Mean | 109 | 128.67 | 139 | |
| CD for trees: 4.241; CD for Spacing: 5.194; CD for Trees x Spacing: NS | | | | |

**Table 9. 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* | 58.2 ± 4.67 | 6.9 ± 0.38 | 22.9 ± 3.90 | 17.6 ± 1.66 |
| *T. arjuna* | 35.9 ± 1.19 | 5.3 ± 0.15 | 8.6 ± 0.44 | 19.4 ± 1.45 |
| *A. senegal* (at boundary) | 49.9 ± 3.17 | 6.2 ± 0.26 | 16.4 ± 3.13 | 8.7 ± 1.06 |
| **Silvi-herbal model-II** | | | | |
| *A. nilotica* | 103.2 ± 4.79 | 9.6 ± 0.25 | 76.1 ± 9.19 | 25.9 ± 1.82 |
| *T. arjuna* | 33.1 ± 0.74 | 4.6 ± 0.14 | 7.8 ± 0.34 | 20.3 ± 1.14 |
| *A. senegal* (at boundary) | 38.7 ± 1.09 | 5.8 ± 0.39 | 23.2 ± 3.64 | 11.7 ± 1.14 |

In silvi-herbal model-I and II. *A. nilotica* attained more GBH, height and canopy spread than *A. senegal* and *T. arjuna* (Table 9). However, pruned biomass was maximum in *T. arjuna* as the trees are lopped every year to regulate its growth up to height of about 2.0 m for integration of silkworm in future. The growth of lemon grass, planted in alley of *A. nilotica* and *A. senegal*, is being monitored for its biomass production. Maximum survival, growth and biomass yield of lemon grass were recorded in tussocks planted at 100x100cm spacing (Plate 4).

Data on growth of trees in gum garden and rocky hillock is presented in Table 10. *A. senegal* attained maximum GBH (31.9 cm) in nine years old gum garden while the maximum height (5.0 m) was recorded in 14 years old block plantation at rocky hillock. Growth of *B. monosperma* was very poor in both the gum gardens.

**Plate 4. Growth of lemon grass tussocks in silvi-herbal model**

**Table 10. 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 (9 years old) | 31.9 ± 0.76 | 4.5 ± 0.10 | 12.3 ± 0.68 | 3.4 ± 0.33 |
| New gum garden (8 years old) | 26.9 ± 0.65 | 4.3 ± 0.09 | 9.5 ± 0.45 | 3.4 ± 0.31 |
| *B. monosperma* | | | | |
| Old gum garden | 1.5 ± 0.24 (CD) | 0.9 ± 0.07 | 0.2 ± 0.04 | – |
| New gum garden | 1.6 ± 0.11 (CD) | 0.9 ± 0.05 | 0.3 ± 0.03 | -- |
| Block plantation on rocky hillock (14 years old) | | | | |
| *A. senegal* (at boundary) | 29.7 ± 0.20 | 5.0 ± 0.08 | 12.8 ± 0.24 | -- |

Data relating to descriptive statistics of gum exudation from *A. senegal* (Plate 5) is given in Table 11. The gum yield in multi-component model, old gum garden, new gum garden and rainfed model ranged from 32.0 – 136, 1.0 – 36.0, 3.0 – 116.0 and 7.0 – 59.0 g $tree^{-1}$ with a mean value of 84.0, 7.89, 29.2 and 30.3 g $tree^{-1}$, respectively. The mean numbers of gum tears $tree^{-1}$ were, 5.5, 1.67, 3.6 and 4.25 in multi-component model, old gum garden, new gum garden and rainfed model, respectively. The value of standard deviation revealed that the gum exudation was more consistent in old gum garden in comparison to other models. In multi-component model, tree to tree gum exudation was highly inconsistent. The numbers of gum tears $tree^{-1}$ had good consistency in all the model. Among all the models, maximum gum yield (84.0 g $tree^{-1}$) was recorded in multi-component agroforestry model while the least (7.89 g $tree^{-1}$) was in old gum garden.

**Plate 5. Naturally exuded gum tear on *A. senegal***

**Table 11. 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 | 03 | 09 | 10 | 04 | | | | |
| Mean | 5.5 | 84.0 | 1.67 | 7.89 | 3.6 | 29.2 | 4.25 | 30.25 |
| Minimum | 2 | 32.0 | 1 | 1.00 | 1 | 3.0 | 2 | 7.0 |
| Maximum | 9 | 136.0 | 3 | 36.00 | 10 | 116.00 | 9 | 59.00 |
| SD | 3.50 | 52.0 | 0.29 | 3.75 | 0.97 | 11.26 | 1.65 | 12.46 |

Descriptive statistics of gum exudation data from *A. nilotica* has been presented in Table 12. The gum yield ranged from 10.0 – 54.0 g $tree^{-1}$ in silvi-harbal model and from 1.0 – 23.0 g $tree^{-1}$ in rainfed agri-silviculture model with respective mean value of 33.75 and 13.20 g $tree^{-1}$. The standard deviation reveals that gum exudation was more consistent in rainfed model than silvi-harbal model.

**Table 12. 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 | 04 | | 10 | |
| Mean | 6.5 | 33.75 | 2.8 | 13.2 |
| Minimum | 3 | 10.0 | 1 | 1.0 |
| Maximum | 10 | 54.0 | 6 | 23.0 |
| SD | 1.44 | 56.35 | 0.57 | 2.81 |

Data on *A. senegal* growth in different bio fence models (Plate 6) is given in Table 13. Maximum collar diameter (45.4mm) and tree height was attained in outer row of double-row model -3 planted at 1.5m apart while minimum in inner row of double row *A senegal* bio fence model-4. Growth of *C. carandas* was maximum when it was alternatively placed with *A. senegal* at 1.5m apart in single row model-1 followed by in double-row model-2 where it is staggered with *A. senegal* in inner row. In all the bio fence models, minimum maintenance pruning was done to make them more effective.

**Plate 6. Double rows *A. senegal* based biofence model**

The penetrability of bio fence model against stray cattle is the crucial factor for providing protection to field crops. Hence, it was measured by projecting the vertical face of a bio-fence using Digitiser V 6.3.0 tool to assess its percentage occupancy. One side of 5 years old *A. senegal* + *C. carandas* based double-row bio-fence was assessed. The length of fence was 47.0m. *A.senegal* and *C. carandas* were placed between two rows and within the row at 2m. The height, canopy width and canopy height of the *A. senegal* were 3.6±1.1m; 3.4±0.96m and 2.9±1.2m, respectively. The height of *C. carandas* was 0.8±0.4m. Data analysis revealed that the projected ground area occupancy (47m X 2m) was 94 m$^2$. The actual ground area occupancy was 160.0 ± 44.0 m$^2$. This is mainly because of the expanding canopy width of the *A. senegal.* The rectangular vertical area occupied by the bio-fence was 60.97 m$^2$. The opening was demarcated and measured for the area and the data indicated that ~13% vertical projection of the bio-fence had opening/gap and the actual vertical area occupied by the fence was 53.15 m$^2$.

**Table 13. Growth of 4-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* | 37.5 ± 4.58 | 1.8 ± 0.13 | 1.6 ± 0.32 | 0.5 ± 0.12 |
| *C. carandas* -1.0m | 3.8 ± 0.33 | 0.4 ± 0.04 | 0.03 ± 0.005 | -- |
| *C. carandas* -1.5m | 7.7 ± 1.29 | 0.6 ± 0.09 | 0.06 ± 0.007 | -- |
| *C. carandas* -2.0m | 5.5 ± 1.29 | 0.5 ± 0.06 | 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) | 29.3 ± 3.30 | 1.8 ± 0.11 | 1.7 ± 0.26 | 0.8 ± 0.11 |
| *C. carandas* (inner row) | 6.2 ± 0.54 | 0.5 ± 3.25 | 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) - 1.0 m | 25.8 ± 4.08 | 1.9 ± 0.21 | 0.6 ± 0.17 | 1.0 ± 0.12 |
| *A. senegal* (outer row) - 1.5 m | 45.4 ± 3.10 | 2.6 ± 0.10 | 1.4 ± 0.11 | 0.9 ± 0.12 |
| *A. senegal* (outer row) - 2.0 m | 26.1 ± 3.13 | 2.0 ± 0.23 | 0.9 ± 0.18 | 0.9 ± 0.16 |
| *A. senegal* (inner row) - 1.0 m | 44.8 ± 6.81 | 2.4 ± 0.24 | 1.1 ± 0.21 | 1.0 ± 0.10 |
| *A. senegal* (inner row) - 1.5 m | 36.9 ± 2.88 | 2.2 ± 0.12 | 1.1 ± 0.12 | 0.9 ± 0.12 |
| *A. senegal* (inner row) - 2.0 m | 43.9 ± 4.63 | 2.4 ± 0.12 | 1.8 ± 0.17 | 1.0 ± 0.10 |
| **Model-4 (Double row) : Distance between plant to plant within row 2.0m and rows are placed apart 1.0m** | | | | |
| *A. senegal* (outer row) | 23.9 ± 2.00 | 1.3 ± 0.09 | 0.31 ± 0.09 | 1.1 ± 0.20 |
| *A. senegal* (inner row) | 28.5 ± 2.30 | 1.5 ± 0.11 | 0.76 ± 0.12 | 1.1 ± 0.10 |

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

A trial was conducted to assess feasibility of using IINRG-gum tapping blazer-75 for tapping gum-butea *(B. monosperma*), gum-dhwara (*A. latifolia*) and gum-gatti (*A. pendula*) in in agroforestry. Trial was initiated in October 2023 for *A. latifolia* and *A. pendula* and in December 2023 for *Butea trees*. Single cut was made on a tree with blazer-75 by hammering with hammer and three replications were used for each tree species. Observation on gum exudation was recorded and exuded gum collected. The results revealed that the incision/ cut made by blazer-75 did not show exudation of gum in *A. pendula* and *A. latifolia* and the incisions dried up after seven days. On butea trees, exudation was noticed but the gum yield was very less (2.0 g $cut^{-1}$). For making cut on the tree, hammering requires force and it takes about 20-25 minutes to make single cut. The healing of wound caused by cut/ incision with the blazer-75 is being monitored. The trial will be repeated on *A. nilotica* and *A. senegal in* summer.

Trial initiated in December 2021 to observe gum exudation in *B. monosperma* throughout the year was repeated during 2022-2023. Every month gum exudation was monitored in *B. monosperma* in response to knotching / incision made on tree stem with the special billhook. Analysis of two years' data indicated that in general, maximum gum yield was obtained in the month of December followed by January and February. From December to June the gum yield declined and during rainy season (month of July, August and September) the gum yield was negligible as the exudates washed away with the rain water. Further, during all the months except March and October, the gum yield was slightly more in the year 2022-2023 as compared to 2021-2022. (Figure 1)

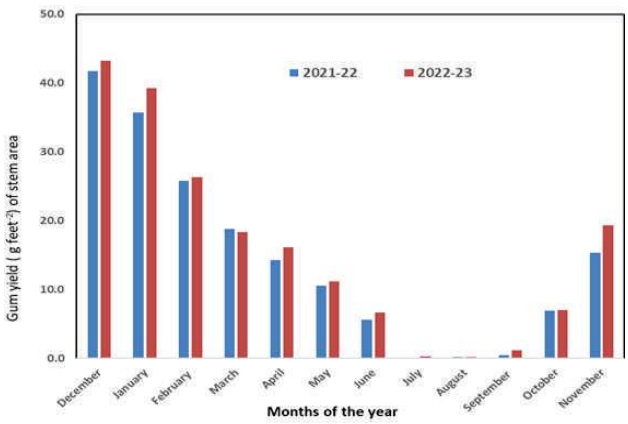



**Figure 1. Month-wise exudation of gum-butea throughout the year**

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

During the year, planting materials (10000 seedlings and 9.5 kg seeds – multiplied to 37000 seedlings in nursery) of *Acacia senegal* (gum arabic) was supplied to ICRISAT Hyderabad for planting on farmer's field in Bundelkhand. Besides, tree growth was monitored in boundary planting on farmer's field of different villages (Plate 7). In garhkundar village at the field Shri Himmat, many well grown trees *Acacia senegal* were dried up and removed by farmers for using wood. The GBH of *A. senegal* on farmer's field ranged from 21.1cm in village ambabai to 39.7cm in garhkundar (Table 14).

**Table 14. 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 village (13 years old)** | | | |
| *A. senegal* (boundary)* | 39.7 | 4.6 | 6.8 |
| *E. officinalis* | 63.6 | 5.5 | 22.2 |
| **Shri Ghanshyam (10 year old)** | | | |
| *A. senegal* (boundary)* | 25.4 | 2.7 | -- |
| **Binwara (Shri Tiwari) (06 years old)** | | | |
| *A. senegal* (boundary)* | 35.7 | 4.1 | -- |
| **Shri Mani Ram (village Ambabai)- 10 year old** | | | |
| *A. senegal* | 21.1 | 3.2 | 7.0 |
| **Kochhabhawar (Shri Janaki Prasad Kushwaha) (18 months old)** | | | |
| *A. senegal* (boundary)* | 17.0 CD (mm) | 1.2 | -- |
| *C. lemon* | 13.0 CD (mm) | 0.8 | -- |
| *C. carendas* | 9.5 CD (mm) | 0.6 | -- |

**Plate 7. Boundary planting of *A. senegal* on farmers' field as bio-fence**

## NRMA/CAFRI/SOL/2019/003/00119:

### Assessment of genetic potential of neem germplasm for higher yield and oil content through molecular markers

*(K Rajarajan, H Anuragi and Alka Bharti*)*

*Azadirachta indica* is multipurpose tree species, used in food , medicine and agriculture. Our study used 20 neem specific polymorphic SSR markers to investigte the genetic diversity among 170 Neem germplasm from three distinct populations (SE: south-estern; NC: north-central; WC: west-central). The SE population exhibited the highest genetic variation, as indicated by the observed heterozygosity (Ho=0.63) and expected heterozygosity (He=0.64) values, while the NC population showed the lowest genetic diversity. Furthermore, evidence of inbreeding was exhibited by the overall positive value of the fixation index (F=0.13). Analysis of molecular variance revealed that 12% of total genetic variation was observed among the populations, whereas 88% was found within the population. Principal component analysis, clustering, and structure analysis were in correspondence with each other and identified three populations of *A. indica* with slight admixtures. This study provide a genetic diversity of *A. indica* germplasm for harnessing its genetic potential and conservation. By combining both morphological and molecular diversity of neem, this project is concluded.

