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ANNUAL REPORT
2020

भा.कृ.अनु.प.-केन्द्रीय कृषिवानिकी अनुसंधान संस्थान

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

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Preface

Agroforestry is the futuristic agriculture that enables sustainable production while also provisioning ecosystem services ensuring livelihood and environmental securities. Most importantly, agroforestry has the conservation agriculture principles well-integrated into the practice and to potentially can help conserve natural resources in different agro-climatic regions. Further, agroforestry is the only pathway to increase the forest cover in the country. In a scenario of decreasing availability of arable lands for agriculture, degradation of soil and water resources, increasing pollution hazards and threats to environment and ecosystem from global warming and climate change, new methodologies in farming systems are needed to meet food, fodder, fibre, firewood, and timber demands of the increasing population that only agroforestry interventions can provision to achieve sustainability. CAFRI, since its inception has been primarily focusing on these aspects through concerted research efforts. The Agroforestry research outputs based on the research activities for 2020 under 17 institutionally funded and 08 externally funded projects were planned in accordance with the recommendations of Research Advisory Committee (RAC) and other advisory bodies. The Institute has the largest germplasm collection of neem and other agroforestry tree species and provides opportunities for explorative research for superior germplasms. The Institute has developed and documented more than 80 agroforestry models for different agro-climatic regions and NABARD has recently identified 4 of those as bankable agroforestry models.

As part of landscape level transformative field research, the Institute is working on KISAN MITrA project (consortium of ICAR-CAFRI and ICRISAT, Hyderabad) for scaling-up initiative, eight pilot sites covering about 40,000 ha area across the seven districts of Bundelkhand are being developed. The emphasis has been on establishing agroforestry models, controlling land degradation through large-scale field bunding upstream and the construction of various *ex-situ* water harvesting structures downstream reviving and rejuvenating traditional water harvesting structures in the target sites. During this year, under ICAR-ICRAF work plan, about 25,000 m^3 rainwater harvesting created at Tara village in Bolangir district and about 7000 m^3 rainwater harvesting capacity created in Boirbhadi village in Nuapada district. *In-situ* rainwater harvesting through field bund preparation has been done in Tara and Boirbhadi villages. Field bund plantation and block plantation of various agroforestry tree species have been done in Bolangir and Nuapada districts.

These success stories enhanced the Institute's visibility thereby registering its potential to be a Nodal Agency for technology backstopping to the Sub-Mission on Agroforestry Offices located in different states that implements the provisions of the National Agroforestry Policy-2014 in the country. At AICRP level, agroforestry is being experimented in its 37 centres across the country located primary in state agricultural universities mostly. These centres are being mentored for providing technical inputs to the Sub-Mission on Agroforestry units in respective states.

Institute Annual Report includes executive summaries (English and Hindi), achievements of various research programmes, important meetings /days observed, details of various awards received by the Scientists as well as other staff of the Institute, research publications, participation in trainings, participation in participation in Workshop/ Webinars /Meetings/Symposia and report of implementation of SCSP schemes.

The Institute organized of Farmers' activities like Farmer's Workshop, Training programmes and exhibitions for transfer of agroforestry technologies and to increase the awareness for speedy adoption of agroforestry. The COVID pandemic situation in the country has affected the R & D process of Agroforestry and its outreach activities. Meaningful plantation drive was carried out by scientists of ICAR-CAFRI, Jhansi in the selected MGMG villages.

I express my gratitude to Dr. Trilochan Mohapatra, Hon'ble Secretary, DARE and Director General, ICAR, New Delhi for his constant guidance, encouragement, and support. I am very much pleased to thank Dr. S K Chaudhari, Deputy Director General (NRM), ICAR, New Delhi for his constant direction and motivation. I gave special thanks to Dr. S Bhaskar, ADG (A, AF&CC) and all the staff members of NRM Division for their enabling support. I acknowledge the services of my predecessors in taking forward the Institutional activities. I acknowledge the efforts made by the PME Cell and the Editors of this report in compiling and timely publication of the report.

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

November, 2021

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

बेर आधारित कृषि–बागवानी प्रणाली में ज्यादातर मामलों में उपचार टी$_8$ (बेर के साथ 75% आरडीएफ + ट्राइकोडर्मा + उर्द – जौ)ने अपनी श्रेष्ठता दिखाई है, हालांकि यह उपचार टी$_6$ (बेर के साथ 75% आरडीएफ + वैम + उर्द – जौ) तथा टी$_2$ (बेर के साथ 100% आरडीएफ + उर्द – जौ) के साथ सममूल्य पर था। इस्तेमाल किए गए ट्रैप में, मिथाइल यूजेनॉल ट्रैप फलों की मक्खियों के लिए इस्तेमाल किए जाने वाले क्यू ल्यूर ट्रैप से बेहतर साबित हुये। सभी उपचार भूखंडों की सतह की मिट्टी में कुछ अपवादों के साथ पर्याप्त मात्रा में जिंक और तांबा शामिल थे। सभी उपचारों में आयरन और मैंगनीज की मात्रा अधिक थी।

अनार + नींबूघास (प्रजाति कृष्णा) कृषिवानिकी प्रणाली में, फल उपज (किलो/प्रति पौधा) 5.56 (टी$_4$वी$_2$) से 12.88 (टी$_2$वी$_1$)तक थी। लेमनग्रास की दो कटाइयों से हरी पत्तियों की संचयी उपज 20.77 (टी$_2$वी$_2$) से 29.57 (टी$_3$वी$_2$) टन/ हेक्टेयर पायी गयी तथा हरी पत्तियों से तेल 112.86 (टी$_2$वी$_1$) से 162.07(टी$_3$वी$_1$) किग्रा/हेक्टेयर ताजा वजन के आधार पर पाया गया।

लघु चक्रीय वृक्ष आधारित कृषिवानिकी प्रणाली का संरचनात्मक और कार्यात्मक विश्लेषण'' नामक परियोजना में चार वर्ष के बाद *एम. दूबिया* में प्रति पेड़ अधिकतम (349.98 किग्रा) शुष्क बायोमास पाया गया। *ए. कदंबा* में शुष्क बायोमास 137.25 किलोग्राम प्रति पेड़ दर्ज किया गया। *एल. ल्यूकोसेफला* में सबसे कम शुष्क बायोमास (64.53 किग्रा/पेड़) दर्ज किया गया था। *एम. दूबिया* में सर्वाधिक कार्बन स्टॉक (174.98 किग्रा/पेड़) देखा गया। जबकि, *एल. ल्यूकोसेफला* में सबसे कम कार्बन स्टॉक (32.26 किग्रा/पेड़) दर्ज किया गया था। *ए. कदंबा* में 68.62 किग्रा/पेड़ का कार्बन स्टॉक पाया गया। विभिन्न वृक्ष प्रजातियों में, वृक्ष के जमीन के ऊपरी हिस्सों में कार्बन स्टॉक 73.75 से 83.85 प्रतिशत के बीच पाया गया। जबकि कार्बन स्टॉक जड़ों के हिस्से में 17.98 से 26.25 प्रतिशत के बीच था।

जुलाई, 2014 के दौरान 03 प्रयोगों के साथ शुरू की गयी। स्थायी भूमि उपयोग और बेहतर उत्पादकता के लिये कृषिवानिकी आधारित संरक्षण कृषि परियोजना के अंतर्गत बेल आधारित कृषिवानिकी प्रणाली, सागौन आधारित कृषिवानिकी प्रणाली और बेल + सागौन आधारित कृषिवानिकी प्रणाली में पाया गया कि जुताई उपचार का उपज और उपज योगदान मापदंडों पर कोई महत्वपूर्ण प्रभाव नहीं पड़ा। अवशेषों को डालने और प्रतिधारण के परिणाम स्वरूप बीज उपज में उल्लेखनीय वृद्धि हुयी।

वर्ष 2020 में, समन्वित कृषि प्रणाली परियोजना के अन्तर्गत लगाये गये अमरूद और सहजन मे प्रति पौधा क्रमशः 25.15 और 10.0 किग्रा पैदावार पायी गयी। इस परियोजना में सब्जी वाली मटर, गेहूँ, मक्का, भिण्डी, कद्दू, लौकी इत्यादि फसलों का सफलता पूर्वक उत्पादन लिया गया। वर्ष 2020 में फसलों तथा फलों के उत्पादन से कुल आमदनी 81265 रूपये प्राप्त हुयी।

रोपण के चार वर्षों के बाद, सागौन + महोगनी + चारा + स्टैगर्ड कन्टूर ट्रेन्च वाले उपचार में सागौन और महोगनी में अधिकतम बढ़वार दर्ज की गयी। मार्च, अप्रैल और मई के दौरान, सभी उपचारों में मिट्टी की नमी की औसत मात्रा 2 प्रतिशत से कम दर्ज की गयी और अगस्त के महीने में 10.43 प्रतिशत (सागौन + महोगनी + चारा + स्टैगर्ड कन्टूर ट्रेन्च) तक पहुंच गयी। चार बरसातों के बाद, टी$_7$ उपचार में मिट्टी का कटाव 6.14 टन/हेक्टेयर से 4.76 टन/हेक्टेयर (टीएमपी + सीएसटी) में और 2.08 टन/हेक्टेयर से 1.80 टन/हेक्टेयर तथा टी$_6$ उपचार (टीएमपी + एचएमबी) में काफी कम हो गया है।

अर्ध–शुष्क परिस्थितियों में उनके अनुकूलन क्षमता के संदर्भ में व्यापक प्रयोगों ने *पोंगामिया पिन्नाटा* के क्लोनल पौधों और रोपित पौधों में अंतर प्रतिक्रियाओं का पता लगाया है। शुष्क गर्म मौसम के दौरान क्लोनल पौधों की तुलनात्मक बेहतर शारीरिक दक्षता ने अंकुरित पौधों की तुलना में इसकी बेहतर अनुकूली क्षमता का संकेत दिया। पेड़ों की तुलनात्मक अनुकूलन क्षमता के साथ अपना जुड़ाव स्थापित करने के लिए शारीरिक सूचकांकों का मूल्यांकन प्रगति पर है।

विभिन्न ल्यूसीनिया प्रजातियों (*एल. डायवर्सिफोलिया, एल. शानोनी, एल. लैंसोलाटा, एल. कोलिन्सि* और *एल. ल्यूकोसेफला*) की लकड़ी के गुणों का आंकलन करने पर पाया गया कि लकड़ी के गुणों के लिए प्रजातियों में बड़ी भिन्नता थी। प्रजाति *एल. डायवर्सिफोलिया* में बेहतर ईंधन लकड़ी और अन्य प्रजातियों की तुलना में *एल. ल्यूकोसेफला* में फाईबर की उच्च लम्बाई और चौड़ाई पायी गयी जो लुगदी के लिए बेहतर है।

पोंगामिया पिनाटा के छह जीनोटाइप में ग्यारह रूप–शारीरिक और जैव रासायनिक लक्षणों का सूखे और नियंत्रण की स्थिति के तहत अध्ययन किया गया। सूखे की स्थिति के तहत सभी माने गये मापदंडों में महत्वपूर्ण अंतर देखा गया। पैरामीटर जैसे SPAD, क्लोरोफिल सामग्री, कैरोटीनॉयड, Fv / Fm, जड़ की लंबाई, सूखी जड़ का वजन, पेरोक्सीडेज (PEX), कैटेलेज (CAT), कुल घुलनशील प्रोटीन, लिपिड पेरोक्सीडेशन और प्रोलीन का अनुमान लगाया गया था। जीनोटाइप में NRCP–9 को सहिष्णु जीनोटाइप के रूप में पहचाना गया। NRCP–9 जीनोटाइप में अन्य जीनोटाइप की तुलना में बेहतर एंटीऑक्सीडेंट प्रणाली, मूल लक्षण अभिव्यक्ति, प्रकाश संश्लेषक रंगद्रव्य और प्रोलीन संचय में वृद्धि हुई थी। इस प्रकार, इस जीनोटाइप के सहिष्णुता तंत्र में शामिल है। इसके अलावा, जीनोटाइप को पांच ज्ञात उम्मीदवार जीनों द्वारा विभेदक जीन अभिव्यक्ति विश्लेषण द्वारा आणविक लक्षण वर्णन के अधीन किया जाता है।

टीबीओ आधारित कृषिवानिकी मॉडल में, *पोंगामिया पिन्नाटा* और नीम में अनियमित फूलों का विकास देखा गया। नीम (4.91 मीटर और 14.05 सेमी) में पेड़ों की क्रमशः औसत ऊँचाई और कॉलर व्यास सबसे अधिक पाया गया, इसके बाद *पोंगामिया पिन्नाटा* (3. 42 मीटर और 8.74 सेमी) की क्रमशः औसत ऊँचाई और कॉलर व्यास दूसरे स्थान पर रहा।

मध्य प्रदेश और उत्तर प्रदेश के आस–पास के जिलों से विभिन्न विशेषताओं वाले कुल 14 *मोरिंगा ओलीफेरा* के जर्मप्लाज्म एकत्र किये गये। औसतन, प्रत्येक 0.5 से 1 किमी की दूरी के बाद, एक मोरिंगा का पेड़ या तो सड़क के किनारे या कृषि क्षेत्र में देखा गया। पत्ती के ब्लेड का आकार गोल से अण्ड़ाकार और पत्ती का रंग हल्के से गहरे हरा रंग पाया गया। मोरिंगा के फूल मध्यम (<2×3 सेमी) से बड़े (>2×3 सेमी) आकार में संकीर्ण से थोड़ी चौड़ी पंखुड़ियों वाले पाए गये।

टीकमगढ़ (म.प्र.) के गाँव डाबर में, निकटवर्ती वन क्षेत्रों से जरूरत की लगभग 51 प्रतिशत ईंधन एकत्र किया गया। केवल 65 प्रतिशत महिलाएं ईंधन की लकड़ी का संग्रह करती पायी गयी। गाँव रौतियाना में, निकटवर्ती वन क्षेत्रों से जरूरत की 68 प्रतिशत ईंधन की लकड़ी को एकत्र किया गया। ईंधन की लकड़ी का संग्रह ज्यादातर महिलाओं (85 प्रतिशत) द्वारा किया गया। गाँव रौतियाना में, उज्ज्वला योजना के कारण ईंधन की लकड़ी के उपयोग में 30 प्रतिशत की कमी देखी गयी। गाँव कुंण्ड़ार में 43 प्रतिशत आवश्यक ईंधन लकड़ी आसन्न वन क्षेत्रों से एकत्र की गयी। यह पाया गया कि ईंधन की लकड़ी का संग्रह ज्यादातर महिलाओं (70 प्रतिशत) द्वारा किया जा रहा है। गाँव कुंण्ड़ार में ईंधन की लकड़ी के उपयोग में 50 प्रतिशत की कमी उज्ज्वला योजना के कारण हुयी। ग्राम सकुली में, निकटवर्ती वन क्षेत्रों से जरूरत की लगभग 54 प्रतिशत ईंधन लकड़ी एकत्र की जाती है। केवल 45 प्रतिशत प्रतिशत महिलाएं ईंधन की लकड़ी का संग्रह करती हैं। गाँव सकुली में, ईंधन लकड़ी के उपयोग में लगभग 25 प्रतिशत की कमी उज्ज्वला योजना के कारण देखी गई है। गाँव शिवरामपुर में आसन्न वन क्षेत्रों से जरूरत की 79 प्रतिशत ईंधन लकड़ी एकत्र की जाती है। गाँव में 92 प्रतिशत महिलाएँ ईंधन की लकड़ी का संग्रह करती हैं। गाँव शिवरामपुर में उज्जवला योजना के कारण ईंधन के उपयोग में लगभग 15 प्रतिशत की कमी देखी गयी।