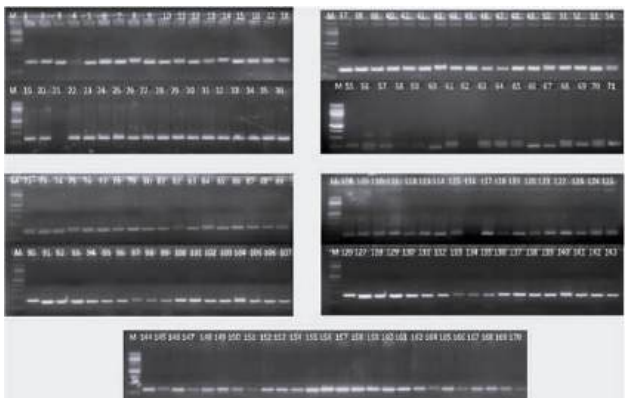


**Figure 1. N017 primer amplification profile of 170 neem germplasm. M-100 bp DNA ladder; 1-170 are the neem accessions.**

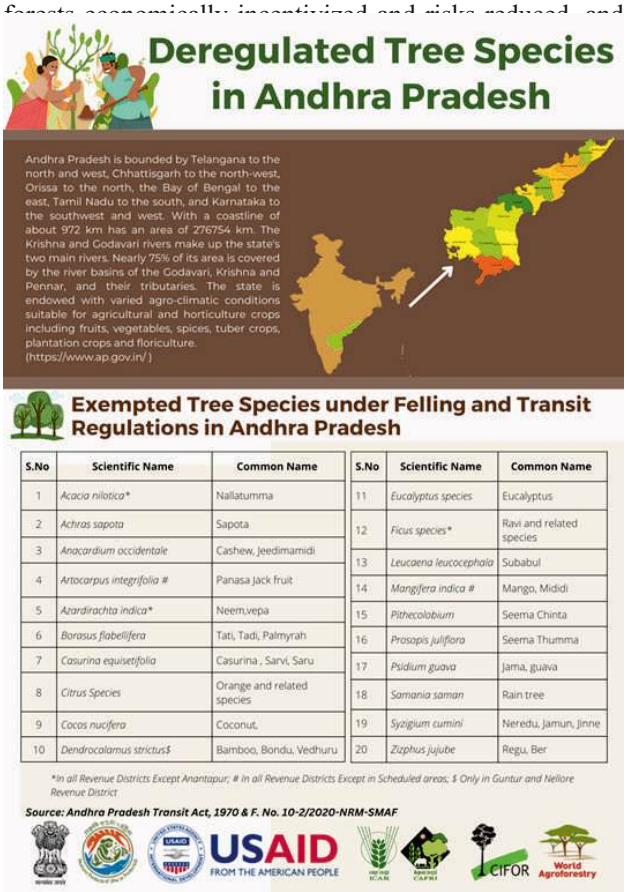
* *On study leave*

## NRMA/CAFRI/SOL/2021/017/00141:

### Trees Outside Forests in India (TOFI)

*(A Arunachalam, AK 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. Key objectives of TOFI programme are (i) Enabling environment strengthened for expansion of trees outside forests, (ii) Expansion of area under trees outside forests economically incentivized and risks reduced, and

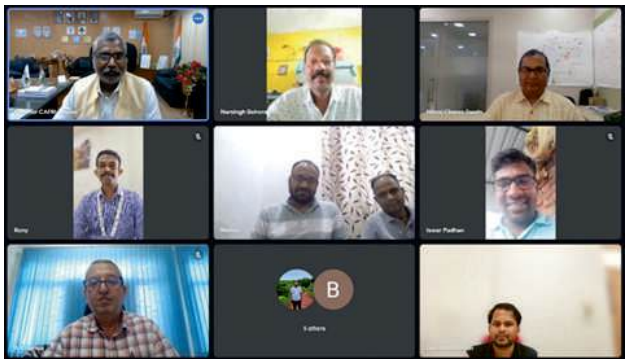



| S.No | Scientific Name | Common Name |
|---|---|---|
| 1 | *Acacia nilotica** | Nallatumma |
| 2 | *Achras sapota* | Sapota |
| 3 | *Anacardium occidentale* | Cashew, Jeedimamidi |
| 4 | *Artocarpus integrifolia #* | Panasa Jack fruit |
| 5 | *Azardirachta indica** | Neem,vepa |
| 6 | *Borasus flabellifera* | Tati, Tadi, Palmyrah |
| 7 | *Casurina equisetifolia* | Casurina , Sarvi, Saru |
| 8 | *Citrus Species* | Orange and related species |
| 9 | *Cocos nucifera* | Coconut, |
| 10 | *Dendrocalamus strictus$* | Bamboo, Bondu, Vedhuru |

| S.No | Scientific Name | Common Name |
|---|---|---|
| 11 | *Eucalyptus species* | Eucalyptus |
| 12 | *Ficus species** | Ravi and related species |
| 13 | *Leucaena leucocephala* | Subabul |
| 14 | *Mangifera indica #* | Mango, Mididi |
| 15 | *Pithecolobium* | Seema Chinta |
| 16 | *Prosopis juliflora* | Seema Thumma |
| 17 | *Psidium guava* | Jama, guava |
| 18 | *Samania saman* | Rain tree |
| 19 | *Syzigium cumini* | Neredu, Jamun, Jinne |
| 20 | *Ziziphus jujube* | Regu, Ber |

*In all Revenue Districts Except Anantapur; # In all Revenue Districts Except in Scheduled areas; $ Only in Guntur and Nellore Revenue District

(iii) Improved access to quality and actionable information about trees outside forests. 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 leading partner of this program. The institute has focused on potential tree species for deregulation in TOFI states and undertaken state-specific engagement to deregulate targeted tree species. Additionally, some problem solving research is also being taken up such as scoping agroforestry potential in the TOFI states. Also, several online and offline meetings and engagements held with TOFI states focusing the potential tree species for deregulation and examining the tree felling and transit legislations. In the lines of assessing and improving TOF and green infrastructure in urban areas, ICAR-CAFRI prepared Roadmap for Green Cover Development in Jhansi City.



**Online Meeting with TOFI Odisha Team.**

**Physical Meeting with TOFI Assam Team at Guwahati.**

## NRMA/CAFRI/SOL/2021/018/00142:

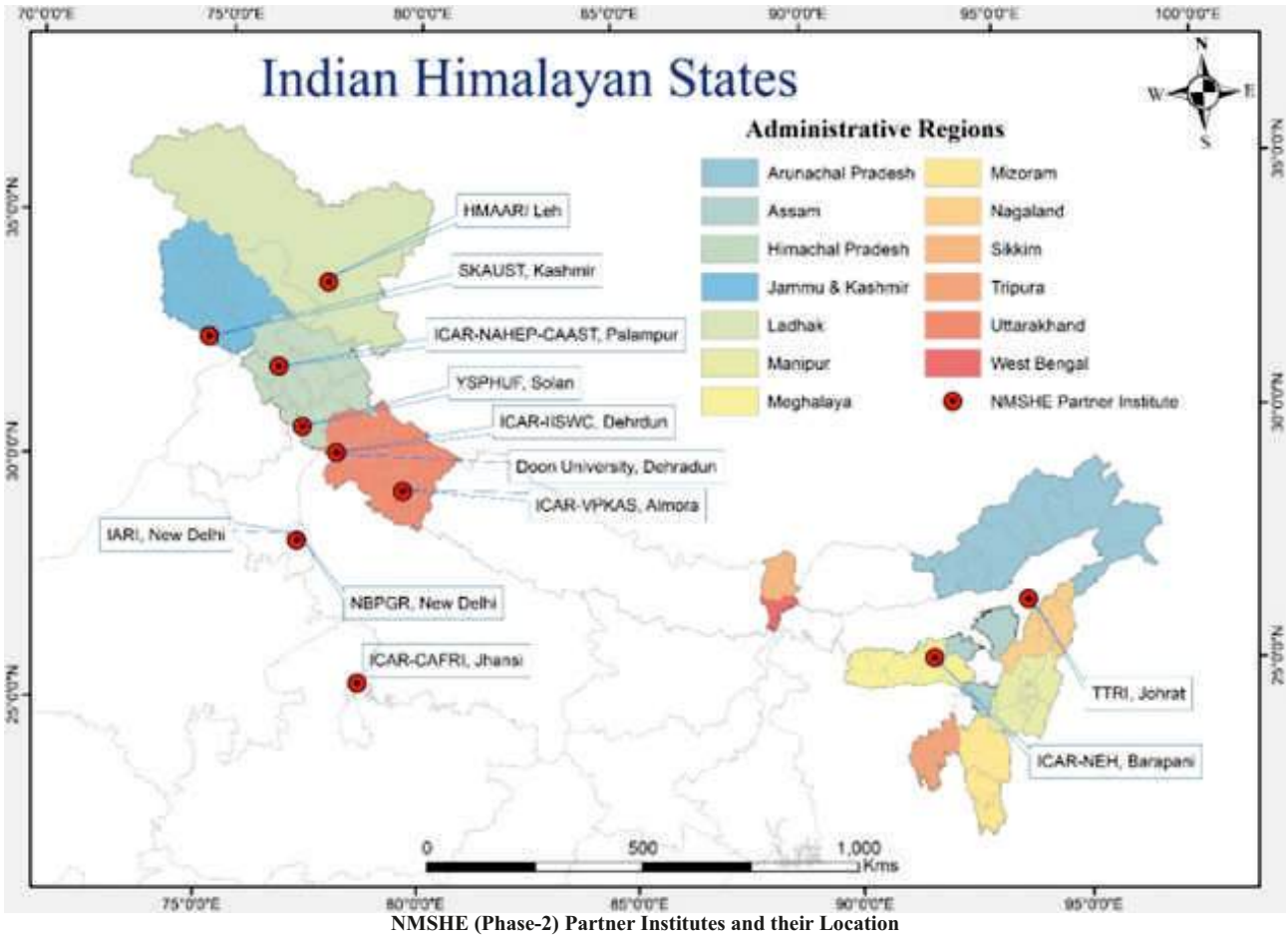
## National Mission on Sustaining Himalayan Ecosystems (NMSHE) -Task Force on Himalayan Agriculture

***(A Arunachalam, AK Handa and Suresh Ramanan S)***

The Indian Himalayan Region, spanning 2500km across 13 states, relies heavily on agriculture as its primary income source. Sustainable agriculture diversifies livelihoods, expands off-farm income, and promotes external development. Modern equipment, seed soil conservation practices, innovation, horticultural crops, and livestock ensure food security for mountain households. Traditional farming practices face threats from climate instability, erratic precipitation, and rising temperatures, particularly in rural communities with limited resources. Contemporary agricultural technology is limited by altitude, slope, aspect diversity, and small landholding challenges. The Department of Science and Technology (DST) (DSThttps://dst.gov.in/climate-change-programme), Government of India, has commissioned the National Mission on Sustaining Himalayan Ecosystems (NMSHE) - Task Force on Himalayan Agriculture to the Indian Council of Agricultural Research (ICAR), with an emphasis on database creation, monitoring for ecological vulnerability, modeling, and simulation, adaptation policy research, pilot studies for revalidation of climate resilient technologies, and capacity building of farmers and other stakeholders. The first phase of the task was successfully concluded from (2015 to 2020, in which 25 ICAR institutes across the IHR worked together to bring climate resilience among the Himalayan farmers. The Task Force developed 115 maps, yield trends, and graphs to analyze agroecosystems, climatic trends, and vulnerability in the IHR. A regional disparity study was conducted to understand precipitation anomalies' time dependence for seasonal drought. The second phase of NMSHE began in 2021, with 12 institutes collaborating in hill agriculture and climate change effect and adaptation studies to achieve objectives. Among this 12 collaborating institutions replaced the JNU, New Delhi centre was replaced with Doon University, Dehradun.

**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 in relation to 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.

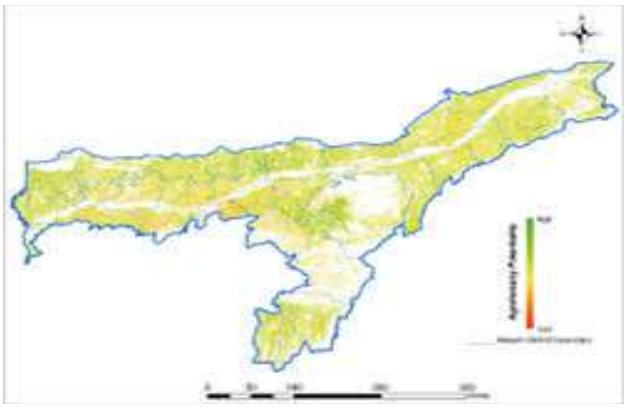



**NMSHE (Phase-2) Partner Institutes and their Location**

The NMSHE II project conducted research and extension interventions to study farmers' perspectives on climate change and pilot-test adaptation technologies. The ICAR-Central Agroforestry Research Institute assessed agroforestry potential in Assam using GIS modeling, finding 48.23% of land suitable for agroforestry. Assam is highly susceptible to natural disasters like floods and erosion due to its extensive river network. The RUSLE method was used to estimate soil erosion in the region, using input variables like rainfall, soil erodibility, slope length, slope steepness, cover management, and conservation practices. A study by TTRI, Assam, investigated the impact of climate change on the microclimate in and around the rainwater harvesting pond. Soil samples were collected from various locations in the South Bank region of Assam, and the average maximum temperature in 2021 was the highest recorded in Tocklai since 1923. The Indian Himalayan region, including districts like Tawang, Thoubal, West Khasi Hills, Saiha, Dimapur, East district, and Sipahijala, is highly vulnerable to climate change due to its extreme dryness and moisture deficiency. Experimental trials were conducted at Sher-E-Kashmir University of Agriculture and Technology in Srinagar, focusing on phonological data on various crops. Farmers reported increased cloudbursts, landslides, and land subsidence events, causing property damage. The study highlighted the need for balanced approaches to precipitation levels in soil management strategies in Anantnag, Srinagar, and Kupwara regions in India. As well as HMAARI, Leh Ladakh is implementing adaptation strategies to address climate change scenarios, including studying indigenous cereal genotypes and introducing drip irrigation systems in remote villages. CSK Himachal Pradesh Krishi Vishwavidyalaya has studied crop harvesting and soil compactness, revealing increased productivity after adopting High-Yielding Varieties and climate-resilient crop varieties. Indigenous people in the Chamba district of Himachal Pradesh have developed a method to extract edible starch from *Aesculus indica* seeds, known as "Seek," which could improve the livelihood and nutritional security of the tribal population. Farmers are experimenting with new fruit crops and educating them on crop management under specific microclimatic conditions. Drip irrigation systems are distributed in Ladakh villages, and a vulnerability assessment and adaptation technology survey for agriculture is conducted in various villages within the Nadaun block, India.

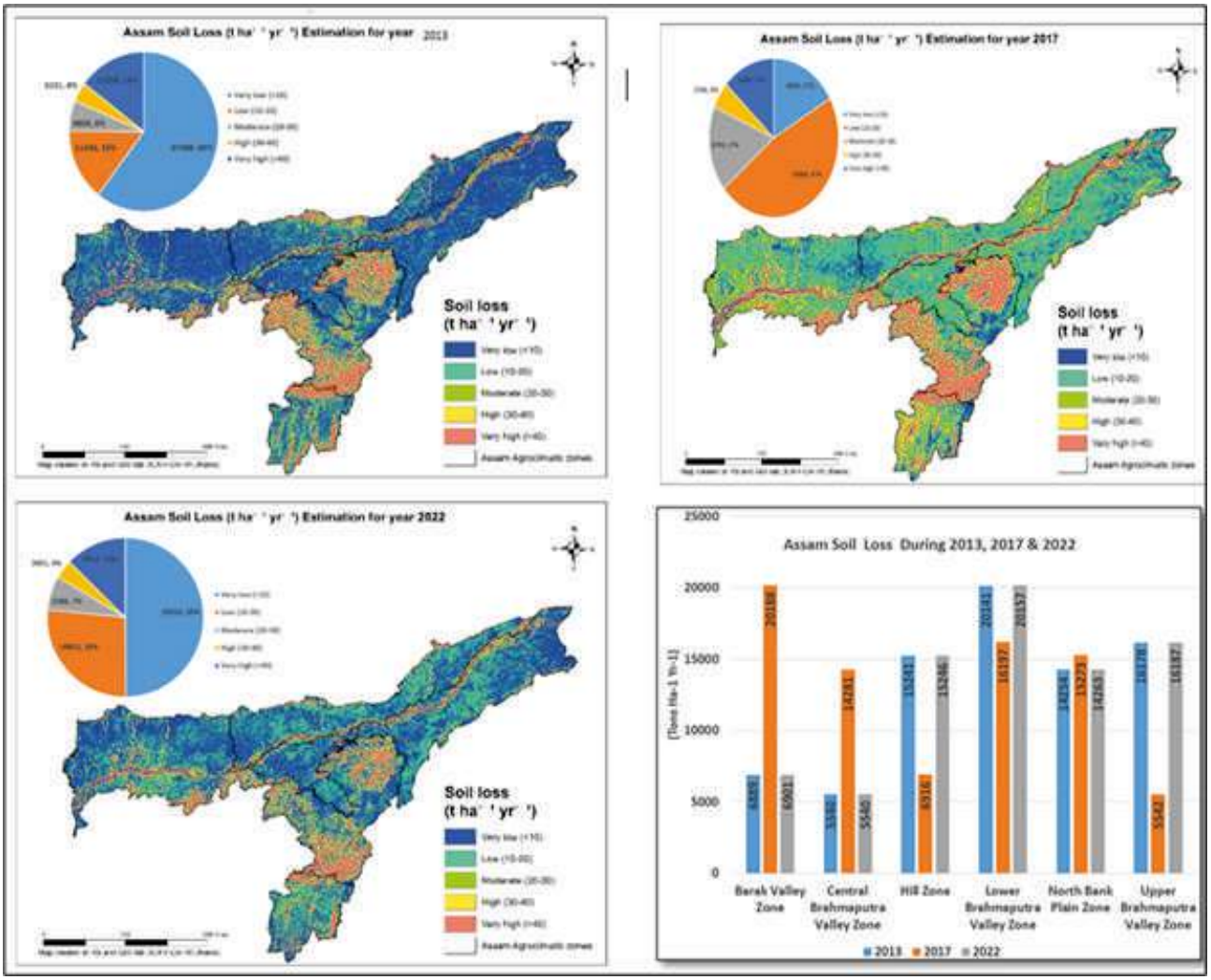
**NRMA/CAFRI/SOL/2021/021/00145:**

**Pilot the solutions of chip-based technology for real-**



Prepare Agroforestry Potential Zone Map (Year 2022 – 23)


Organize One-week training on Climate Change Impact Modelling for the Indian Himalayan Region




Prepare Assam Soil Loss Estimation for Years 2013, 2017 & 2022

**time and RFID-passive monitoring of gene-bank and agroforestry species for scaling up**

***(K Rajarajan and H Anuragi)***

This is a jointly implemented pilot project by ICAR-NBPGR-IIHR-CAFRI with ICRAF. In this project, the tree germplasm are being monitored through real-time or active chips. ICAR- Central Agroforestry Research Institute, Jhansi is maintaining various multipurpose tree (MPTs) germplasms including *Azadirachta indica, Acacia nilotica, Pongamia pinnata* etc. by installed advanced chip-based technology or RFID (Radio Frequency Identification) tags in 30 trees in the field gene bank. These tree genetic

resources are managed by RFID tags as passive management by digitally entering the morphological and health status data are being updated in SAMS portal (Figure 2) from a different time to time along with its IC number, images, and latitude and longitude. We also installed chips in 50 neem trees for real time monitoring of tree germplasm and retrieving the information digitally with little or no human intervention.

**Figure 1. RFID tags installed in neem germplasm at CAFRI, Jhansi**

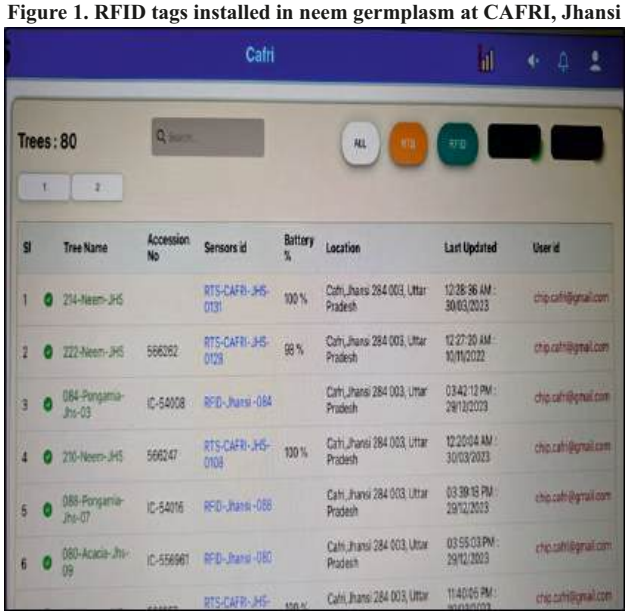



**Figure 2. Data updation in SAMS portal**

## NRMA/CAFRI/SOL/2022/001/00147:

## Agri-Drone Project

***(Asha Ram)***

The project was funded by ICAR-ATARI, Kanpur, under the RKVY Project. This project began in year 2022. Under this project various spray demonstration have been carried out at institute research farm and at farmers' fields. Benefits of drone technology in agroforestry have also been explained to the farmers during the drone demonstrations. Besides liquid fertilizers, other tree based (neem) pesticides have also been used during the demonstrations.

## 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, DR Bhardwaj and DR Bhardwaj)***

Effect of CAD More Liquid and CAD Grow Liquid on strawberry, tomato, pea, and mustard In strawberry, tomato, pea, and mustard the spray of CAD More Liquid (CML) revealed significant differences among plant growth and yield parameters. The fruit set ratio was higher in all three biostimulants applied treatment compared to control. All CAD More Liquid (Botanical extract, including seaweed extract) applied treatments showed higher yield in strawberry, tomato, pea, and mustard compared to the control. However, phytotoxicity, flower drop, and disease incidence have not been observed in all treatments. In all crops, the spray of CAD Grow Liquid revealed significant differences among plant growth and yield parameters. All treatments showed higher yield compared to the control. All CAD Grow Liquid applied treatments showed higher yields in strawberry, tomato, pea, and mustard compared to the control. However, phytotoxicity, flower drop, and disease incidence have not been observed in all treatments.

## 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 utilization of resources for a given location. Despite several challenges like frequent droughts, the increasing costs of cultivation, 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 has been performed under the project.

- Several systematic survey were conducted in Bangra and Baragoan block for successful implementation of the pomegranate-based agroforestry system at farmers field. The soil and water samples were collected from the farmer's field of both the block and analysis was done.
- Conducted time to time survey and gave demonstration of field layout, digging pits, bed preparation, planting of pomegranate to all selected beneficiary famers field completed.
- Tissue culture plants of pomegranate were purchased from Jain Irrigation Ltd., Jalgaon Maharashtra and distributed uniformly to all the farmers of both block.
- 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 (seed, fertilizers, pruning secateurs, nursery material, and plant protection accessories) for implementation of the project.
- Development of the demonstration block of pomegranate at ICAR-CAFRI has been completed.
- Conducted time-to-time surveys in Bangra and Baragoan blocks and gave demonstrations of training and pruning of pomegranate, bed preparation for vegetable seedlings, seed treatment, and nursery raising of vegetable seedlings.
- For better skill enhancement, Field level Krishivaniki Schools were organized at farmers fields in each block and experts delivered lectures on agronomic management and good agricultural practices in pomegranate. Besides this hands-on training were also provided on training and pruning of pomegranate to all the farmers.
- Time to time project monitoring was conducted and suggestions were given to farmers for better implementation of the project implementation.
- Two PIMC (Project implementation and monitoring committee meeting) were conducted and discussed about 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* Lam.] is an important multipurpose tree species of *fabaceae* family having high spiritual and medicinal significance since Vedic times. It is popularly known as Dhak or Teshu or 'flame of forest' owing to its impression of fire or flame in the forest canopy at the time of its blooming. Palash has been considered as a holy tree or Brahma vriksha in Vedic literature and also has traditionally been a cynosure of contemporary medicine in Ayurveda, Unani and homoeopathy systems of medicines since ancient times. Even today, it is a potential source of pharmacological properties for pharmaceutical industries. Being an important tree species, developing quality planting material (QPM) is highly required for having large scale, uniform and high quality plantation as well as conservation of the species more particularly the white and yellow flower types. *In-vitro* regeneration or plant tissue culture is a modern biotechnological tool that can effectively produce a large scale of QPM from a small piece of explant irrespective of time and season. However, the faster and efficient regeneration protocol is still not available till date. In this regard, attempts are being made for *in-vitro* regeneration of both red and yellow flower Palash trees identified through surveying in nearby locations. Different explants were used to induce callusing, shooting and rooting using Murashige and Skoog (MS) media and woody plant media enriched with different concentrations of plant growth regulators (PGRs).

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


**Figure 2. *In-vitro* regeneration of red and yellow flower colored Palash (*B. monosperma*)**

**NRMA/CAFRI/SOL/2022/005/00151:**

**Strengthening Community Resilience by Diversifying Cropping System through Agroforestry Interventions in Central India**

***(A Arunachalam, AK Handa, RP Dwivedi, Naresh Kumar, Asha Ram and Suresh Ramanan S)***

ICAR-Central Agroforestry Research Institute, Jhansi has implemented the project entitled, "Strengthening

Community Resilience by Diversifying Cropping System through Agroforestry Interventions in Central India" (Sub Project of Building community resilience by alleviation of water scarcity and land degradation through Integrated Natural Resource Management in Bundelkhand in Uttar Pradesh) as one of the consortium partners. The duration of this project is for two years i.e. 2023-2025 and has two objectives viz., 1. Integrating crop-livestock-tree based farming for diversified rural livelihood, and 2. Developing capacity of the farming community through knowledge sharing and farmers participatory research/demonstrations.

Project team visited the selected villages and interacted with the farmers for agroforestry adoptions. A comprehensive agroforestry plan was developed for the project villages in collaboration with the ICRISAT. During this period various agri-horticulture systems were established on farmer fields of Nota, Pasrai, Bamanua and Bhadokhar villages. In this villages, Lemon, Guava and Aonla were planted under agri-horti sytem. In the project villages, large scale plantation on Teak, Melia and *Acacia Senegal* (on boundaries) were planted on the farmers' field (32 acres). ICAR-CAFRI also facilitated field level crop demonstrations. Technical knowledge on best management practices for kharif and rabi crops was provided to the farmers for higher productivity. Data collection and regular monitoring of agroforestry plantation and providing of technical management inputs to the agroforestry farmers. Rooted slips of NB Hybrid were also planted on fields bunds for increasing fodder availability.

**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)***

Sun light is a pre-requisite for the plant growth and metabolism but shade stress is a major abiotic stress posed by the perennial trees on the underlying annual crops in an agroforestry system. Development of shade stress tolerant crop cultivars could enhance the overall productivity of the system. Understanding the morphological, physio-chemical and molecular mechanisms is of outmost importance for breeding for shade-stress tolerance in crops. A popular legume, green gram (*Vigna radiata* var. Virat) was evaluated under different regimes of shade stress (0% shade or open as control, 25%, 50% and 75% shade as treatments) at research farm of ICAR-CAFRI, Jhansi during summer and kharif seasons of 2023. Various morphological parameters i.e., germination percent, seedling length, root and shoot length, number of primary branches, number of leaves, leaf area, plant height, leaf area index, stem girth, etc., and seed yield attributes like number of pods per plants, number of seeds per pod, hundred seed weight, seed yield per plant were studied. Root parameters like project area, total root length, number of root tips, number of forks, number of segments, maximum diameter, estimated root volume, etc. were studied using root scanner. Further, the physio-chemical parameters such as chlorophyll content, carotenoid content, malondialdehyde content (MDA), chlorophyll fluorescence, cell membrane stability (CMS), electrical conductivity (EC), antioxidant properties like catalase, peroxidase, etc. were also recorded following standard protocols. Growth pattern of crops under shade significantly varied between kharif and summer season. Seed yield and attributing characters got reduced significantly at 50% shade in both the seasons during 2023. Terminal heat stress is a major growing challenge for summer crops and partial shade obtained under agroforestry system offers an opportunity to deal with growing challenge of terminal heat for the crops. In

next years, the experiments will be replicated for better accuracy of results followed by whole transcriptomics and metabolomics studies using latest available NGS tools that would help in identification of candidate genes, metabolites and underlying molecular and physiological mechanisms responsible for shade-stress adaptation in the crops.

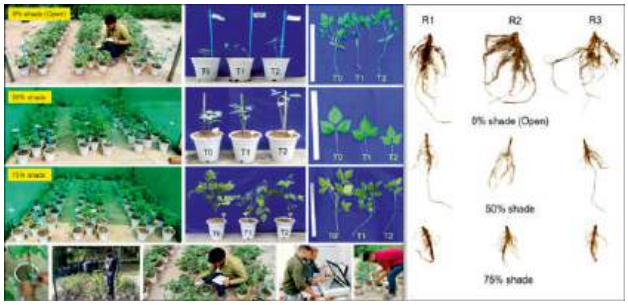



**Figure 1. Effect of different shade stress regimes on the plant growth and root architecture of mungbean (*Vigna radiata* var. Virat) under various regime of shade stress**

### NRMA/CAFRI/SOL/2023/001/00154:

### The Economics of Ecosystems and Biodiversity (TEEB) for Agriculture and Food Initiative in India

***(A Arunachalam, AK Handa and Suresh Ramanan S)***

"The Economics of Ecosystems and Biodiversity" (TEEB) as a global Agriculture and Food application is currently being undertaken in twelve countries of the world under the EU-funded project titled 'Economics of Ecosystems and Biodiversity: Promoting Sustainable Agriculture and Food Sector' (TEEB Agriculture and Food Implementation) with a noble cause to protect the ecosystem and valuing the hidden services of agriculture. The project undertakes scenario building, biophysical modelling, and valuation to reveal the costs/benefits of policy inaction in comparison to the costs/benefits of policy action for conserving nature and biodiversity. With an aim of "making natures' invisible values visible" using a framework to measure the true value that ecosystem and their services provide to society ultimately helping in practical orientation for adopting ecosystem services economics to support conservation planning and multidimensional policy decisions.

With primary objective to mainstream the values of biodiversity and ecosystem services into decision making TEEB initiative helps decision makers to a) recognize the range of benefits provided by ecosystem and biodiversity, b) demonstrate their values in economic terms and c) capture those values in decision making appropriately. Further, the project involves testing of agricultural interventions, policies and schemes, which have already been applied by the governments at different levels or are proposed, which are lively to stimulate positive livelihood and biodiversity benefits and assess their hidden or unaccounted outcomes on four "capital" viz. 'natural', 'human', 'produced' and 'social'. The UNEP global project titled "Economics of Ecosystems and Biodiversity: Promoting a Sustainable Agriculture and Food Sector", hereinafter referred to as TEEBAgriFood Initiative, is funded through the European Union Partnership Instrument (EUPI). The initiative was launched in 2019 and is being implemented in 7 countries, namely, Brazil, China, India, Indonesia, Mexico, Thailand and Malaysia. The TEEBAgriFood application in India started in 2019 and ends in December 2023. The application of the TEEBAgriFood framework in India assesses organic farming and agroforestry initially in the Ganga basin region of India covering two States of Uttar Pradesh and Uttarakhand. With the recommendation of the Project Steering Committee (PSC) co-chaired by the Ministry of Agriculture and Farmers Welfare and the Ministry of Environment, Forests and Climate Change, the TEEB AgriFood Framework was initiated in the state of Assam to have a quick understanding of the north-east Indian ecological setting with State as a single unit. The study led by ICAR-Central Agroforestry Research Institute, Jhansi, Uttar Pradesh (India) along with its partners (South Asian Forum for Environment, Tocklai Tea Research Institute, Doon University, World Agroforestry, Assam Agricultural University) gave useful data, information and statistics that have been analyzed using modeling, simulations and forecasting within RCP 4.5 climate scenario for scoping of organic farming and agroforestry. While doing so, several data sets of the State and Central Government have also been compiled for a better understanding given the existing government policies and programs. ICAR-CAFRI also enabled the implementation of TEEBAgrifood Landscape at Assam.

### NRMA/CAFRI/SOL/2023/004/00157:

### Laboratory bio-assay of newer fumigant molecules against storage insects

***(Venkatesh YN)***

The main objective of this study is to test the bioefficacy of EDN (Ethanedinitrile) against timber insect pests. Initially, the field was surveyed to know the timber insect pest incidence in different agroforestry tree species. To test the

bioefficacy timber insects were collected from *Dalbergia sissoo*, *Acacia nilotica.* The collected insect culture was maintained in the laboratory for testing and to quantify the gut microbiome. To know the exact species of the Cerambycidae grubs we extracted the DNA and sequencing of DNA is initated.

**Fig 1. Cerambycidae grubs culture for bio-efficacy studies**

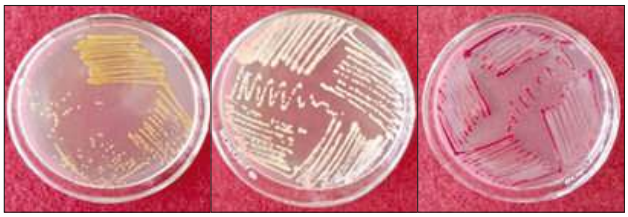


**Fig 2. Isolation, purification, and preservation of gut bacteria and fungi from Cerambycidae larvae**

**NRMA/CAFRI/SOL/2023/005/00158:**

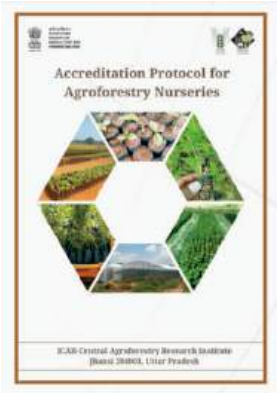
**RKVY-Quality Planting Material (QPM) Project**

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

The RKVY-Quality Planting Material (QPM) project, initiated in 2023 under the Rashtriya Krishi Vikas Yojana (RKVY), aims to enhance the quality and availability of planting material for agroforestry. The initiative is crucial for the promotion of agroforestry practices, which contribute to sustainable agriculture, environmental conservation, and socio-economic development. One of the major achievements of this project is the official notification of ICAR-CAFRI as the nodal agency for agroforestry in India. This designation underscores the institute's pivotal role in coordinating and leading agroforestry initiatives across the country. Another significant developement is the revamp of the Submission on Agroforestry (SMAF), now implemented as a component of RKVY with a specific focus on Quality Planting Material (QPM). This strategic integration ensures that agroforestry efforts are aligned with national agricultural development goals and benefit from RKVY's comprehensive support framework.

In this regard, ICAR-CAFRI has developed Accreditation Protocols for Agroforestry Nurseries. These protocols are designed to strengthen institutional arrangements for the large-scale production and certification of quality planting material. This initiative is critical for ensuring that nurseries adhere to high standards Thus, promoting the widespread adoption of agroforestry practices that meet the objectives of the National Agroforestry Policy.