गर्मी के मौसम के दौरान, *अकेसिया सेनेगल* में गोंद का उत्सर्जन देखा गया, जो कृषि–बागवानी–सिल्विकल्चर मॉडल में 11.34 से 133.24 ग्राम / पेड़ और बारानी कृषि–सिल्विकल्चर मॉडल में 1.51 से 110.0 ग्राम / पेड़ तक भिन्न था। गम गार्डन में गोंद की उपज 0. 73 से 177.39 ग्राम प्रति पेड़ के बीच पायी गयी। इसी तरह, *अकेसिया नीलोटिका* में, गोंद की उपज सिल्वी–हर्बल मॉडल में 8. 25 से 26.59 ग्राम पेड़ और बारानी एग्री–सिल्विकल्चर मॉडल में 0. 43 से 3.23 ग्राम / पेड़ तक होती है। सामान्य तौर पर, *ए. सेनेगल* के पेड़ों ने विभिन्न मॉडलों में *ए. निलोटिका* की तुलना में बेहतर उत्सर्जन और गोंद की उपज दिखाई। विभिन्न मॉडलों में अंतर–फसलों (गर्मी और सर्दियों की फसलों) की उपज पेड़ों से काफी प्रभावित हुई थी और पेड़ों के पास प्रभाव अधिक थे जो पेड़ के तने से दूर की दूरी पर शून्य हो गए थे।

वर्ष के दौरान, किसानों के खेतों में रोपण के लिए गोंद और फल देने वाली पौधों की प्रजातियों के लगभग 35,000 पौधे वितरित किए गये। गोंद देने वाले दो वृक्ष आधारित कृषिवानिकी मॉडलों की मृदा स्वास्थ्य स्थिति का आकलन किया गया।

कृषि–बागवानी–सिल्विकल्चर मॉडल में, विभिन्न पेड़ों (*ए. सेनेगल, एगल मार्मेलोस, साइट्रस लिमोन* और *कैरिसा कैरानाडस*) ने मिट्टी के गुणों (पीएच, ईसी, कार्बनिक कार्बन, N, P, K, Fe, Mn, Zn और Cu) पर परिवर्तनीय प्रभाव प्रदर्शित किया। मिट्टी की गहराई (0–15 और 15–30 सेमी) ने मिट्टी के गुणों को काफी प्रभावित किया और सतह की मिट्टी से पीएच, कार्बनिक कार्बन, N, P, K और Cu के अपेक्षाकृत उच्च मूल्यों को दर्ज किया गया। बारानी कृषि–सिल्विकल्चर मॉडल में, उच्च मिट्टी पीएच, Ec, N, P, K और Mn सामग्री *ए. सेनेगल* और Zn और Cu सामग्री *ए. नीलोटिका* से दर्ज की गई थी।

मध्य भारत के उत्तर प्रदेश में बुंदेलखंड क्षेत्र गरीबी और खराब सामाजिक आर्थिक स्थिति एवं पानी की कमी और भूमि क्षरण का केंद्र है। किसान मित्र (आई सी ए आर–सी ए एफ आर आई और आई सी आर आई एस एटी, हैदराबाद) परियोजना के तहत बुंदेलखंड के सात जिलों में लगभग 40,000 हेक्टेयर क्षेत्र में आठ पायलट स्थलों को विकसित किया जा रहा है। अपस्ट्रीम में बड़े

पैमाने पर फील्ड बंडिंग के माध्यम से भूमि क्षरण को नियंत्रित करने और डाउनस्ट्रीम में विभिन्न एक्स–सीटू जल संचयन संरचनाओं के निर्माण पर जोर दिया गया है। हवेलियों नामक पारंपरिक जल संचयन संरचनाओं को पुनर्जीवित करना और उनका कायाकल्प करना एक उच्च प्राथमिकता रही है। वनस्पति आच्छादन बढ़ाने के लिए, आजीविका में सुधार और पोषण सुरक्षा मुहैया कराने के लिए कृषिवानिकी को बढ़ावा दिया जा रहा है। आई सी ए आर–सी ए एफ आर आई और आई सी आर आई एस एटी, ने एक खास कोर वॉल अवधारणा पेश की है जिसे भारी बारिश के दौरान टूटने वाले मिट्टी के तटबंधों को मजबूत करने की क्षमता है। अतिरिक्त पानी के सुरक्षित निपटान के लिए चिनाई आउटलेट का निर्माण किया गया है। यह कार्य उत्तर प्रदेश में बुंदेलखंड क्षेत्र के सात जिलों में सभी आठ परियोजना स्थानों में किए गए हैं। इस पहल के तहत कुल 16 ऐसी संरचनाओं का कायाकल्प किया गया है। इन हस्तक्षेपों ने लगभग 0.5 मिलियन क्यूबिक मीटर (एमसीएम) की भंडारण क्षमता बनाई थी। भंडारण क्षमता बढ़ाने के अलावा हवेलियों के जीर्णोद्धार से फसल में तेजी आई है। बुंदेलखंड उत्तर प्रदेश के सात जिलों में आठ स्थानों को शामिल करते हुए 22 गांवों में कृषिवानिकी वृक्षारोपण का बड़े पैमाने पर उन्नयन किया गया है। आई सी ए आर–सी ए एफ आर आई और आई सी आर आई एस एटी,के साथ 2020 के दौरान 1,50,000 से अधिक वृक्षारोपण (खण्ड वृक्षारोपण, सीमा वृक्षारोपण, फल आधारित कृषिवानिकी प्रणाली और पोषण सुरक्षा के लिए वृक्षारोपण) किया गया है। परियोजना गाँवों में विभिन्न फल आधारित कृषिवानिकी मॉडल और उच्च घनत्व वाले बाग भी विकसित किए गए थे।

किसानों को शामिल कर गांव में विभिन्न किस्मों के पेड़–पौधे बांटे और लगाए गये। देशी बेर एक वृक्ष (झाड़ी) प्रजाति है जो अधिकांश गाँवों में उपलब्ध है, लेकिन खराब गुणवत्ता वाले फल देती है। नियमित रूप से नवोदित होने पर ये पेड़ अच्छी गुणवत्ता वाले बेर फल पैदा करने का अवसर रखते हैं। वर्ष 2020 में बेहतर लगभग 2000 पेड़ों के तनों को काटकर गुणवत्ता वाले अंकुरों को रोपित किया गया। विभिन्न गतिविधियों को शामिल करते हुए 3000 से अधिक किसानों के सहभागी क्षेत्र प्रदर्शन किये गये।

कृषि जलवायु क्षेत्र–1 के नौ जिलों जम्मू–कश्मीर के कुलगाम, बडगाम, पुलवामा, उधमपुर और उत्तराखंड के पौड़ी गढ़वाल, चंपावत और हिमाचल प्रदेश के कुल्लू, कांगड़ा, सिरमौर में कृषिवानिकी के तहत क्षेत्र को, अच्छी तरह से स्थापित पद्धति का उपयोग करके, मैप किया गया था। कृषिवानिकी क्षेत्र कांगड़ा जिले में सबसे अधिक (77159.9 हेक्टेयर) पाया गया, उसके बाद पौड़ी गढ़वाल जिले में (58675.51 हेक्टेयर)। लेकिन भौगोलिक क्षेत्र के प्रतिशत के रूप में, इन जिलों में कृषिवानिकी क्षेत्र 9.0 से 20.7% के बीच था। कृषि जलवायु क्षेत्र–1 के सभी नौ जिलों में कृषिवानिकी क्षेत्र के मानचित्रण में 90 प्रतिशत से अधिक सटीकता पायी गयी।