Looking forward, the RKVY-QPM project aims to expand the network of accredited agroforestry nurseries across India, continuously enable Accreditation to keep pace with technological advancements and evolving agroforestry practices, and increase awareness and training programs for farmers and nursery operators about the benefits and techniques of agroforestry. Additionally, the project seeks to foster collaborations with national and international agencies to enhance the reach and impact of agroforestry initiatives. The RKVY-Quality Planting Material project represents a significant step towards achieving the sustainable agriculture and environmental goals outlined in the National Agroforestry Policy. With ICAR-CAFRI's leadership and the support of RKVY, this project is set to make substantial contributions to the agroforestry sector in India, benefiting farmers, the environment, and the economy at large.

## Inter-Institutional Collaborative Project

### Study on soil hydrothermal environment under natural and synthetic mulch

*(Nilimesh Mridha (PI), D B Shakyawar, Atul Singha, Manik Bhowmick, Haokhotang Baite, Ashok Yadav (CC-PI), Vinod Kadam and Manoj Kundu)*

The study on performance of different coloured Capsicum under different types of mulches i.e. Jute, Wool, Plastic and rice straw based mulches revealed that, plastic mulches performed better followed by Jute, wool, rice straw and control. The results of plant growth, leaf and root parameters are depicted in Figure 1 whereas the results of fruit and yield parameters are depicted in figure 2. The maximum plant height (53.81 cm) was observed under jute mulches followed by plastic mulch (48.24 cm), rice straw mulch (46.20 cm), control (46.75 cm) and least was observed in wool mulch (45.36 cm). Maximum leaf length, leaf width, leaf fresh weight and leaf dry weight were observed in Jute mulches and least were recorded in control except i.e. leaf dry weight which was observed in rice straw mulch.

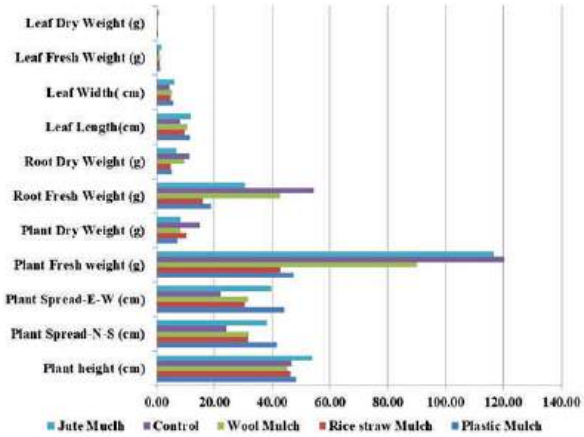



**Figure 1. Plant growth, leaf and root parameters of capsicum under different mulches**

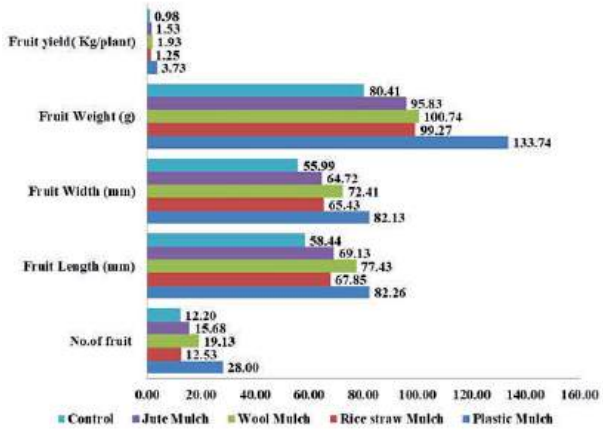



**Figure 2. Fruit yield parameters of capsicum under different mulches**

# 2. Research Achievements

## 2.6: Other Research Activities

### 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), hybrid corn, urd bean and paddy (kharif season) were grown successfully. From the roadside moringa plantation, about 250 kg moringa pods were harvested. In agri-horti block about 2.7 t guava fruits were harvested from 40 guava plants. Bunds of the field were utilised for pigeon pea and NB hybrid (grass) production. 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 and goat rearing were also carried out succefully. During year 2023, total goat flock was increased by seven 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.

**Chickpea and NB Hybrid**

**Guava+Paddy**

**Harvesting of guava from agroforestry based farming system model**

# 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 (Figure 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.

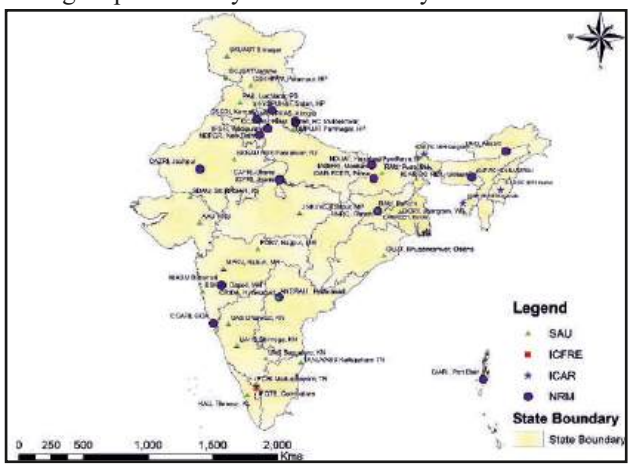



**Fig. 26: Showing the distribution of AICRP on Agroforestry Centres across the country**

### 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

Assam Agricultural University, HRS, Kahikuchi has conducted a survey, diagnostic, and design study in Brahmaputra regions. The soil consists of new alluvium on both banks of the Brahmaputra and old alluvium towards the foothills. Shallow rivers flowing from the Bhutan hills with torrential currents cause enormous losses of animal lives, properties, and crops every year. Farmers rear animals like cows, bullocks, buffaloes, pigs, goats, and birds (ducks, hens, and pigeons) for their livelihood security, with no common grazing land available, leading to reliance on stall feeding. The edible crop residue, grasses, legumes, and leaves of various trees contribute roughage for the animals. Some of the fodder trees used by the farmers include *Artocarpus heterophyllus*, *Ficus hispida*, *Ficus gibbosa*, *Ficus infectoria*, *Streblus asper*, *Anthocephallus cadamba*, *Leucaena leucocephala*, *Albizia* spp., Terminalia *tomentosa*, and bamboo species. Firewood, a major source of fuel, is generally obtained from trees growing in homesteads, farmland, and nearby forest areas. Additionally, trees like *Sterculia vilosa*, *Lagestromia speciosa*, *Bischofia javanica*, *Trewia nudiflora*, *Terminalia arjuna*, *Albizia procera*, *Albizia lebbek*, *Albizia lucida*, *Toona ciliata*, *Cassia fistula*, and *Cassia javanica* are grown for fuelwood and timber, while *Tectona grandis* and *Dalbergia sissoo* are used as timber.

GB Pant University of Agriculture & Technology, Pantnagar conducted a survey, diagnostic, and design study in Thalisain Block in Pauri Garhwal District of Uttarakhand. Indigenous germplasms of lesser-known cereals, pseudocereals, and pulses are used, with home gardens containing horticulture trees being prevalent. In the hilly stair form fields, forest trees are available, and the work is shouldered primarily by the women of the families. Migration of boys for education and able men for employment is a major issue.

Sri Karan Narendra Agriculture University, RRS, Fatehpur Shekhawati conducted a survey in some areas of Sikar, Jhunjhunu, Bikaner, and Churu. Pearl millet, sesame,

groundnut, green gram, cluster bean, cowpea, and moth bean are the main crops of the Kharif season, while wheat, barley, mustard, and gram are grown as irrigated crops in the Rabi season. *Ailanthus excelsa* trees are planted on the boundary of the farm, with *Prosopis cineraria*, *Tecomella undulata*, *A. leucophloea*, and *A. nilotica* variety cupressiformis found in agricultural fields. *Capparis deciduas*, *Acacia tortilis*, and *Prosopis juliflora* are found in wasteland and panchayat land. Progressive farmers have planted Aonla, Beal, Pomegranate, Ber, and Citrus species as horti-agriculture models, with some planting *Acacia senegal* (locally known as khairi) on farm boundaries as live fencing to protect the farm from animals.

Professor Jayashankar Telangana State Agricultural University, Hyderabad conducted a diagnosis and design survey of agroforestry systems in the Central Telangana Zone (CTZ). Most of the agroforestry farmers in Bhadradri Kothagudem district follow an Eucalyptus-based Agri-silvi system or Silvi-pastoral system. Farmers prefer to grow cotton or chilies during the first year, sesame during the second year, and fodders or pulses (mung bean, urd bean, cowpea, etc.) during the third and fourth years. Absentee landlords adopt eucalyptus alone as block plantations, while part-time and full-time farmers adopt eucalyptus plus crops. Farmers are able to reap 62.5 tons per hectare yield from eucalyptus under rainfed conditions, and 150-175 tons per hectare under irrigated conditions.

The University of Agricultural Sciences, Dharwad conducted a design and diagnostic survey. In the Northern Dry Zone, common tree species include *Tamarindus indica*, *Azadirachta indica*, *Hardwickia binata*, *Prosopis cineraria*, and *Acacia nilotica*. In irrigated areas of this zone, Teak, *Melia dubia*, Sapota, Mango, Pomegranate, Papaya, and Grapes are dominant species. In the Transitional Zone, the predominant perennial components are Teak, Terminalia, Dindal, Sandal, Red Sanders, Mahogany, Mango, Sapota, Guava, Curry leaf, Jack, and Jamun, with Teak planted on the bunds or channels of irrigation. Perennial vegetables like curry leaf and drumstick are very common in the farming system. Sandal, Mahogany, and Melia dubia have been cultivated on a large scale in recent years. In the Hill Zone, multi-storied agroforestry systems are noticed in farmers' fields, with important species including Arecanut, Coconut, Kokum, *Erythrina indica*, Jack, Tea, Cardamom, and Jamun. Paddy is the main field crop grown in lowland conditions, with pepper as an additional component (climber) in this multi-component system. In the Coastal Zone, Jack, Coconut, Cashew, and Kokum are the main fruit tree species grown, with *Casuarina equisetifolia* and *Acacia auriculiformis* mainly grown as windbreaks. The University of Agricultural and Horticultural Sciences, COF, Ponnampet conducted a study in the remaining parts of the Kodagu district, observing that the majority of farmers are keen to grow trees yielding fruits and commercial timbers.

**System Research and Tree Germplasm Collection, Evaluation and Improvement works**

| Name of the centre/State | MPTS working upon | Agroforestry models under trial/ development |
|---|---|---|
| Assam Agricultural University - HRS, Kahikuchi | *Gmelina arborea*, *Bamboo* species evaluation | *Gmelina arborea* based Agrisilvicultural system, Jackfruit based Agroforestry system, *Acacia mangium* based Agrisilvicultural system |
| Professor Jayashankar Telangana State Agricultural University, Hyderabad | *Azadirachta indica*, *Pongamia pinnata*, *Melia dubia* | Melia dubia based Agroforestry system, Custard apple based Hortipastoral system, Mango based in Agrihorticultural system |
| Birsa Agricultural University, Ranchi | Multipurpose Tree Species (MPTs) | *Melia azedarach* under Silvipastoral System, Tephrosia Alley cropping based Agrisilviculture system, *Gmelina arborea* based Agrisilvicultural system |
| Bidhan Chandra Krishi Viswavidyalaya, West Bengal - Jhargram | *Acacia auriculiformis* | *Gmelina arborea*-ber agroforestry system, Dysoxylum binectaiferum -mango based agroforestry system, Anthocephalus cadamba - mango agroforestry system, Gmelina arborea based Agrisilvicultural system |
| Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli | *Melia dubia*, *Gmelina arborea*, *Bamboo* sp., *Tectona grandis*, *Garcinia indica*, *Pongamia pinnata*, *Madhuca latifolia*, *Acacia mangium*, *Anacardium occidentale* | *Melia dubia* block plantation, Bamboo based plantation agroforestry system, Cashew based plantation agroforestry system |

| | | |
|---|---|---|
| Chaudhary Charan Singh Haryana Agricultural University, Hisar | *Populus deltoides*<br>*Melia composita*<br>*Eucalyptus* | Eucalyptus-Kinnow based agroforestry system, Poplar based agroforestry system, Eucalyptus clone-based agroforestry system |
| Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur | *Toona ciliata*<br>*Sapindus mukorossi*<br>*Leucaena leucocephala*<br>*Melia dubia* | Harar based silvipastoral system, *Leucaena leucocephala* silvipastoral agroforestry system, *Toona ciliata* based agroforestry system |
| Tamil Nadu Agricultural University, Mettupulayam | *Toona ciliata* | Fodder bank (18 species)<br>Multifunctional Agroforestry Model (Circular) |
| G.B. Pant University of Agriculture and Technology, Pantnagar | 94 indigenous and exotic MPTs including 7 species of bamboos have been maintained at Patharchatta (Old) site and total 54 indigenous and exotic MPTs suitable for agroforestry systems together with 14 species of bamboos have been collected at Haldi (New-AFRC) site.<br>*Dalbergia sissoo*<br>Eucalyptus species | Eucalyptus based agroforestry,<br>Carbon sequestration of Poplar based agroforestry system (Mustard) |
| Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur | *Dalbergia sissoo* | Mango based agri-horticulture system, *Dalbergia sissoo* based agroforestry system, *Gmelina* based agroforestry system, *Pongamia pinnata* based agroforestry system |
| Kerala Agricultural University, Thrissur | *Tectona grandis* | Boundary plantation of fast-growing fodder trees; Bamboo-based agroforestry |
| Mahatma Phule Krishi Vidyapeeth, Rahuri | 21-tree germplasm under evaluation | Agri-horticultural system of different fruit tree species, Teak based Agroforestry system |
| Acharya Narendra Deva University of Agriculture and Technology, Ayodhya | *Dalbergia sissoo*<br>Eucalyptus clones | *Casuarina equsetifolia* and *Psidium guajava* based agri-silvi-horti system, Agri-silviculture system (*Dalbergia sissoo, Casuarina equisetifolia, Eucalyptus)*, *Dalbergia sissoo* based Silvipastoral system |
| Orissa University of Agriculture and Technology, Bhubaneshwar | *Gmelina arborea* | Fruit based agrisilvihorticultural system (Jackfruit, Mango, Cashew),<br>Silvipastoral system (*Acacia mangium, Acacia auriculiformis, Samanea saman*) Mango + Pineapple Agrihorticultural system,<br>Agrisilvicultural System (*Acacia mangium, Tectona grandis)*, *Gmelina arborea* based Agrisilvicultural System |
| Punjab Agricultural University, Ludhiana | *Populus deltoides*<br>*Melia composita*<br>*Eucalyptus* (Clones)<br>*Dalbergia sissoo* | Poplar based agroforestry, Eucalyptus based agroforestry |
| Dr. Panjabrao Deshmukh Krishi Vidyapeeth, College of Agriculture Nagpur | *Melia dubia*<br>*Bamboosa balcooa*<br>*Ailanthus excelsa* | Citrus based Agroforestry System, Bamboo based Agri-silviculture system, *Ailanthus excelsa* based system, Teak based Agroforestry system, *Melia dubia* based agroforestry system, *D. stocksii* based agroforestry system |
| Dr. Rajendra Prasad Central Agricultural University, Pusa | *Populus deltoides*<br>*Dalbergia sissoo* | Bombax ceiba based Agrisilvicultural system, Bamboo plantations |
| Sardarkrushinagar Dantiwada Agricultural University, SK Nagar | *Ailanthus excelsa*<br>*Azadirachta indica*<br>*Melia*<br>*Moringa oleifera* | *Ailanthus*-based medicinal plants agroforestry system, *Melia dubia* based Agroforestry, *Melia azedarach* agroforestry system, Boundary Plantation |

| | | |
|---|---|---|
| Sardarkrushinagar Dantiwada Agricultural University, SK Nagar | *Ailanthus excelsa*<br>*Azadirachta indica*<br>*Melia*<br>*Moringa oleifera* | *Ailanthus*-based medicinal plants agroforestry system, *Melia dubia* based Agroforestry, *Melia azedarach* agroforestry system, Boundary Plantation |
| Sri Karan Narendra Agriculture University, Regional Research Station, Fatehpur-Shekhawati | *P. cineraria* | *Ailanthus excelsa* based system, *Hardwickia binata* based agroforestry system, Effect of agroforestry systems on soil properties, Irrigation and mulching schedule for budded *P. cineraria* |
| Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Jammu (J & K) | *Terminalia chebula* | *Terminalia chebula* based Silvipastoral System, *Melia composita* based agroforestry system |
| Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Srinagar | *Salix alba* var. Caerulea | Apple based system, Apricot based agroforestry system, Walnut based agroforestry system, Salix based silvi-pastoral system |
| Tamil Nadu Veterinary and Animal Sciences University, Kattapukkam | - | Hortipasture in degraded wastelands, *Psidium guajava* based pasture system, Gliricidia based silvipastoral system, Cocus nucifera based Hortipastoral system |
| The University of Agricultural and Horticultural Sciences, Shivamoga | *Bamboo* sp.,<br>Mahogany | Litsea based agroforestry, Bamboo based agroforestry<br>*Dendrocalamus stocksii* based agroforestry |
| University of Agricultural Sciences, Bengaluru | *Tamarindus indica*<br>*Pongamia pinnata,*<br>*Melia dubia, Casuarina* | *Melia dubia* based agroforestry system, Mango , based agroforestry system, Teak based agroforestry system, Sandal based agroforestry system, Mahagony based agroforestry system |
| University of Agricultural Sciences, Dharwad | *Pongamia pinnata,*<br>*Tamarindus indica,*<br>Thorn less bamboo,<br>*Azadirachta indica,*<br>*Melia dubia,*<br>*Embilica officinalis,*<br>*Carisa carandas* | Neem based agroforestry system, Sapota-timber species-based agroforestry system, TBO based agroforestry, Fodder tree based agroforestry system (7 species), Red sanders block plantation |
| Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Solan | *Grewia optiva*<br>*Morus alba* | Fruit tree based agroforestry systems, *Grewia optiva* based agroforestry system, *Morus alba* based agroforestry system, *Sapindus mukrosii* based agroforestry system and peach-based agroforestry system |

**Subsidiary activity**

**Quality Planting Materials**

More than 90000 seedlings of different MPTs were produced in nurseries and were sold and/or distributed besides different other intercrops.