पाली जिले में नीम और खेजड़ी प्रजातियों के तहत कृषिवानिकी क्षेत्र और राजस्थान के जोधपुर जिले में केवल खेजड़ी प्रजातियों का मानचित्रण किश गया और पहले से विकसित वर्णक्रमीय हस्ताक्षरों का उपयोग करके अनुमान लगाया गया है। राजस्थान के जोधपुर एवं पाली जिले में नीम और खेजड़ी प्रजातियों के तहत अनुमानित क्षेत्र क्रमशः 26493.05 हेक्टेयर (2.13%) और 13572.43 हेक्टेयर (1.1%) और खेजड़ी प्रजातियों के तहत 100584.05 हेक्टेयर (0.39%) पाया गया।

इस वर्ष के दौरान बोलनगीर जिले के तारा गांव में लगभग 25,000 घन मीटर वर्षा जल संचयन और नुआपाड़ा जिले के बोइरभदी गाँव में लगभग 7000 घन मीटर वर्षा जल संचयन क्षमता का निर्माण इस परियोजना के तहत किया गया, जिसका शीर्षक ग्रामीण आजीविका को बदलना और कृषिवानिकी के माध्यम से प्राकृतिक संसाधन प्रबंधन के संयोजन से प्रवास को रोकना है। ओडिशा का बोलांगीर और नुआपाड़ा जिला ओडिशा के बोलांगीर और नुआपाड़ा जिलों में छोटे धारकों को कृषिवानिकी प्रणालियों के माध्यम से पौष्टिक भोजन का उत्पादन करने में सक्षम बनाने की एक उप परियोजना के अंतर्गत किया गया। तारा और बोयरभडी गाँवों में खेत में बांध तैयार करके वर्षा जल संचयन किया गया है। बोलनगीर और नुआपाड़ा जिले के लिए विभिन्न कृषिवानिकी वृक्ष प्रजातियों के फील्ड बांध वृक्षारोपण और ब्लॉक वृक्षारोपण की योजना बनायी गयी।

Executive Summary

The executive summary of the research and development activities carried at ICAR-Central Agroforestry Research Institute during 2020 is presented here under:

The ber based agri-horti system indicated that in most of the cases treatment T_8 (Ber with 75% RDF + Trichoderma + Black gram – Barley) showed its superiority but at par with either treatment T_6 (Ber with 75% RDF + VAM + Black gram – Barley) or T_2 (Ber with 100% RDF + Blackgram – Barley). Among the traps used, the Methyl eugenol traps proved better than the Cue lure traps used for fruit flies. Surface soil of all the treatment plots contained sufficient amount of Zn and Cu with few exceptions. The contents of Fe and Mn were high in all the treatments.

In pomegranate + lemongrass agroforestry system, the fruit yield (kg/pl) was from 5.56 (T_4V_2) to 12.88 (T_2V_1). The cumulative yield from two cuts of lemongrass yielded 20.77 (T_2V_2) to 29.57 (T_3V_2) t/ha green leaves having oil 112.86 (T_2V_1) to 162.07 (T_3V_1)kg /ha on fresh weight basis.

In "Structural and functional analysis of short rotation tree based agroforestry system" four years old project *M. dubia* recorded the maximum (349.98 kg) dry biomass per tree. In *A. cadamba*, dry biomass of 137.25 kg per tree was recorded. The lowest dry biomass (64.53 kg/tree) was recorded in *L. leucocephala*. The maximum carbon stock (174.98 kg/tree) was observed in *M. dubia*. Whereas, the lowest carbon stock (32.26 kg/tree) was recorded in *L. leucocephala*. In *A. cadamba*, carbon stock of 68.62 kg/tree was observed. Among different tree species, share of above ground parts to carbon stock varied from 73.75 to 83.85%. Whereas, the share of roots to carbon stock varied from 17.98 to 26.25%.

In the project on "Agroforestry based conservation agriculture for sustainable landuse and improved productivity project" initiated during July, 2014 with 03 experiments, Bael based Agroforestry system; Teak based Agroforestry system and Bael + Teak based Agroforestry system indicated that tillage treatments had no significant impact on yield and yield contributing parameters. The residue addition and retention resulted in significant increase in seed yield.

In Agroforestry based Integrated Farming System, average moringa and guava production was recorded 10.0 and 25.15 kg/plant, respectively. Different crops like vegetable pea, sweet corn, wheat, bhindi, bottle guard, pumpkin, bitter guard were successfully grown in the system. During the year 2020, from crop and fruit production about Rs. 81,000/- gross income has been generated.

After four years of planting, maximum growth parameters of teak and mahagoni were recorded in treatment having teak+ mahagoni+ pasture+ contour staggered trenches. During March, April and May, average soil moisture content was recorded below 2% in irrespective of all the treatments and reaches upto 10.43% (in Teak+Mahagoni+ Pasture+CST) in Month of August. After forth rainy season, soil erosion is reduced drastically from 6.14 t /ha to 4.76 t/ha in T_7 treatment (TMP+CST) and from 2.08 t/ha to 1.80 t/ha in T_6 treatment (TMP+HMB).

Differential responses in clonal plants and seedlings of *Pongamia pinnata* in field with reference to their adaptability in semi-arid conditions have been noted. Clonal plants exhibited comparatively better physiological efficiency during dry hot summer season than the seedling plants. Evaluation of physiological indices have been progressing to establish their association with the comparative adaptability of the trees.

On estimation wood properties parameters for different Leucaena species (*L. diversifolia, L. shanonii, L. lanceolata, L. collinsii* and *L. leucocephala* it was found that the large variation was observed among the species for wood properties. The species *L. diversifolia* registered for superior fuelwood properties and *L. leucocephala* had superior pulpwood qualities with higher fibre length and width as compared to other species.

Eleven morpho-physiological and biochemical traits were studied in six genotypes *Pongamia pinnata* under drought stress and control condition. Significant differences were observed for all the considered parameters under drought stress condition. The parameters *viz.* SPAD, chlorophyll content, carotenoid, Fv/Fm, root length, dry root weight, peroxidase (PEX), catalase (CAT), total soluble protein, lipid peroxidation, and proline were estimated. Among the genotypes NRCP-9 were identified as tolerant genotype. NRCP-9 genotype had superior antioxidant system, rood trait expression, increased photosynthetic pigments and proline accumulation as compared to other genotypes. Thus, involved in the tolerance mechanism of this genotype. Further, the genotype is subjected to molecular characterization by differential gene expression analysis by five known candidate genes.

In TBOs based agroforestry model, the development of irregular flowers was observed in *Pongamia pinnata* and *Azadirachta indica*. The average height and collar diameter of trees was found to be highest in *Azadirachta indica* (4.91 m and 14.05 cm) followed by *Pongamia pinnata* (3.42 m and 8.74 cm).

A total of 14 *Moringa oleifera* germplasm with variable characteristics were collected from nearby districts of Madhya Pradesh and Uttar Pradesh. On an average, after every 0.5 to 1 km distance, a moringa tree was observed either on the roadside or at the farm area. The shape of leaf blade varied from round to obtuse and leaf color with light to dark green. Moringa flowers were found to be medium (<2×3 cm) to large (>2×3 cm) in size with narrow to little bit broader petals.

During summer season, exudation of gum in *Acacia senegal* was observed, which varied from 11.34 to 133.24 g/tree in agri-horti-silviculture model and 1.51 to 110.0 g/tree in rainfed agri-silviculture model. In gum garden, the gum yield varied from 0.73 to 177.39 g/tree. Similarly, in *Acacia nilotica*, gum yield ranged from 8.25 to 26.59 g/tree in silvi-herbal model and 0.43 to 3.23 g/tree in rainfed agri-silviculture model. In general, *A. senegal* trees showed better exudation and gum yield than *A. nilotica* in different models. The yield of inter-crops (summer and winter crops) in different models was significantly affected by woody components and effects were more pronounced near the trees which nullified at farther distances from the tree trunk.

During the year, approximately 35,000 seedlings of gum and fruit-yielding plant species were distributed for planting on farmers' fields. Effect of soil moisture dynamics on exudation of gum from *A. senegal* in irrigated as well as rainfed conditions was studied by working out a correlation matrix among all parameters of rainfall, soil moisture and gum exudation. Under irrigated conditions, positive but non-significant correlation existed between soil moisture content and mean gum yield (g/tree) and number of trees exuding gum. Total annual rainfall in preceding year had direct influence on the number of trees with multiple exudations in a year (r = 0.763). For rainfed conditions, total gum yield exhibited better degree of positive correlation with soil moisture content (r = 0.559). Significant positive correlation also existed between total gum yield and number of trees with multiple exudations in a year (r = 0.957). Soil health status of two gum-yielding tree based agroforestry models was assessed. In agri-horti-silviculture model, various woody components (*A. senegal, Aegle marmelos, Citrus limon* and *Carissa caranadas*) exhibited variable effects on soil properties (pH, EC, organic carbon, N, P, K, Fe, Mn, Zn and Cu). Soil depths (0-15 and 15-30 cm) significantly affected soil properties and relatively higher values of pH, organic carbon, N, P, K and Cu were recorded from surface soil. In rainfed agri-silviculture model, higher soil pH, EC, N, P, Fe and Mn contents were recorded from *A. senegal* and Zn and Cu contents from *A. nilotica*.

Bundelkhand region of Uttar Pradesh in Central India is a hotspot of water scarcity and land degradation, beset with poverty and poor socioeconomic conditions. Under the KISAN MITrA (consortium of ICAR-CAFRI and ICRISAT, Hyderabad) scaling up initiative, eight pilot sites covering about 40,000 ha area across the seven districts of Bundelkhand are being developed. The emphasis has been on controlling land degradation through large-scale field bunding upstream and the construction of various *ex-situ* water harvesting structures downstream. Reviving and rejuvenating traditional water harvesting structures called havelis has been a high priority. Upscaling of agroforestry for increasing the vegetation cover, improving livelihood and nutritional security is another most important objective being addressed. ICAR-CAFRI and ICRISAT have introduced a novel core wall concept that has been introduced under the initiative to strengthen the earthen embankments that breach during heavy rains. Masonry outlets have been constructed for the safe disposal of excess water. These interventions have been undertaken in all the eight project locations across the seven districts of UP Bundelkhand region. A total of 16 such structures have been rejuvenated under this initiative. These interventions have created a storage capacity of about 0.5 Million Cubic Meter (MCM) and led to crop intensification in the region. Large scale upscaling of agroforestry planation has been done in 22 villages covering eight locations in seven districts of Bundelkhand UP. More than 1,50,000 plantations (bund plantation, boundary plantation, fruit based agroforestry system and plantation for nutritional security) have been done during 2020. Various fruit based agroforestry models and also high density orchards were developed in project villages.

Different varieties of tree species were distributed and planted in village by involving farmers. Ber is a native tree (bush) species available in most of pilot villages but produce poor quality fruits.These trees hold opportunity to produce good quality ber fruits if undergo regular budding. Nearly 2000 tree stems were cut and budded with improved quality shoots in the year 2020. More than 3000 farmers' participatory field demonstrations were undertaken covering a range of activities.

Agroforestry area in nine districts of ACZ-1 *viz.* Kulgam, Budgam, Pulwama, Udhampur from Jammu & Kashmir and Pauri Garhwal, Champawat from Uttarakhand and Kullu, Kangra, Sirmaur from Himachal Pradesh has been mapped using already developed methodology. Estimated agroforestry area was found highest in Kangra district (77159.9 ha) followed by Puari Garhwal district (58675.51 ha). But as a percentage of geographical area, agroforestry area in these districts ranged from 9.0 to 20.7%. More than 90 per cent accuracy was found in mapping agroforestry area in all nine districts of ACZ-1.

The agroforestry area under Neem and Khejri species in Pali district and only Khejri species in Jodhpur district of Rajasthan has been mapped and estimated using already developed spectral signatures. Estimated area under Neem and Khejri species has come out to be 26493.05 ha (2.13%) and 13572.43 ha (1.1%), respectively in Pali district and 100584.05 ha (0.39%) under Khejri species in Jodhpur district of Rajasthan.

During this year about 25,000 m^3 rainwater harvesting created at Tara village in Bolangir district and about 7000 m^3 rainwater harvesting capacity created in Boirbhadi village in Nuapada district underthe project entitled, "Transforming rural livelihood and check migration through agroforestry in conjunction with natural resource management in Bolangir and Nuapada district of Odisha" a sub project of "Enabling small holders in Bolangir and Nuapada districts of Odisha to produce nutritious food through agroforestry systems". *In situ* rainwater harvesting through field bund preparation has been done in Tara and Boirbhadi villages. Field bund plantation and block plantation of various agroforestry tree species has been planned for Bolangir and Nuapada district.

1. General

In the era of changing climate every country is looking for ensuring the food security of its citizen. In this context, agroforestry emerges to be the integrated and sustainable model of food production catering to environmental services while assuring sustainable production as well. Judicious integration of tree species with agricultural crops and/or animals is the way to achieve the targeted 4 per cent sustained growth in agriculture by optimizing the farm productivity and enhancing livelihood opportunities of small farmers, landless and in particular women.

Agroforestry systems significantly contribute towards livelihood improvement through 5Fs, *i.e.* food, fodder, fuel, fibre and fertilizer. Trees on farm can also help in generating diversified off-farm employment opportunities by supporting large number of wood based industries. Despite these magnificent contributions, the adoption level of agroforestry practices among the farmers is still limited. This calls for organized efforts in setting priorities and strategies for upliftment of rural livelihood 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 33 years achieving several milestones in integrating trees, crops and livestock on the same farmland. The institute addresses the national agroforestry mandate through basic, strategic and adaptive research to systematize the science of agroforestry and has developed robust agroforestry models for different agro-climatic regions, and handholds different states in the country for implementation of the objectives of agroforestry policy through skilling and human resource development program.

VISION

To improve 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 agro climatic zones.

INFRASTRUCTURE FACILITIES

Laboratories

ICAR- CAFRI has a main office building with six well-equipped laboratories (Plant Physiology; Soil Analytical; Plant Protection; Tissue Culture & Tree Improvement; Horticulture and Agroforestry).

Library

The Institute's Library is well furnished and equipped with LAN facilities. Library operations are automated using Koha Library Management Software. The library has 4549 books including Hindi books and subscribes 08 Indian Journals. Library also provided services like borrowing facility, Reference service etc.

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 (www.cafri.res.in).The entire network administration of computers, internet and website management is looked after by the Agricultural Knowledge Management Unit (AKMU).