**Farmers' Outreach**

The AICRP-Agroforestry centres registered a net outreach of agroforestry technologies to benefit over 15000 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 Coordinating centres of the project undertook various activities for the welfare of weaker sections of the society belonging to Schedule Tribe and Schedule Cast categories by providing various inputs in form of seedlings, seeds of intercrops, fertilizers, small equipment for ensuring livelihood opportunities and nutritional security. The centres also conducted capacity building programmes for skill upgradation and knowledge enhancement for adopting agroforestry-based land use system.

**Annual Group Meeting of Agroforestry at PJTSAU**

The Annual Group Meeting for 2021-22 held at PJTSAU,

Hyderabad to deliberate on the progress of the AICRP on Agroforestry with participation from 26 centres from SAUs and ICAR voluntary centres. Dr. S.K. Chaudhari, DDG(NRM), ICAR, New Delhi was the Chief Guest of the inaugural session. Dr. Ch, Srinivasa Rao, Director, NAARM, Hyderabad and Dr. M. Venkata Ramana, Registrar, PJTSAU, Hyderabad Delhi addressed the session appreciated the efforts of the ICAR-CAFRI as well as OIC, PJTSAU. The program was presided over by Dr. A. Arunachalam, Project Coordinator & Director, CAFRI who presented the overview of the AICRP on Agroforestry with specific emphasis on its salient achievements. The Chief Guest released the Annual Report-2023 of AICRP on Agroforestry and also technical bulletins from the centres. The inaugural session was attended by all ICAR-CAFRI scientists, staff, and employees. The event was coordinated by Dr. A.V. Ramanjaneyulu OIC, PJTSAU; Dr. A. K. Handa, Principal Scientist and Sh. Suresh Ramanan, S., Scientist and the vote of thanks was given by Dr. A.V. Ramanjaneyulu OIC, PJTSAU.

The Officers-in-charge (OICs) of the centre presented their progress reports in the subsequent technical sessions and discoursed on the findings. The Project coordinator commented and provided suggestions for improvements. The project coordinator also appreciated the efforts for presenting the common experiments in the centres collectively. It was also reiterated that OICs should present only the progress of AICRP on agroforestry work and refrain from presenting other scientific achievements to avoid duplicity in reporting. All centres are requested to get in touch with the AICRP secretariat for any assistance regarding data analysis and interpretation. On the second day, the progress reports presentation of Officers-in-charge (OICs) continued under the chairmanship of Dr. Rajbir Singh, ADG (AA&CC), NRM, ICAR, New Delhi. The ADG insisted on documentation of success stories based on the intervention from AICRP centres and appreciated the publications from the centres. Dr. B.P. Bhatt, Principal Scientist, NRM, ICAR, New Delhi recommended the OIC should explore new thematic areas like Genomics, Variety/Clone development, Hydrology & Evapotranspiration Carbon and Calories, Nutrients and Nutrition, Scoping the entire plant, Tree-crop-livestock integration, Soil Health, Value addition, Tools and tool kits, etc. in the ambit of agroforestry under the AICRP on Agroforestry project. In the afternoon session, an exclusive session on Tree Genetic Resources Accessioning and Registration from Dr. K.P. Mohapatra, NBPGR, New Delhi presented on getting Indigenous Collection (IC) number for germplasm collection in the AICRP centres The AICRP unit at ICAR-CAFRI will provide assistance to the centres.

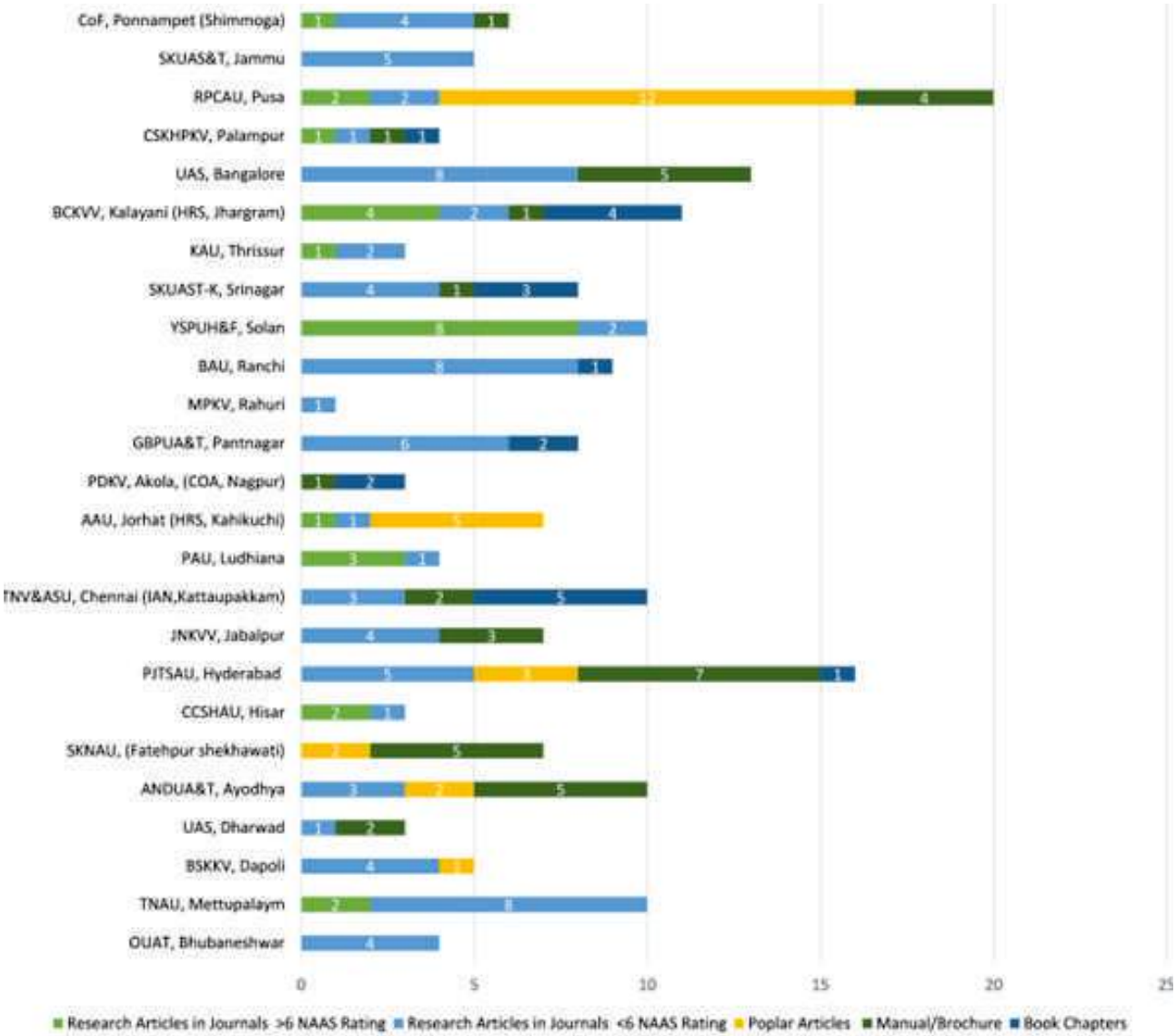
The Ministry of Agriculture and Farmers Welfare has notified the ICAR-Central Agroforestry Research Institute, Jhansi as nodal agency for QPM related activities. In this regard, the The AICRP unit of ICAR-CAFRI also presented the recent developments on the Quality Planting Material (QPM) including accreditation framework for nurseries. Commenting on the development, the ADG advised that AICRP centres can be roped in as nursery auditors during the piloting of the framework. The field visits on the agroforestry trials at PJTSAU was also carried out parallelly and an exclusive field visit to the Agroforestry laboratory cum Field Centre and the Agroforestry Biodiversity Park was conducted on third day.

The group meeting ended with commitment to all partners and delegates to adhere to the decisions taken and action points devised with timelines. Certificates were given to best centres at the plenary session. On the sidelines of meeting, the Agroforestry Variety Identification Committee (AVIC) convened and scrutinised two proposals on identification of neem variety and to carry out multi-location trails proposal for elite genotype of *Cassia auriculata.* The proposal were accepted and recommended for further necessary action.

**Symposium on Quality Planting Materials**

On the sidelines of the AICRP Group Meeting, a National Symposium on Quality Planting Material was also organized where it was informed to house that the Ministry of Agriculture and Farmers Welfare has notified the ICAR-Central Agroforestry Research Institute, Jhansi as nodal agency for QPM related activities. The AICRP unit of ICAR-CAFRI also presented the recent developments on the Quality Planting Material (QPM) including accreditation framework for nurseries. Commenting on the development, the ADG advised that AICRP centres must be roped in as nursery auditors during the piloting of the framework.

## Research Publications



# 4. Awards and Recognitions

**a) Institutional**

- Ministry of Agriculture and Farmers' Welfare, Government of India, notified the ICAR-CAFRI, Jhansi as National Nodal Agency for Agroforestry for QPM under RKVY (2023).

**b) Team**

- Ashok Yadav, Sandeep Garg, Neha Gangwar, Vinay Nayak, AK Handa and Ayyanadar Arunachalam received first prize in poster presentation i.e. "Chironji Gond ka Nutraceutical Vishleshan or LC-MS/MS Vidhi ke Madhyam Se Bioactive Compound Profiling" organized by ICAR-Central Agroforestry Research Institute, Jhansi under Hindi Pakhwada (14-29 September 2013) on 29.09.2023
- Sandeep Garg, Ashok Yadav, Vinay Nayak, Priyanka Singh, R.P. Diwedi, Badre Alam and Ayyanadar Arunachalam received second prize in poster presentation i.e. "Bundelkhand Ke Ardh Sushk Kshetra Me Tulsi Ki Kheti: Sthiti, Hastchep, Chunotiya or Safalta Ki Kahani" organized by ICAR-Central Agroforestry Research Institute, Jhansi under Hindi Pakhwada (14-29 September 2013) on 29.09.2023
- Outstanding Partnership Award Science Award 2022 (Resilient Farm and Food Systems Program) conferred to the ICAR-CAFRI team for implementing `Agroforestry based landscape resource conservation for strengthening ecosystem services and rural livelihoods in Central India' by the ICRISAT, Hyderabad.

**c) Individual**

- Dr. K. Rajarajan conferred ISAF Fellowship Award for the year 2022 during the foundation day of Indian Society of Agroforestry (ISAF) on 18th June, 2023.
- Dr. K Rajarajan conferred Employee of the Month (December, 2023) by the Director, ICAR-Central Agroforestry Research Institute, Jhansi.
- Dr. Ahajyothi received Dr. Rana Memorial Best Poster Award for the poster (*Bacillus subtilis* as a shuttle microbe potential for broad spectrum antifungal activity and growth promotion in agroforestry) presented in 64th Annual International Conference of Association of Microbiologists of India – 2023 Microbes for LiFE: A strategy for well-being (MLiFE-2023) during December 1-3rd, 2023
- Dr. A. Arunachalam notified as member, National Advisory Committee of the 13th NABS- National Conference on Current Perspectives for Sustainable Development in Life Sciences,
- Environment and Agriculture; organized by Periyar University and NABS on 23rd -25th January, 2023.
- Dr. A. Arunachalam notified as member, Advisory Board, National Conference on Agro- ecology based Agri-food Transformation Systems. Organized by ICAR-Indian Institute of Farming System Research and Farming System Research and Development Association, Modipuram on 27-28 January, 2023.
- Dr. A. Arunachalam notified as member, Organizing Committee of the National Symposium on Digital Farming: The Future of Indian Agriculture. Organized by Indian Society of Agrophysics, Bhopal on 2nd -3rd February, 2023.
- Dr. A. Arunachalam received Dr. M.S. Swaminathan Gold Medal during the 8th National Conference on Agricultural Scientific Tamil organized by TNFSU, Nagapattinam during 25th - 26th February, 2023; organized by Agricultural Scientific Tamil Society, New Delhi.
- Dr. A. Arunachalam notified as session Chairperson, International Conference on Averting Adverse Climate Change Impacts-2023 and National Symposium on Searching Innovative Technological Solutions for safeguarding humanity (AACCI-SITS-2023) on 2nd - 3rd March, 2023.
- Dr. A. Arunachalam notified as Co-Patron, Organizing Committee of the International Conference on Biodiversity, Food Security, Sustainability & Climate Change on 25th -28th April, 2023; organized by Assam Agricultural University, Jorhat and Prof H.S.Srivastava Foundation for Science, Lucknow.
- Dr. A. Arunachalam notified as Co-Patron, Organizing Committee, 1st International Conference on Nature and Natural Sciences (ICNS 2023) on 5th -6th May, 2023; organized by the Asian Biological Research Foundation, Allahabad.
- Dr. Ashok Yadav, received 1st prize in the volleyball event organized by ICAR-CAFRI on the occasion of foundation day of ICAR-CAFRI Jhansi on 08th May, 2023.
- Dr. Ashok Yadav, received 1st prize in the Badminton Singles event organized by ICAR-CAFRI on the

occasion of foundation day of ICAR-CAFRI Jhansi on 08th May, 2023.