Research Farm and facilities

The Institute Research Farm spreads in 214.079 acres, possessing dug well (5), submersible (4), jet pump (1) and farm pond (2). About 85% its acreage is being utilized for various agroforestry based experiments and general crop cultivation. Crop cultivation at Research Farm is totally dependent on rainfall and operation of canal during *kharif* and *rabi* seasons, respectively. The details of crop production and revenue generated during 2020-21 are given in the table:

Organizational Setup

DIRECTOR & PROJECT COORDINATOR

Governance & Guidance

Research Programmes

- System Research
- Natural Resource and Environment Management
- Tree Improvement, Post Harvest & Value Addition
- HRD, Technology Transfer & Refinement

Service Sections

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

NRM Division, ICAR HQ

- QRT (2016-2021)
- RAC (2018-2021)
- IMC (2018-2021)

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 IINRG

Season/Crops	Area (ha)	Production (qt)	Revenue generated from farm produce (₹)	
***Kharif* 2020**				
Blackgram (KUG 479)	4.25	6.33	Aonla	75000.00
Greengram (IMP 2-3)	3.30	1.40	Guava	20050.00
Til (RT 315)	2.10	4.10	Ber	13500.00
Paddy	0.50	7.55	Lemon	4475.00
Dhaincha	1.20	Green manuring	Fuelwood	21000.00
Guar	1.00	Green manuring		
Total	**12.35**		**Total**	**134025.00**

During *rabi* season 2020-21 about 13.92 ha area (7.72 ha experimental and 6.20 ha general cultivation) was utilized for cultivation of different crops, the details are given below:

Crop	Sown area (ha)		
	Experimental	General	Total
Wheat (DW110/HD2967)	3.55	0.4	**3.95**
Barley (DWRB92)	1.75	3.9	**5.65**
Gram (Jaki 9218)	0.25	0.55	**0.80**
Mustard (Giriraj/RH406)	1.75	1.05	**2.80**
Pea	0.2	0.3	**0.5**
Chickpea	0.15	-	**0.15**
Sweet corn	0.07	-	**0.07**
Total	**7.72**	**6.20**	**13.92**

The Institute Research Farm generated revenue to the tune of ₹ 11.02 lakhs from sale of saplings, grains, fruits, firewood and straw during the reporting period. 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.

Others

The Institute has computer laboratory, committee room, conference hall 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.

Academic

Institute has been recognized by the Bundelkhand University as a study Institute to conduct Ph.D. programme. The Institute conducts M.Sc. dissertation and Ph.D. courses in Agroforestry, Horticulture, Environmental Sciences, Plant Protection, Soil Science, Biotechnology and Soil &Water Conservation from different recognized Universities. Institute contributing to education through UG teaching under collaborate programme with Rani Laxmibai Central Agricultural University, Jhansi; Bundelkhand University, Jhansi; Sam Higginbottom Institute of Agriculture, Technology Science, Allahabad; Swami Vivekananda College of Agricultural Engineering and Technology and Research Station;, IGKV, Raipur (C.G.) and BUAT, Banda (U.P.).

Budget (2020-21)

(₹ in Lakhs)

S.No.	Head	Budget	Expenditure
1.	**ICAR-CAFRI, Jhansi**		
	a. Capital (Grant for creation of Capital Assets)	19.32	19.32
	b. Establishment Expenses (Grant in Aid-Salaries)	765.97	765.97
	c. Grant in Aid-General. Pension Benefits	47.19	47.19
	d. Grant in Aid-General (including HRD)	268.50	268.50
	Total	**1100.98**	**1100.98**
2.	**Plan Schemes**		
	All India Coordinated Research Project on Agroforestry (AICRP on Agroforestry)	1122.00	1122.00
	Harvest and post-harvest processing and value addition of natural resins, gums and gum resins (HPVA; ICAR, New Delhi)	19.48	19.48
	IP&TM	0.5840	0.5840
3.	**Externally funded projects**		
	Transforming rural livelihood through agroforestry based natural resource management in drought prone Bundelkhand region, UP (Sub Project of KISAN MITrA project for doubling farmers' income in Bundelkhand region of Uttar Pradesh)- ICRISAT, Hyderabad	36.04	36.02
	Establishment of Hi-Tech nursery for the production of quality planting material- UP Agroforestry Mission, Lucknow	0.46	0.46
	Transforming rural livelihood and checking migration through agroforestry in conjunction with natural resource management in Bolangir and Nuapada districts of Odisha- ICAR-ICRAF Work Plan	0.68	0.68
	Assessment of genetic potential of neem germplasm for higher yield and oil content through molecular markers- ICAR-ICRAF Work Plan	6.48	6.23
	Assessment of area under agroforestry systems/species in agro-climatic zones of India- ICAR-ICRAF Work Plan	0.38	0.38
	Whole transcriptome sequencing of *Pongamia pinnata* for drought stress tolerance- ICAR-ICRAF Work Plan	4.50	3.97
4.	**Resource Generation**	**Target**	**Achievement**
	2020-21	---	13.16
5.	**SC SP Fund**		
	Capital	12.13	12.13
	General	21.80	21.79
		33.93	**33.92**

2. Research Achievements

2.1: System Research Programme

NRMACAFRISIL201000200085

Nutrient management in ber based agri-horticulture System

(Sudhir Kumar, Rajendra Prasad, Inder Dev and Y N Venkatesh)

In ber based agri-horti system ten treatments, *viz.* T_1- Ber (100% RDF), T_2- Ber (100% RDF) + Guar - Wheat, T_3- Ber (75% RDF), T_4- Ber (75% RDF) + Guar - Wheat, T_5- Ber (75% RDF) + VAM, T_6- Ber (75% RDF) + VAM + Guar - Wheat, T_7- Ber (75% RDF) + *Trichoderma,* T_8- Ber (75% RDF) + *Trichoderma* + Guar - Wheat, T_9- Ber (75% RDF) + VAM + *Trichoderma* + Guar - Wheat and T_{10}- Guar - Wheat, were imposed before *kharif*, 2020 onwards by adapting RBD with three replications at the spacing of 6 x 8m.The main objective of the experiment is to find out suitable nutrient management schedule for enhanced system productivity, profitability and sustainability under semi- arid conditions and also to observe "whether by incorporating the bio-inoculants one can save fertilizer without compromising the production and quality of produce".

The observation recorded on fruits during 2019-2020 that all the fruit characters considered were influenced significantly except TSS. Maximum average fruit weight (23.16g) was found significantly higher in treatment T_7, where as it was minimum (21.42 g) in treatment T_5. Average bigger size fruits were harvested in treatment T_7 (3.51 x 3.42 cm) followed by T_8 (3.52 x 3.39 cm). Fruit volume ranged from 21.83 cc in treatment T_4 to 23.83 cc in treatment T_7 and found significant. Likewise, pulp weight was recorded more in treatment T_7 (21.72 g) and it was less in T_5 (19.98 g) and found significant among the treatments. Stone weight ranged from 1.28 g (T_4) to 1.50 g (T_3) however pulp/stone ratio varied from 13.96 (T_5) to 15.84 (T_4). Total Soluble Solids (TSS) were found non-significant but recorded more in T_9 (18.25), T_7 (18.10) and T_6 (17.57^{0}B) whereas it was recorded less in T_2 (16.78^{0}B). As far as number of fruits /plant is concerned, it was significantly higher in treatment T_3 (2944.50) and lowest in treatment T_2 (1581.14). Fruit yield was significantly more in treatment T_3 (66.22 kg /plant) and found at par with treatments T_8 (65.56), T_7 (57.43) and T_6 (54.25 kg /plant).

The plants were pruned in the month of May, 2020 and ranged from 13.70 (T_4) to 21.04 (T_1) kg /plant on fresh weight basis, and 7.30 to 11.23 kg /plant on dry weight basis in the same treatments. In both the cases treatments were found significant. After pruning cent percent survival was observed in the field. The plant growth observations were recorded and the data revealed significantly maximum collar diameter in treatment T_1 (16.02 cm) which was at par with treatment T_3, T_5, T_6, T_7 and T_2. Minimum collar diameter was recorded in treatment T_4 (12.89 cm). First time Canopy spread was found significant and observed more in treatment T_8 in both the directions *i.e.* East-West (6.24 m) and North-South direction (6.28 m).

Ber based agri-horti system

Barley (BHS 400 C/S) was sown (@ 100 kg/ha) during *rabi* season, 2019 on residual fertility under rainfed condition and harvested in April, 2020. Barley recorded grain yield in the range of 2327 to 2518 kg/ha and corresponding straw yield was recorded in the range of 2492 to 2732 kg/ha in different treatments. The treatments T_{10} (pure crop) and T_6 (Ber- 75% RDF + VAM + Black gram - Barley) recorded highest grain yield of 2517 and 2518 kg/ha and were significantly higher as compared to other treatments. Similar trend was observed in corresponding straw yield (Fig. 1). During *kharif,* 2020, guar variety (BG 2) was sown on July 04, 2020 (30 kg/ha) with recommended dose of nutrients (20 Kg N/ha + 50 Kg

Ber + Barley

Ber + Guar

Fig. 1: Ber based agri-horti system

P/ha). The crop was failed due to faulty seed supplied by the supplier. Again it was sown on July 28 & 29, 2020 following recommended dose of fertilizers and seed rate per hectare. The seed yield varied in the range of 871 to1012 kg/ha. The treatments T_{10} (pure crop) and T_6 (Ber-75% RDF + VAM + guar-barley) recorded highest seed yield of 1012 and 995 kg/ha and was significantly higher with respect to other treatments. Similar trend was observed for corresponding straw yield which varied in the range of 3417 to 4126 kg/ha.

During *rabi,* 2020 wheat variety HI-8737 (Pusa Anmol) was sowed at the seed rate of 100 kg/ha on residual fertility under rain-fed condition and the production is awaited.

Monitoring and collection of Fruit flies (Diptera: Tephritidae) by setting traps

The study was conducted by installing methyl eugenol and cue lure Para pheromone traps during July, 2020 to Feburary, 2021 (Fig. 2). Fruit flies were collected at weekly interval throughout the cropping period, and then collected fruit flies brought to laboratory for counting and stored in 70% ethyl alcohol for further identification. Traps were replaced every month freshly for better results. In Methyl eugenol traps, highest number of fruit flies (361/trap) were recorded during July month and the lowest number (0.00 / trap) during November to December is (Fig. 2). When comes to Cue lure traps the number of fruit flies vary from 0 to 7.5 per week and highest number of fruit flies(7.5 /trap) were trapped during September month and lowest (0.00/ trap) during November to December (Fig. 3). However, number of fruit flies trapped was more during *kharif* season as compared to *rabi* season. This information will be of great importance for the study of species diversity, incidence, temporal and spatial distribution and correlation with weather parameters for better development of management practices of fruit flies.

Fig. 2: Fruit fly traps

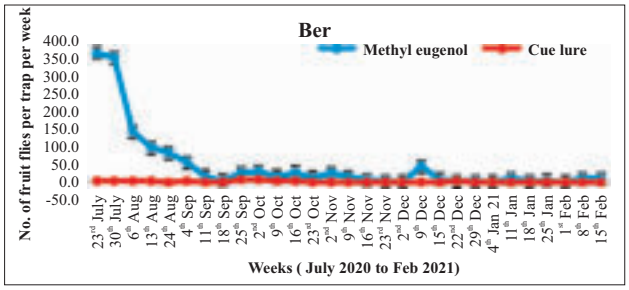


Fig. 3: Seasonal variation in catches of fruit flies by setting of pheromone traps

Effects of different treatments on soil characteristics

To assess the effect of different treatments on soil characteristics, soil samples were collected from tree rhizosphere (0.5 m away from tree trunk) at 0-15 and 15-30 cm depths, and analyzed in laboratory. In surface soil, pH and EC ranged from 6.53-6.83 and 190-385 µS/m, respectively. The SOC varied from minimum 0.49% in T_{10} to maximum 1.08% in T_5 and T_8. Available N varied from 263.6 to 388.9 kg/ha, P from 18.5 to 28.6 kg/ha and K from 128.2 to 463.5 kg/ha. Similar trend continued in sub-surface soil with few exceptions. In general, except soil pH, values of other soil parameters decreased in sub-surface layer in comparison to surface soil. In respect to micro-nutrients, surface soil of all the treatment plots contained sufficient amount of Zn and Cu with few exceptions. The contents of Fe and Mn were high in all the treatments. In sub-surface soil, micro-nutrients content declined when compared with surface layer. The soil of T_{10} was deficient in Zn.

NRMACAFRISIL201600100099

Performance of pomegranate integrated with lemon grass under organic regime

(Sudhir Kumar, Rajendra Prasad and Y N Venkatesh)

The experiment planned and executed in the field by

Monitoring and collection of Fruit flies (Diptera: Tephritidae) by setting traps

Fig. 4: Fruit fly traps

The study was conducted by installing methyl eugenol and cue lure Para pheromone traps during July, 2020 to February, 2021 (Fig. 4). Fruit flies were collected at weekly interval throughout the cropping period, and then collected fruit flies brought to laboratory for counting and stored in 70% ethyl alcohol for further identification. Traps were replaced every month freshly for better results. In Methyl eugenol traps highest number of fruit flies (391/trap) was recorded during July month and the lowest number during November to December is (0.00/trap) (Fig. 5). When comes to Cue lure traps the number of fruit flies vary from 0 to 45 per week and highest number of fruit flies (45/trap) were trapped during October month and lowest (0.00/ trap) during November to February. However, more number of fruit flies were trapped during *kharif* season as compared to *rabi* season. This information will be of great importance for the study of species diversity, incidence, temporal and spatial distribution and correlation with weather parameters for better development of management practices of fruit flies.

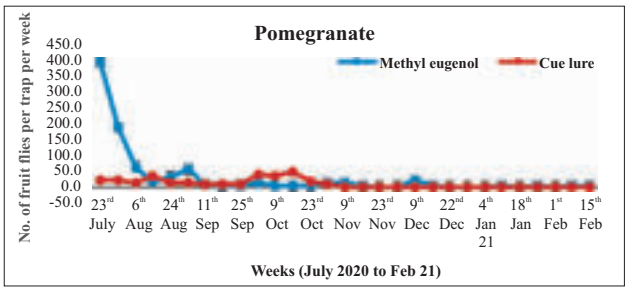


Fig. 5: Seasonal variation in catches of fruit flies by setting of Pheromone traps

Bio insecticides Evaluation against Insect pests of Pomegranate

Six insect pests' *viz.* fruit borer (*Virachola isocrates),* semi looper (*Achaea janata*), bark eating caterpillar (*Indarbela* sp.), termites, aphids and thrips (Fig. 6) have been noticed on pomegranate during 2020-21 of which, fruit borer and aphids were serious pests. Hence, subsequent study was conducted on evaluation of bio insecticides on fruit borer and aphids with six treatments [T_1- Control,T_2- *Metarhizium anisopliae,*T_3- *Beauveria bassiana,*T_4- *Verticillium lecani,*T_5- Neem oil and T_6- Imidacloprid (17.5 SL)] and three replications in randomized block design. Treatments were imposed at 15 days intervals and observations were recorded at 3, 5, 7, 10 and 15 days interval on percent of aphids infestation and fruit borer damage.

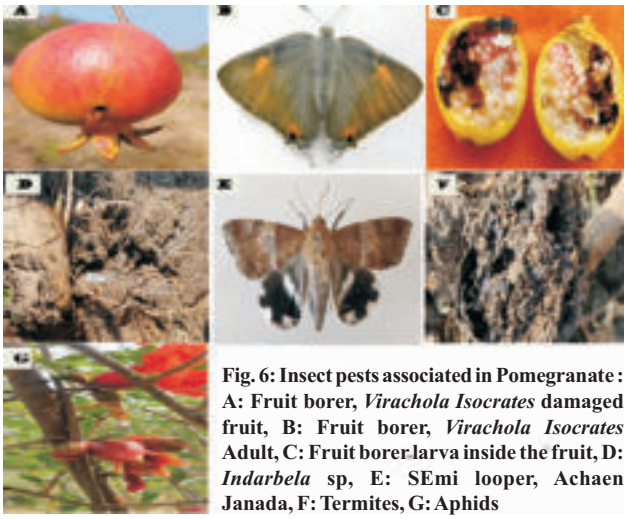


Fig. 6: Insect pests associated in Pomegranate : A: Fruit borer, *Virachola Isocrates* damaged fruit, B: Fruit borer, *Virachola Isocrates* Adult, C: Fruit borer larva inside the fruit, D: *Indarbela* sp, E: SEmi looper, Achaen Janada, F: Termites, G: Aphids

The lowest per cent infestation of aphids and fruit borer (9.66 and 11.00) were recorded in new molecule insecticide, Imidacloprid (17.5 SL) which was significantly superior over rest of the bio insecticide treatments. This was followed by neem oil (14.66 and 16.00%) and *Verticillium lecani* (15.79 and 17.00%). The highest fruit infestation was observed in untreated *i.e.* control (24.26 and 20.00%), Fig. 7. The result indicated that Imidacloprid (17.5 SL) is more effective against aphids and fruit borer in comparison to bio insecticides.