- Dr. Ashok Yadav, received 1st prize in the Badminton doubles event organized by ICAR-CAFRI on the occasion of foundation day of ICAR-CAFRI Jhansi on 08th May, 2023.
- Dr. Priyanka Singh received *"Mahila Krishi Vaigyanik Award 2022"* by Indian Society of Agroforestry (ISAF) during foundation day of ISAF on 19th June 2023.
- Dr Asha Ram awarded ISAF Gold Medal for the year 2022 during the foundation day of Indian Society of Agroforestry (ISAF) on 18th June, 2023.
- Dr. A. Arunachalam notified as chairman, Project Monitoring Committee for the NABARD project titled `Development and evaluation of pomegranate-based agroforestry system in Bundelkhand region for higher productivity and economic returns in farmers' field', ICAR- CAFRI, Jhansi (2023-25).
- Dr. A. Arunachalam notified as member, Steering Committee of FOLU (The Food and Land Use Coalition) India's NCMA (Nature based solution for climate mitigation and adaptation) Program w.e.f. 20
- Dr. A. Arunachalam notified as Project Director - The Economics of Ecosystems and Biodiversity (TEEB) for Agriculture and Food Initiative in India (2023-24) - 186832.69 USD.
- ISA Associateship Award Dr. Asha Ram awarded the ISA Associateship Award 2022 by the Indian Society of Agronomy in recognition of his outstanding contribution in agronomy discipline. Award was given during the Agronomy National Symposium at Goa during 21-24 November 2023.
- Dr. A. Arunachalam notified as supervisor of Pandey, K. (M.Sc. Environmental Science) – Influence of biochar on growth characteristics of *Sapindus mukorosii* Gaertn. Submitted to Gautam Buddha University, Greater Noida (2022-23).
- Best employee of the month awarded during January to June 2023 to the staff members of ICAR-CAFRI, Jhansi have Shri Suresh Ramanan S., (January), Shri Rajendra Singh (March), Shri Tridev Chaturvedi (March), Shri Jai Janardan Singh (March), Shri Om Prakash (March), Dr. Hirdayesh Anuragi (April), Dr. R. P. Dwivedi (June) and Shri Gautam Saxena
- Dr. Ashok Yadav was nominated as a member in the Committee constituted for the specifications of the indented equipment for the College of Agriculture, College of Horticulture & Forestry, and other Sections of the RLBCAU, Jhansi on 3rd August 2023 with notification Ref No: 1058/RLBCAU/ DE /2023
- Dr Ashok Yadav was appointed as an Editorial Board Member of the American Journal of Agriculture and Forestry (AJAF) ISSN Print: 2330-8583; ISSN Online: 2330-8591 from October 10, 2023 to October 10, 2026
- Dr. Ashok Yadav was a member of the "Scientific Advisory Meeting" on 22nd December 2023 of Krishi Vigyan Kendra Bharari Jhansi, Uttar Pradesh.
- Dr. Ashok Yadav was a member of the "Scientific Advisory committee" in 64th Annual International Conference of Association of Microbiologists of India - 2023 titled "Microbes for LiFE (Lifestyle for Environment): A strategy for well-being (MLiFE-2023)" from December 1-3rd, 2023 organized by Department of Microbiology, Bundelkhand University, Jhansi, Uttar Pradesh, and ICAR-CAFRI Jhansi, Uttar Pradesh, India.
- Editorial board member, Indian Research Journal of Extension Education, Society of Extension Education (SEE), Agra. 2023.
- External Examiner for conducting practical examination and evaluation of answer books of theory examination (B.Sc. Hons. Agriculture) at Rani Lakshmi Bai Central Agricultural University, Jhansi, 2023.
- Dr R.P. Dwivedi participated in the meeting as Member of Board of Studies in Bundelkhand University, Jhansi on 14.09.2023.
- Dr R.P. Dwivedi Delivered lecture as resource person on the topic "Extension and Communication Approaches for Sustainable Agriculture" during winter school at Department of Extension, RVSKVV, Gwalior on 05.10.2023

# 5. Ongoing Research Projects (2023)

| Title of the Project | PI/Co-PI |
|---|---|
| **(A) Agroforestry System Research (ASR) Programme** | |
| Assessment of conservation agroforestry | **Asha Ram** |
| 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 Dev Nath**/ Suresh Ramanan S. |
| **(B) Tree Improvement Research (TIR) Programme** | |
| Multi-locational evaluation of *Melia dubia* clones | **A.K. Handa**/ Naresh Kumar |
| Genetic characterization of neem germplasm for high azadirachtin yield | **K. Rajarajan**/ Hirdayesh Anuragi |
| 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 |
| Assessment of ecosystem services in silvi-pastoral system in semi-arid conditions | **Asha Ram** |
| | |
| **(D) Agroforestry Extension Research (AER) Programme** | |
| Constraints in adoption of agroforestry in Bundelkhand region of Central India | **R.P. Dwivedi**/ Sushil Kumar and Priyanka Singh |
| Evaluating 3R's for carbon neutrality in melia based agroforestry system | **Sushil Kumar**/ Sovan Debnath and Mr. Suresh Ramanan S |
| 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 | Duration | Agency | Budget (Rs. Lakh) |
|---|---|---|---|---|
| Harvest and post-harvest processing and value addition of natural resins, gums and gum-resins | **Rajendra Prasad** A K Handa and Badre Alam | 2008- Ongoing | ICAR, IINR&G Ranchi | 179.62 |
| National Agriculture Innovation Fund (NAIF) Scheme | **Suresh Ramanan S.** Ashok Yadav | 2017-Ongoing | ICAR-NAIF | 7.40 annual |

**All India Coordinated Research Project on Agroforestry**

| Title of the Project | PI/Co-PIs | Year of Start | Completion | Agency | Budget (Rs. Lakh) |
|---|---|---|---|---|---|
| All India Coordinated Research Project on Agroforestry (AICRP-Agroforestry)* | **Dr. A Arunachalam (Project Coordinator)** A K Handa (Nodal Scientist) & Suresh Ramanan S (Associate Scientist) | 1997 | Ongoing | ICAR, | 1237.91 |

*AICRP-Agroforestry Secretariat

**Externally Funded Projects**

| Title of the Project | PI/Co-PIs CC-PI/CC-Co-PI | Duration | Agency | Budget (Rs. Lakh) |
|---|---|---|---|---|
| Trees Outside Forests in India (TOFI) | **A Arunachalam** Project Director PI: A K Handa, Co-PIs: 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** Project Coordinator PI: A K Handa & Co-PI: Suresh Ramanan S, | Oct, 2021-Mar, 2026 | DST, New Delhi | 952.6 (CAFRI Component: 1.74 Cr.) |
| Pilot the solutions of chip-based technology for real time and RFID-passive monitoring of field gene bank and agroforestry species for scaling up | **K Rajarajan**, H Anuragi | 2022-June, 2024 | ICRAF-ICAR Work Plan | 8.11 |
| 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-Mar, 2024 | IRM Enterprises Pvt. Ltd. Ahmedabad | 41.96 |
| "Agri-Drone Project" | **Asha Ram** | Aug, 2022-Mar, 2024 | ICAR, New Delhi | 17.50 |
| 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 | 24.65 |
| *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) | **Director, CAFRI,** A K Handa, Suresh Ramanan S | Nov, 2023-Mar, 2027 | MA & FW, GOI | 28.56 |
| The Economics of Ecosystems and Biodiversity (TEEB) for Agriculture and Food Initiative in India | **A. Arunachalam** Coordinator A K Handa, Nodal Member & Suresh Ramanan S, Member | Jun 1, 2023-Mar, 2024 | UNEPs Nairobi, Kenya | 76.94 |
| Laboratory bio-assay of newer fumigant molecules against storage insects | **Venkatesh YN** | Jun, 2023-Mar, 2024 | ICAR-NCIPM, New Delhi | 3.13 Lakh |

**Research Project concluded in 2023**

| S.No. | Title of the Project | PI/Co-PIs |
|---|---|---|
| 1. | Text mining for assessing research trends and gaps of agroforestry perennials: A Big data analysis approach | **Suresh Ramanan S.**/ A. Arunachalam |
| 2. | Impact assessment of agroforestry and water conservation interventions on livelihood of farmers in Garhkundar-Dabar watershed | **Sushil Kumar**/ Priyanka Singh |
| 3. | Economic impact of ICAR-CAFRI interventions in Parasai-Sindh watershed | **Priyanka Singh**/ R.P. Dwivedi |

**Externally Funded Projects concluded in 2023**

| Title of the Project | PI/Co-PIs | Duration | Agency | Budget (Rs. Lakh) |
|---|---|---|---|---|
| Assessment of genetic potential of neem germplasm for higher yield and oil content through molecular markers | **K Rajarajan,** H Anuragi & Alka Bharti* | 2019- March, 2023 | NRAA, Govt. of India | 21.95 |

**Inter-Institutional Collaborative Projects concluded in 2023**

| Title of the Project | PI/Co-PIs | Duration | Funding of the Project |
|---|---|---|---|
| Farmer FIRST programme (FFP): Scaling up and integration of fodder technologies in existing farming system for sustainable livestock productivity in Bundelkhand | **Purshottam Sharma** (PI) Sunil Seth S K Mahanta Harsh Vardhan Singh Mukesh Choudhary & RP. Dwivedi | 2016-2022 | Inter-Institutional (IGFRI Jhansi) |
| Study of soil-hydrothermal environment under natural vs. synthetic mulch | **Nilimesh Mridha** (PI), D.B. Shakyawar, Atul Singha, Manik Bhowmick, Haokhotang Baite, Ashok Yadav, Manoj Kundu, Dipak Nayak & Vinod Kadam | April 2020-March,2023 | Inter- Institutional (NINFET Kolkata, (W.B.) |

# 6. Important Events/Meetings/Days Observed

## *Days Observed*

### Celebration of 95th Foundation Day of ICAR

ICAR, New Delhi celebrated 95th Foundation Day on 16th July, 2023. On the occasion, ICAR-CAFRI, Jhansi displayed the research publications and Annual Report of the institute and AICRP on Agroforestry during ICAR Foundation Day and Technology Day at NASC complex New Delhi along with other ICAR institutes exhibited Agroforestry Technologies generated for the benefit of farmers and others. Dr A. Arunachalam, Director of the institute participated in the event and attained an interface meeting between NRM institutes of ICAR and industry at New Delhi on 17th-18th July, 2023. During the interaction meeting future collaborative areas with industry has been identified.

### International Women's Day

ICAR-CAFRI, Jhansi organized International Women's Day on 8th March, 2023 under the UN theme 'DigitALL – Technology and innovation for gender equality'. The women employees of the institute have graced the occasion and shared their strong opinions on gender equality and equity.

### International Day of Forests and World Water Day

ICAR-CAFRI, Jhansi organized International Day of Forests and World Water Day on 21st March, 2023. On the occasion, 5 KM long Walkathon-Walk for Agroforestry (Krishivaniki Pad Yadra) was organised in the research farm area of the CAFRI. During the walk, Dr. RP Dwivedi chanted the slogans on Agroforestry. Apart from Agroforestry Ambassadors, CAFRI employees as well as staff working on different projects also participated enthusiastically in the programme.

### International Heritage Day

ICAR-CAFRI, Jhansi in collaboration with Indian Society of Agroforestry (ISAF), Jhansi and Indo-Global Social Service Society (IGSSS) New Delhi jointly organized "International Heritage Day" on 18th April, 2023 with theme "Agroforestry for Low carbon Future**." Dr. Ajit Kumar Shasany, Director, CSIR- National Botanical Research Institute, Lucknow** was the chief guest of the function and delivered an expert talk on the occasion. All the Staff members and 25 Farmers from Mahoba district (Uttar Pradesh) were participated.

### Earth Day

ICAR-CAFRI, Jhansi celebrated "Earth Day" on 21st April, 2023 to raise awareness regarding the importance of climate change and way to protect our planet. Prof. S.P. Singh, Geologist, Bundelkhand University, Jhansi delivered an expert talk on the occasion as chief guest of the function. All the Staff members participated in a quiz contest and attended the programme.

### World IP Day, 2023

ICAR-CAFRI, Jhansi celebrated "World IP Day" on 26th April, 2023 with the theme "Women and IP: Accelerating Innovation and Creativity" and in this context a workshop is also organized to celebrate the "Can Do" attitude of women researchers, scientists, Inventors, creators and entrepreneurs.

### 36th Foundation Day of ICAR-CAFRI, Jhansi

ICAR-CAFRI, Jhansi celebrated its 36th Foundation Day on 8th May, 2023. On this occasion Prof. A. K. Singh, VC, RLBCAU, Jhansi was Chief Guest. Dr. Franklin L. Khobung Jt Secretary, Ministry of Agriculture and Farmers Welfare, Govt. of India; Dr. R.B. Sinha, IFS Sr. Policy Advisor FAO India Office and Dr. Rajbir Singh, ADG (NRM), ICAR H.Q. were the Guests of Honour of the function. Director, CAFRI presided over the event and also presented power point presentation outlining the accomplishments of the Institute's 35 years of research, training, and extension efforts. The Chief Guest and Guests of Honour on this occasion released bulletins, success stories, agroforestry techniques, strawberry booklets, etc. published by the institute. The dignitaries honoured 23 Agroforestry ambassadors with awards, and digital applications were also released. The exhibition stalls of Rani Laxmibai Central Agricultural University Jhansi, ICAR-IGFRI Jhansi, Krishi Vigyan Kendra, Jhansi, Indo Global Social Service Society, New Delhi, and Farmers Producer Organisations Mr. Shiva Likdhari, Mr. Dilip Rajput, and Mr. Pushpendra Yadav were also displayed on the occasion. All the Staff members attended the programme.

### International Day for Biological Diversity

ICAR-CAFRI, Jhansi organized a program on International Day for Biological Diversity with the theme "From Agreement to Action: Build Back Biodiversity" on 23rd May, 2023. On the occasion a "Biodiversity- Walk" was conducted in the institute to spread the awareness and deepen understanding biodiversity. The programme was attended by all the scientific, administration, technical staff, research associates and young professionals.

**World Environment Day**

ICAR-Central Agroforestry Research Institute, Jhansi organized World Environment Day on 5th June, 2023 in a hybrid mode with participation from representatives of the All India Coordinated Research Project on Agroforestry from throughout the country. On the occasion, plantation drive was initiated in the premises of the institute by the guests. On the eve of the event, CAFRI employees and staff's, research scholars, young professionals, and field assistants pledged to live environmentally friendly lives (LiFE) in honour of World Environment Day. 10 peoples were honored with certificates of Agroforestry ambassadors. The dignitaries presented prizes to the winners of an online quiz and drawing competition organised for the students from schools across the country. From District Mahoba, 25 farmers and women took part in the program.

**Ninth International Yoga Day (IYD 2023)**

ICAR-Central Agroforestry Research Institute, Jhansi celebrated Ninth International Yoga Day (IYD 2023) in the office premises on 21st June, 2023. On the occasion, all the 47 employees of the institute 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.

**77th Independence Day**

ICAR-Central Agroforestry Research Institute, Jhansi celebrated the 77th Independence on 15th August, 2023. This day commemorating the 76th years of Indian independence with zest and fervour. The national flag was hoisted by the Director of the institute.

**National Honey Bee Day**

ICAR-Central Agroforestry Research Institute, Jhansi celebrated National Honey Bee Day on 21st August, 2023 and introduced apiary in agroforestry. On the occasion, Dr. D. B. Ahuja (Emeritus Professor), RLBCAU, Jhansi delivered an expert talk on the 'Importance of Honey bees in the Agroforestry system'. All the Staff members attended the programme.

**World Soil Day celebration**

On December 05, 2023, World Soil Day was celebrated to emphasizing the importance of higher agricultural education to maintain health of soil and water, as the two resources are source of life on earth. Director CAFRI, underlined need for extension of agroforestry on farmland to improve soil health and mitigate challenges of climate change.

***Events Observed***

**International Year of Millets 2023**

ICAR-CAFRI, Jhansi celebrated "International Year of Millets 2023" on 2nd January, 2023 and organized a brain storming session at CAFRI, Jhansi to give impetus for millets cultivation.

**Workshop on "Capacity Building and Vulture Mapping of Uttar Pradesh"**

UP State Biodiversity Board, Lucknow in collaboration with University of Lucknow and the Environment, Forest and Climate Change Department Govt. of Uttar Pradesh organized 1-day workshop on "Capacity Building and Vulture Mapping of Uttar Pradesh" at CAFRI, Jhansi on 9th January, 2023. In this workshop Forest Range Officers, Sub Divisional Officers and District Forest Officers were participated.

**Drone application in Agroforestry**

ICAR-CAFRI, Jhansi introduces Drones application in Agroforestry under agri-drone project of Indian Council of Agricultural Research (ICAR) New Delhi on 12th January, 2023.

***Vichar Manch***

*Vichar Manch* was organized by ICAR-CAFRI, Jhansi on 7th February, 2023. Dr. Puneet Chaudhary, Chief Medical Officer, RLBCAU, Jhansi was the Chief Speakers on the occasion. All the Staff members attended the programme. He talked about mental stress and how to create healthy working atmosphere.

**Hindi Workshop**

ICAR-CAFRI, Jhansi organized quarterly Hindi Workshop on 12th May, 2023. On the occasion, Dr. V. K. Sharma, Deputy Director, State Institute of Rural Development, Itanagar, Arunachal Pradesh was the chief speaker and chief guest of the programme. Dr. Madhuparna Sharma, Assistant Professor, Govt. college Itanagar, Arunachal Pradesh was the Guest of Honour of the programme. The programme was attended by all the scientific, administration, technical staff, research associates and young professionals.

**Celebration of *VAN MAHOTSAV* (1st -7th July, 2023) at ICAR-CAFRI**

ICAR-CAFRI, Jhansi celebrated *Van Mahotsav* Week (1st - 7thJuly, 2023) in which large scale plantation of tree to be undertaken at institute premises. All the employee of the institute along with project staff were participated.

**ICAR-CAFRI, Jhansi participated in AgriExpo 2023**

ICAR-CAFRI, Jhansi participated in AgriExpo 2023 (Shree Annotsav) organized by Agricultural Department, Government of Uttar Pradesh at Rani Durgavati Medical

College, Banda. Shri Surya Pratap Sahi, Agricultural Minister, Government of Uttar Pradesh along with other dignitaries graced the occasion.

**Hindi Pakhwada 14-29 Sept, 2023**

ICAR-CAFRI organized Hindi Diwas from Hindi Pakhwada 14-29 Sept, 2023. Various competitions were held in which staff of CAFRI participated.

**Swachhta Campaign Drive**

ICAR-CAFRI organized Cleanliness drive programmes from 2nd-31st October, 2023. Cleaning work was done in the institute campus as well as in different villages of Jhansi. In this programme, scientists, technical staff and research scholars were participated. The events were widely covered in newspapers.

**Honb'le Secretary, DARE and DG, ICAR visited ICAR-CAFRI, Jhansi**

Honb'le Secretary, DARE and DG, Indian Council of Agricultural Research Dr. Himanshu Pathak visited on 5 October, 2023 at ICAR-CAFRI, Jhansi and reviewed the work being done and here. He also affirmed that agroforestry is the way forward for ensuring livelihood security of farmers and also environmental security. He conferred the Honorary Fellowship Award for his contributions to the agricultural and agroforestry sciences in the current climate change scenario by the Indian Society of Agroforestry at Jhansi, Uttar Pradesh.

**Celebration of Vigilance Awareness week**

All staff members of ICAR-CAFRI Jhansi participated in Vigilance Awareness week and took pledge on 01.11.2023 on the occasion and created awareness to eradicate corruption.

***Meetings Observed***

**The RAC Meeting**

ICAR-CAFRI, Jhansi conducted Research Advisory Committee Meeting on 20th March, 2023 in hybrid mode. The meeting was chaired by Dr. Parvinder Kaushal, Vice-Chancellor, Uttarakhand University of Horticulture & Forestry, Uttarakhand alongwith constituent members Dr. A.K. Shukla, Vice-Chancellor, RVSKVV, Gwalior; Dr. N.B. Singh, Vice-Chancellor, B.N. University, Udaipur; Dr. K. Sammi Reddy, ICAR-NIASM, Baramati; Dr. Rajbir Singh, Assistant Director General, ICAR, New Delhi; Dr. K.T. Parthiban, Dean, (Forestry), Forest College and Research Institute, Mettupalayam and Dr. N. Narasimha, Former Professor, Bangalore Agriculture University and 10 progressive farmers were manifested as Agroforestry Ambassadors and keeping in view their contribution in promotion of Agroforestry, certificates were distributed by the chairman and members of Research Advisory Committee.

**Meeting with UNEP representatives**

ICAR-CAFRI, Jhansi conducted two Days meeting with UNEP representatives with regard to the implementation of "The Economics of Ecosystems and Biodiversity - TEEB Agri-Food in Assam" on 13th July, 2023.

**A meeting on collaborative research with World Neem Organization**

ICAR- CAFRI Jhansi had a meeting under the Chairmanship of Director CAFRI with President, Secretary and Treasurer of World Neem Organization to discuss the future areas for collaborative research, on 24th September, 2023.

**The Annual Group Meeting of AICRP on Agroforestry**

A three day Annual Group Meeting of AICRP on Agroforestry and Symposium on Quality Planting Material Production concluded during 16-19 October, 2023 at PJTSAU Hyderabad. The meeting was attended by scientists from different coordinating centres of the project located all over the country. The meet was inaugurated by Dr S K Chaudhari, Deputy Director General NRM ICAR New Delhi. Dr A Arunachalam Director CAFRI Jhansi and Project Coordinator of the project highlighted the project achievements for the last year. Dr Rajbir Singh ADG Agronomy Agroforestry and Climate Change ICAR and Dr. B P Bhatt from ICAR headquarters also participated in the meet.

**TEEB AgriFood Initiative for promotion of agroforestry in Assam**

On 18th November 2023, Director, ICAR-CAFRI, Jhansi presented the results of TEEB AgriFood Initiative for Assam to the stakeholders and discussed on various aspects of promotion of agroforestry and organic farming in the State. Further, the action plan for the TEEB AgriFood Learning Landscape was launched. The stakeholders consultation was held in NIRD Conference Facility in Guwahati and the launch was graced by Additional Chief Secretaries - Shri R.S. Prasad, IAS (Environment and Forest) and Dr Ashish Bhutani, IAS (Agriculture), Shri A Saikia (Industries Dept), Ms Sonali Ghosh, IFS (Project Director, Kaziranga), Dr Babu (Tocklai Tea Research Institute) and may others from civil society, academia, partner institutions and media.

# 7. Participation in Workshop/Webinars/Meetings/Symposia

| Duration | Event | Organizer | Participants |
|---|---|---|---|
| 24 January 2023 | Workshop on Importance of plant variety conservation and the implication of PPV&FRA | ICAR-CAFRI, Jhansi | Dr. Sovan Debnath & Dr. Priyanka Singh |
| 16-25 January 2023 | Workshop on Airborne hyperspectral remote sensing in agriculture | ICAR-IARI, New Delhi | Dr. Venkatesh YN |
| 24 February 2023 | Workshop on Promotion of agroforestry in Uttar Pradesh | U.P. Forest Dept. | Dr. Sovan Debnath |
| 24 March 2023 | National Seminar on Market Led Agriculture towards One Nation One Market | RLBCAU , Jhansi in association with ICSSR, New Delhi | Dr. Priyanka Singh |
| 17 May 2023 | Webinar on Monetizing carbon credits in farmlands for benefitting Indian farmers | MANAGE, Hydrabad | Dr. Sovan Debnath |
| 30 May 2023 | Webinar on "Linking FPOs to Alternative Marketing System" | MANAGE, Hydrabad | Dr. Priyanka Singh |
| 19-21 June 2023. | 6$^{th}$ International Conference on Advances in Agriculture Technology and Allied Sciences (ICAATAS 2023) | | Dr. Priyanka Singh |
| 5 July 2023 | Udhamita Vikas Aur Aajeevika Samvardhan (work4progress) | Action Aid Association, NGO, Jhansi | Dr. Sushil Kumar |
| 3-12 July 2023 | Workshop on "Hands-on Training on physiological and bio-molecular techniques for Crop Improvement" | RLBCAU, Jhansi | Dr. Badre Alam |
| 17 July 2023 | Kharif Utpadkta Gosthi/Kisan Mela/ Pradarshani | Agriculture Department, Jhansi | Dr. Sushil Kumar |
| 23 July 2023 | *Kharif Kissan Gosthi* at BUAT Banda | Agriculture Department, Govt of U.P | Dr. Ashok Yadav & Dr. Naresh Kumar |
| 6 September 2023 | Project implementation and monitoring meeting (PIMC) under the NABARD-funded project | NABARD & CAFRI, Jhansi | Dr. Ashok Yadav |
| 8-9 September 2023 | National conference on medicinal plants, natural products and Indian system of medicine (NCMP-2023) | Jointly organized by V Sivaram Research Foundation and ICAR-CAFRI, Jhansi | Dr. Badre Alam, Dr Asha Ram, Dr. Sushil Kumar, Dr. Hirdayesh Anuragi, Venkatesh YN, Dr. Ashok Yadav, Ashajyothi, M & Dr. Priyanka Singh |
| 4 October 2023 | Online workshop on "Tree Genetic Resources for Agroforestry" | ICAR-CAFRI, Jhansi. | Dr. Badre Alam, Dr. Priyanka Singh, Dr. Ashok Yadav & Dr. Sovan Debnath |
| 4-5 October 2023 | Millets Karyashala/Pradarshani | Agriculture Department, Jhansi | Dr. Sushil Kumar |
| 16-18 October 2023 | Annual Group Meeting of AICRP on Agroforestry and Symposium on Quality Planting Material Production | PJTSAU, Hyderabad | Dr. K. Rajarajan |

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|---|---|---|---|
| 20 October 2023 | Rabi Utpadkta Gosthi/Mandal Estariya Tilhan Mela | Agriculture Department, Jhansi | Dr. Sushil Kumar |
| 7-9 November 2023 | Future prospects of crop biofortification in India: An Antidote to malnutrition | MANAGE and ICAR-CAFRI | Dr. Venkatesh YN & Dr. Ashajyothi, M. |
| 16-17 November 2023 | National Symposium for UNEP EUPI TEEB AgriFood India Project (online) | ICAR-CAFRI, Jhansi. | Dr. Priyanka Singh |
| 22-24 November 2023 | Symposium on "Climate Smart Agronomy for Resilient Production Systems and Livelihood Security" | ICAR-Central Coastal Agricultural Research Institute, Goa | Dr Asha Ram |
| 1-3 December 2023 | 64th Annual International Conference Association of Microbiologists of India-2023 Microbes for LiFE: A strategy for well-being (MLiFE-2023) | Microbiologists of India, Bundelkhand University and ICAR-CAFRI, Jhansi | Dr. Sushil Kumar, Dr. Venkatesh Y.N. & Dr. Ashajyothi, M. |
| 19 December 2023 | Annual Workshop of All India Network Project on HPVA of NRGs in virtual mode | ICAR-CAFRI, Jhansi | Dr. Badre Alam |

# 8. Publications

**(A) Research Article**


Alam, B., Taria S. and Kumar S., Handa A.K. and Arunachalam, A. (2023). Clonal plants revealed higher physiological efficiencies in photosystem protection and antioxidant activities than seedling plants of *Pongamia pinnata* to cope with hot summer climate. *Indian Journal of Agroforestry* 25(1): 65-69.

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Jaivik Kheti: Buniyadi Siddhant aur Abhyas (2023) Priyanka Singh, A Arunachalam, RP Dwivedi and Sushil Kumar. Extension Leaflet 07/2023, ICAR-CAFRI, Jhansi.

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**(E) Symposia/ Seminar/ Workshops (Abstracts/ Full Paper)**

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# 9. Trainings and Capacity Building

## A. Participation in Trainings

| Event | Duration | Organizer | Participants |
|---|---|---|---|
| Training Programme on Advances in Mobile Application Development | 07th-11th August, 2023. | ICAR-NAARM, Hyderabad (Virtual mode) | Dr. Hirdayesh Anuragi |
| Training on Biosecurity and Biosafety: Policies, Diagnostics, Phytosanitary Treatments and Issues | 04th-14th September, 2023. | ICAR-NBPGR, New Delhi, | Dr. Hirdayesh Anuragi |
| Training programme on Next Generation Sequencing and DATA Analysis organized | 16th-20th October, 2023. | ICAR-NAARM, Hyderabad (Virtual mode) | Dr. Hirdayesh Anuragi |
| Plant Microbiomes: Theory and Application' | 20th February-03rd March, 2023 | Joint efforts of ICAR-IARI, New Delhi, The Netherlands Institute of Ecology and Leiden University, Netherlands. | Dr. Ashjyothi |
| NAHEP sponsored Training cum Workshop on " Airborne Hyperspectral Remote Sensing for Agriculture" | 16th-25th January, 2023 in Hybrid Mode | Organized at the Division of Agricultural Physics, ICAR-IARI, New Delhi | Dr. Ashok |
| Online Training Programme on "Impactful ICT Applications and Technologies in Agriculture" | 06th-10th February, 2023 | ICAR-NAARM | Dr. Ashok |
| Online Training Programme on " "Monetizing Carbon Credits in Farmlands for benefiting Indian Farmers" | 17th-19th May, 2023 | Organized jointly by ICAR-Central Agroforestry Research Institute, Jhansi (Uttar Pradesh) and National Institute of Agricultural Extension Management, Hyderabad (Telangana) | Dr. Ashok Yadav |
| 10 days training on "Biosecurity and Biosafety: Policies, Diagnostics, Phytosanitary Treatments, and Issues" | 4th-14th September, 2023, | ICAR-National Bureau of Plant Genetic Resources, New Delhi | Dr. Ashok Yadav |
| Training on "Phenomics: High throughput phenotyping for climate resilience crops non-invasive approaches | 26th October-4th November, 2023 | Nanaji Deshmukh Plant Phenomics Center, Division of Plant Physiology, ICAR-IARI | Dr. Sukumar Taria |
| Participated in XVI Agricultural Science Congress organised | 10th-13th October, 2023 | NASS, New Delhi and ICAR-CMFRI | Dr. Sukumar Taria |

**B. Training organized for Employees and other stakeholders**

| Event | Duration | Venue | Participants | Coordinaters |
|---|---|---|---|---|
| Training on "Improved agricultural practices | February 06-07, 2023 | ICAR-CAFRI, Jhansi | 25 | Dr. Asha Ram, Dr. Naresh Kumar & Dr. Priyanka Singh |
| Training on "Improved agricultural practices" | February 08-09, 2023 | ICAR-CAFRI, Jhansi | 25 | Dr. Asha Ram, Dr. Naresh Kumar & Dr. Priyanka Singh |
| Training on "Organic farming, improved agricultural practices and low cost crop" | March 02-03, 2023 | ICAR-CAFRI, Jhansi | 25 | Dr. Sushil Kumar, Dr. Asha Ram & Dr. Priyanka Singh |
| Organized "Hands on-training programme on Basic Plant Biotechnology Techniques for ITM students | March 12-15, 2023 | ICAR-CAFRI, Jhansi | 19 | Dr. K.Rajarajan & Dr. Badre Alam |
| Online Training Programme on “Monetizing Carbon Credits” | May 17-19, 2023 | ICAR -CAFRI, Jhansi in collaboration with National Institute of Agricultural Extension Management (MANAGE), Hyderabad | | Dr.A. Arunachalam & Mr. Suresh Ramanan S. |
| Training program on Future Prospects of Crop Biofortification in India: An Antidote to Malnutrition | November 07-09, 2023 | ICAR -CAFRI, Jhansi in collaboration with National Institute of Agricultural Extension Management (MANAGE), Hyderabad | 66 | Dr. Hirdayesh Anuragi & Dr. M. Ashajyoti |
| Climate change impact modelling for Indian Himalayan Region | November 20-24, 2023 | ICAR-CAFRI, Jhansi | | Dr. A.K. Handa & Mr. Suresh Ramanan S. |
| Training program on "Climate resilient integrated farming practices" | December 05-06, 2023 | ICAR-CAFRI, Jhansi | 30 | Dr. R.P. Dwivedi, Dr. Naresh, & Dr. Asha Ram |
| Training of Trainers (ToTs) on Agroforestry | December 6-9, 2023 | Bhubaneswar, Odisha. | 20 | Dr. A.K. Handa, Mr. Suresh Ramanan S. & Dr. Subhash Ch. Mohapatra |
| Training program on "Climate resilient integrated farming practices in Farmlands for benefiting Indian Farmers" | December 14-15, 2023 | ICAR-ACFRI, Jhansi | 30 | Dr. R.P. Dwivedi, Dr. Naresh & Dr. Asha Ram |

# 10. Scheduled Caste Sub Plan (SCSP) Programme

ICAR-CAFRI is implementing SCSP 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 twelve programmes were organized in which different SC-SP welfare materials like equipments/tools were distributed to the farmers/farm women. Six trainings and Agroforestry Awareness programmes were organized for the benefit of SC community.

The institute has organized 6 training programmes in which 25-30 farmers/farmwomen from Bundelkhand villages have participated.

The ICAR-CAFRI also funded Rs. 7.00 Lakh from SCSP Scheme to RLBCAU, Jhansi.

**Table. Details of the training cum distribution camps organized during 2023 under SCSP at ICAR-CAFRI, Jhansi**

| Sr. No. | Total No. of villages | Beneficiaries of SC farmers | | Distributed items in 2023 |
|---|---|---|---|---|
| | | Male | Female | |
| 1 | 28 | 868 | 440 | 1308 |
| | | | | Spray Pump, Engine Operated Spray Pump Sewing Machines, Solar light, Chaff cutter, Tirpal, Vermi-bag, Grass cutter Machines, Irrigation Pipe, Plastic Irrigation pipe and Tricycle. |

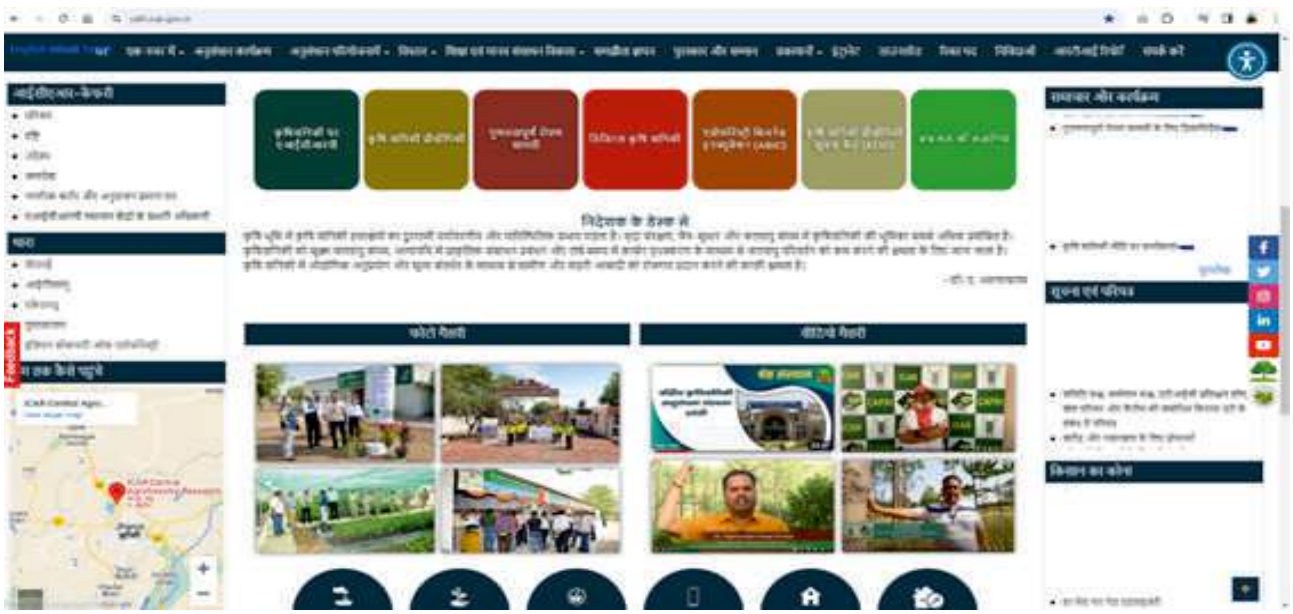
# 11. Distinguished Visitors

- Dr. Puneet Chaudhary, Chief Medical Officer, RLBCAU, Jhansi visited ICAR-CAFRI on 7th February, 2023.
- Sh. Bhupesh Pal, DDM, NABARD was the Chief Guest of the program and Shri Raheesh Singh Yadav, Program Director, Haritika Society visited ICAR-CAFRI on 9th February, 2023.
- Shri Manoj Singh, IAS, Additional Chief Secretary, EF&CC Department, Govt. of Uttar Pradesh and Smt. Mamta Sanjeev Dubey, IFS Principal Chief Conservator of Forest & HoFF, EF&CC Department, Govt. of Uttar Pradesh visited ICAR-CAFRI on 24th February, 2023.
- Shri K.K. Singh, IFS, Chief Conservator of Forests, Jhansi Forest Division, Dr. B Gangwar, Director, Faculty of Agricultural Science, Bundelkhand University, students and professors visited ICAR-CAFRI on 28th February, 2023.
- Sh. Prabhat Panday, RTO, Jhansi visited ICAR-CAFRI on 2nd March, 2023.
- Dr. S.K. Dhyani, Senior Agroforestry Expert, World Agroforestry (ICRAF), New Delhi. On the occasion, Sonya Dewi,Director of Asia and Aqeel Hasan Rizvi, Project manager were visited ICAR-CAFRI on 15th March, 2023.
- Dr. S.K. Chaudhari, Hon'ble Deputy Director General (Natural Resource Management), ICAR and Dr. Parvinder Kaushal, Hon'ble Vice Chancellor, University of Horticulture & Forestry, Bharsar, Uttarakhand visited ICAR-CAFRI on 7th April, 2023.
- Prof. S.P. Singh, Geologist, Bundelkhand University, Jhansi visited ICAR-CAFRI on the occasion of "Earth Day" on 21st April, 2023.
- Dr. Franklin L. Khobung, Joint Secretary, Ministry of Agriculture and Farmers Welfare, Govt. of India; along with Dr. R.B. Sinha, IFS Sr. Policy Advisor FAO India Office and Dr. Rajbir Singh, ADG (NRM), ICAR HQ visited ICAR-CAFRI on 8th May, 2023 .
- Dr. V. K. Sharma, Deputy Director, State Institute of Rural Development, Itanagar, Arunachal Pradesh and Dr. Madhuparna Sharma, Assistant Professor, Govt. College Itanagar, Arunachal Pradesh visited ICAR-CAFRI on 12th May, 2023.
- Sh. Sham Lal Goyal, IAS, Former Chief Secretary, Government of Maharashtra, Dr. Prabhat Pandey, RTO, Jhansi and Dr. Trilochan Singh, Former Scientist, Wadia Institute of Himalayan Geology, Dehradun visited ICAR-CAFRI on 5th June, 2023.
- Prof. P.V. Vara Prasad, University Distinguished Professor, Kansas State University, USA visited ICAR-CAFRI 20th June, 2023 along with Dr. S.K. Dubey, Former Head, IISWC, Agra Centre and discussed global perspectives of sustainable intensification in agriculture.
- Dr. Rajbir Singh ADG (AAF&CC), ICAR visited ICAR-CAFRI on 8th June, 2023
- Honb'le Secretary, DARE and DG, Indian Council of Agricultural Research Dr. Himanshu Pathak visited ICAR-CAFRI, Jhansi on 5th October, 2023 and reviewed the work being done here.
- Shri Hargovind Kushwaha, President, International Baudh Research Centre Lucknow and Minister of State, UP Govt. graced the world soil day program on 5th December, 2023.
- Prof. N.K. Singh, JC Bose Fellow at NIPB, New Delhi visited and interacted with CAFRI scientists on 29th December 2023.

# 12. Digital Reforms

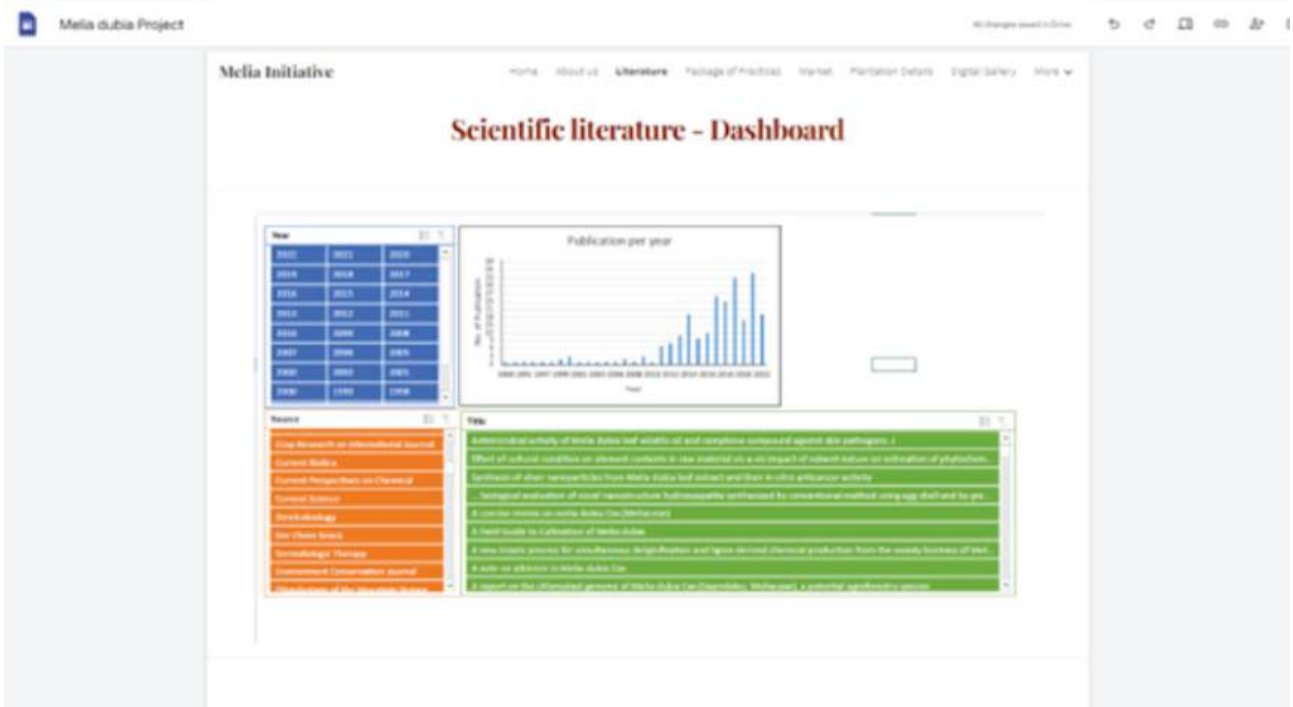
ICAR-CAFRI's new official website https://cafri.icar.gov.in is now multilingual presently in English, Hindi and Tamil. The compatibility features to specially abled viewers and mobile users are also enabled. It has also designed the digital payment gateway using bank details and UPI Two android mobile applications developed by the institute namely, 'FarmTree' and 'Learn Agroforestry' 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 *viz.*, Facebook, YouTube, Twitter, Instagram and LinkedIn.

CAFRI has fully implemented the digital platforms like e-office, ERP, e-HRMS, ARMS, KRISHI, SPARROW, PIMS, PFMS, etc. for its official works. All publications after 2021 have been digitized and furbished electronically as well. Identity cards of institute employees are upgraded using QR code as per Brand ICAR Document.

### *Melia dubia* initiative: A dashboard

In order to provide a common platform to all interested individuals/ institutes and other stakeholders to discuss status and way forward about *Melia dubia* and its promotion and to deliberate on potential impact of *Melia dubia* on overall timber production in the country a Stakeholders Consultation on *Melia dubia* was organized by the ICAR-Central Agroforestry Research Institute in hybrid mode on 23rd August, 2022 under the chairmanship of Director, ICAR-CAFRI. This database is constantly updated based on the information provided by the Knowledge patterns. Currently, the database is hosted by the ICAR-Central Agroforestry Research Institute, Jhansi https://cafri.icar.gov.in/melia-initiative/

# 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, Scientist, Senior Scale (Soil Science) | |
| 10. Dr. Hirdayesh Anuragi, Scientist, Senior Scale (Genetics & Plant Breeding) | |
| 11. Sh. Sukumar Taria, Scientist (Plant Physiology) (on Study Leave) | w.e.f. 26/12/2020 |
| 12. Mrs. Alka Bharati, Scientist (Agricultural Biotechnology) | |
| 13. Sh. Y N Venkatesh, Scientist (Agricultural Entomology) | |
| 14. Dr. Ashok Yadav, Scientist, Senior Scale (Fruit Science) | |
| 15. Sh. Suresh Ramanan S, Scientist (Agroforestry) | |
| 16. Dr. (Ms.) Priyanka Singh, Scientist (Agricultural Economics) | |
| 17. Mrs. M Ashajyothi, Scientist (Plant Pathology) | |
| 18. Dr. Priti Tigga, Scientist (Agricultural Physics) | |
| **Technical** | |
| 1. Sh. Rajesh Srivastava, Chief Technical Officer (Art & Photo) | |
| 2. Sh. Rajesh Kumar Singh, Assit. Chief Technical Officer | |
| 3. Sh. S P Singh, Assit. Chief Technical Officer | |
| 4. Sh. Ram Bahadur, Assit. Chief Technical Officer | |
| 5. Dr. Ajay Kumar Pandey, Senior Technical Officer | |
| 6. Dr. Pradyuaman Singh, Senior Technical Officer | |
| 7. Mrs. Shelja Tamrakar, Senior Technical Assistant (Library) | |
| 8. Sh. Het Ram, Technical Officer (Driver) | |
| 9. Sh. Kashi Ram, Sr. Technical Officer (Driver) | |
| **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. Om Prakash, Private Secretary | |
| 7. Sh. Ajay Kumar Gaur, Private Secretary | |
| 8. Sh. Deepak Vij, Personal Assistant | |

| | |
|---|---|
| 9. Sh. Tridev Chaturvedi, Personal Assistant | |
| 10. Sh. Jai Janardan Singh, Assistant | |
| 11. Mrs. Kaushalya Devi, Sr. Clerk | |
| **Skilled Supporting Staff** | |
| 1. Sh. Jagdish Singh | |
| 2. Sh. Ram Din | |
| 3. Sh. Pramod Kumar | |
| 4. Sh. Munna Lal | |
| **New Staff** | |
| 1. Dr. Priti Tigga, Scientist (Agricultural Physics) | Joined on 20.07.2023 |
| 2. Sh. Gautam Saxena, AO | Joined on 28.04.2023 |
| 3. Sh. Ajay Kumar Gaur, Private Secretary | Joined on 10.11.2023 |
| **Transfer** | |
| 1. Mrs. Kirti Chaturvedi, Personal Assistant has been relieved on 10.11.2023 to ICAR-IGFRI, Jhansi | |
| **Promotion** | |
| 1. Sh. Rajesh Srivastava, promoted to the post of Chief Technical Officer | w.e.f. 01.01.2022 |
| 2. Smt. Shelja Tamrkar, promoted to the post of Technical Officer | w.e.f. 24.11.2022 |
| **Retirement/Voluntary Retirement** | |
| 1. Dr. A Datta, Chief Technical Officer on 31.08.2023 | |
| 2. Sh. Rajendra Singh, Chief Technical Officer on 30.11.2023 | |
| 3. Sh. Prince, Technical Officer, Mechanic on 31.12.2023 | |

# Annexure-I

## Research Advisory Committee (RAC)
## (2021-2023)

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

# Annexure-II

## Institute Management Committee (IMC)
## (2022-2025)

| | |
|---|---|
| **Dr. A. Arunachalam**<br>Director<br>ICAR-CAFRI,<br>Jhansi (U.P.) | **Dr. F. Murli Gopal**<br>Principal Scientist,<br>ICAR-CPCRI,<br>Kasargod , Kerala |
| **Dr. V.K. Yadav**<br>Principal Scientist,<br>ICAR-IGFRI,<br>Jhansi | **Dr. R.S. Yadav**<br>Principal Scientist,<br>ICAR- HQ,<br>New Delhi |
| **The Assistant Director General (ADG)**<br>(AAF & CC) NRM, Division<br>Indian Council of Agricultural Research,<br>Krishi Anushandhan Bhavan-II<br>New Delhi-110012 | **Dr. A.K. Handa**<br>Principal Scientist,<br>ICAR-CAFRI,<br>Jhansi |
| **Director**<br>Agriculture, Govt. of UP,<br>Lucknow (U.P.) | **Dr. Suneel Pandey**<br>ITC Limited,<br>Bhadra Chalam (Telangana) |
| **Director - Research,**<br>RLBCAU, Jhansi | **Sr F & AO**<br>ICAR-IIPR, Kanpur (U.P.) |
| **Director - Extension,**<br>RVSKVV,<br>Jabalpur (M.P.) | **Dr. A. K. Handa**<br>Principal Scientist,<br>ICAR-CAFRI, Jhansi |
| **F&AO**<br>ICAR-CAFRI,<br>Jhansi | |

# Annexure-III

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

| Chairman : Dr. A. Arunachalam, Director | | | | |
|---|---|---|---|---|
| **Category** | **Staff Side** | | **Office Side** | |
| **Administration** | **Sh. Birendra Singh**<br>AAO | **Member, CJSC** | **Dr. A.K. Handa**<br>Pr. Scientist | Member |
| | **Sh. Jai Janardan Singh**<br>Assistant | **Secretary, IJSC** | **Dr. Rajendra Prasad**<br>Pr. Scientist | Member |
| **Technical** | **Smt. Shelja Tamrakar**<br>Sr. Technical Assistant | Member | **Sh. Rajendra Singh**<br>CTO | Member |
| | **Sh. Kashi Ram**<br>Sr. Tech. Asstt. (Driver) | Member | **A.O./H.O.** | Member |
| **Skilled Supporting Staff** | **Sh. Pramod Kumar**<br>SSS | Member | **Sh. P.K. Pandey**<br>F & AO | **Member Secretary** |
| | **Sh. Munna Lal**<br>SSS | Member | | |

# Annexure-IV

## Farm Calendar-2023

| 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. Updation of tree register |
| | | 9. Tree counting in sub blocks |
| 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. White wash 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. 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 *Baishakhi* |
| 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 |
| | | 7. Interaction meets with farm incharges of neighboring institutes |
| | | 8. Distillation 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 |

| | | |
|---|---|---|
| 7. | July | 1. Farm management committee meeting (first week) |
| | | 2. Interaction meeting with scientists and stakeholder |
| | | 3. Plantation drive in farm area |
| 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 |
| 10. | October | 1. Farm management committee meeting (first week) |
| | | 2. Storage/price fixation/sale of *kharif* season crops |
| | | 3. Land preparation and sowing of rabi season crop (gram) |
| | | 4. Field day *rabi* season |
| | | 5. Interaction meeting with scientists and stakeholder |
| | | 6. Insurance renewal of Tractors (UP 93 AG0342; UP 93 AG 0227; UP 93 AG 0336) |
| | | 7. Pre and post preparatory operations for *rabi* season crops |
| 11. | November | 1. Farm management committee meeting (first week) |
| | | 2. Sowing of *rabi* season crops |
| | | 3. Pruning of MPTs |
| | | 4. Need based operations in *rabi* season crops |
| 12. | December | 1. Need-based cultural operations in *rabi* season crops |
| | | 2. Annual store verification |

# Notes

# Notes

Swachh Bharat Abhiyan

स्वच्छ भारत

एक कदम स्वच्छता की ओर

आज़ादी का अमृत महोत्सव

Agrisearch with a human touch

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