Effects of different treatments on soil characteristics

From pomegranate-lemongrass agroforestry system, soil samples were collected from 0-15 and 15-30 cm depth, and analyzed in laboratory. Data revealed that in comparison to

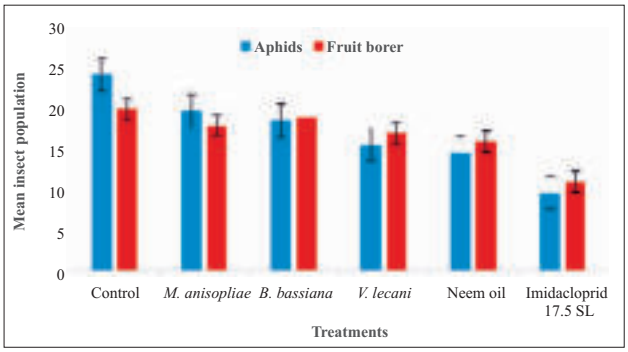


Fig. 7: Efficacy of bio insecticides on Aphids and Fruit borer pests of Pomegranate

pure lemongrass treatment, other plots had higher values of studied soil parameters. Variation in SOC, available NPK, and micro-nutrients across all the treatment plots indicate that source of nutrition to pomegranate plants had varying effects on soil characteristics. In general, fertility status of surface soil was better than sub-surface layer. Micro-nutrient contents were sufficient in all the treatments with higher values in surface soil than sub-surface layer.

NRMACAFRISIL201600200100

Structural and functional analysis of short rotation tree based Agroforestry system

(Naresh Kumar, Asha Ram, Inder Dev, Kamini (ICAR-IGFRI, Jhansi) and Priyanka Singh)

This project was initiated in the year 2016 to assess the performance of three fast growing tree species *viz.*, *Anthocephalus cadamba, Melia dubia* and *Leucaena leucocephala*. The main objectives of the project are to assess growth, biomass and carbon sequestration trends in tree components, to evaluate tree-crop interactions and its impact on crop productivity, and to study the wood properties in relation to fuel wood, pulp & paper industries and small timber. Sixteen plants of each tree species was planted in each plot (16x 20 m = 320 m^2). For calculation of carbon sequestration in trees through destructive method some additional rows of trees were planted. Every year, three trees of each species from 4 x 5 m spacings were harvested for calculation of biomass and carbon stock in tree components. The rotation age of eight years was fixed for final harvesting of trees.

The growth data of tree species was recorded and through destructive method the carbon stock in different parts of tree species was calculated during 2020. Tree-crop interactions were also studied.

Biomass and carbon stock in *A. cadamba, M. dubia* and *L. leucocephala*

The observations on height and diameter at breast height (dbh) were recorded. Excavation was done by manual digging, up-rooting and by using high pressure water to detach soil from roots. Prior to excavation the area around the tree was watered thoroughly to soften the ground and make it possible to excavate without damaging the tree roots and also to extract entire root system.

The above ground parts and below ground parts of tree species were separated. After taking their fresh weight, they were kept in oven for drying at 70± 2°C till constant weight and then there oven dry weight was measured. Carbon stock in the above ground parts and below ground parts was calculated by following formula:

Carbon stock= 50% of the oven dry biomass (IPCC, 2006)

At the age of four year, maximum tree height was recorded in *M. dubia* (11.30 m), followed by *L. leucocephala* (9.70 m) and *A. cadamba* (8.0 m). The maximum diameter at breast height (dbh) was also recorded in *M. dubia* (22.00 cm), followed by *A. cadamba* (15.87 cm) and *L. leucocephala* (12.01 cm). *M. dubia* recorded the maximum (349.98 kg) dry biomass per tree. In *A. cadamba,* dry biomass of 137.25 kg per tree was recorded. The lowest dry biomass (64.53 kg/tree) was recorded in *L. leucocephala.*

The maximum carbon stock (174.98 kg/tree) was observed in *M. dubia* whereas, the lowest carbon stock (32.26 kg/tree) was recorded in *L. leucocephala*. In *A. cadamba*, carbon stock of 68.62 kg/tree was observed. Among different tree species, share of above ground parts to carbon stock varied from 73.75 to 83.85 % carbon stock whereas, the share of roots to carbon stock varied from 17.98 to 26.25%.

Tree-crop interactions

The effect of shade on wheat as well as blackgram yield was

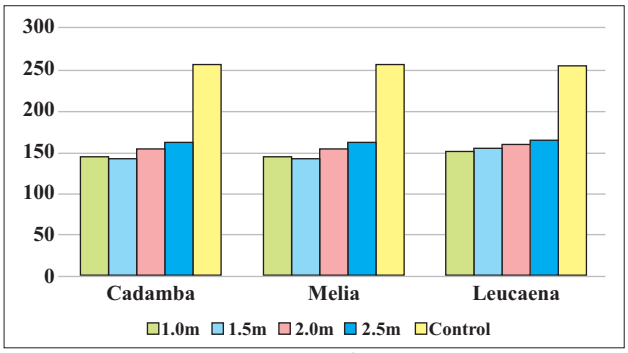


Fig. 8: Wheat Grain yield (g/m^2) under 4x5 m spacing

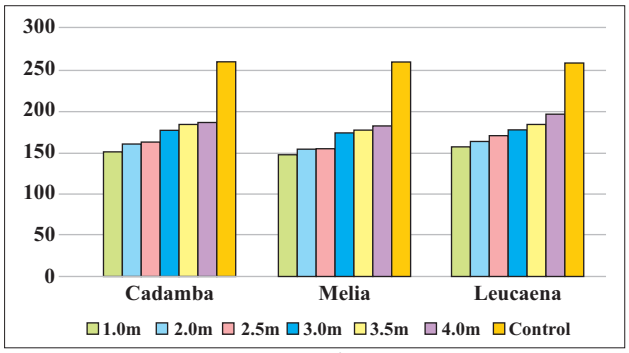


Fig. 9: Wheat Grain yield (g/m^2) under 8 x 2.5 m spacing

observed in all the tree species. However, the reduction in yield was more in 4 x 5m spacing as compared to 8 x 2.5m spacing. It was observed that crop yield was minimum at 1 m distance (*i.e.* nearest to the tree row) from the plants of all the tree species grown at 4 x 5m (Fig. 8&9) and 8 x 2.5 m spacings under study (Fig. 10 & 11).

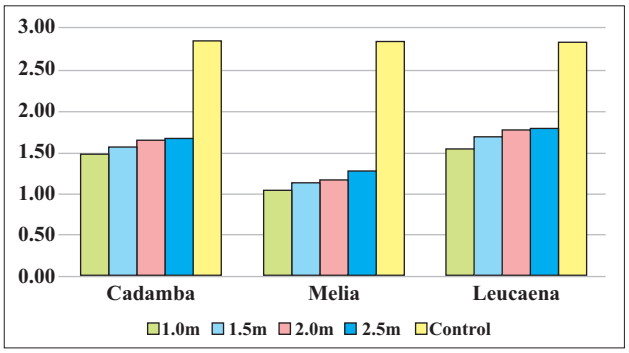


Fig. 10: Blackgram yield (g/m^2) under 4 x 5 m spacing

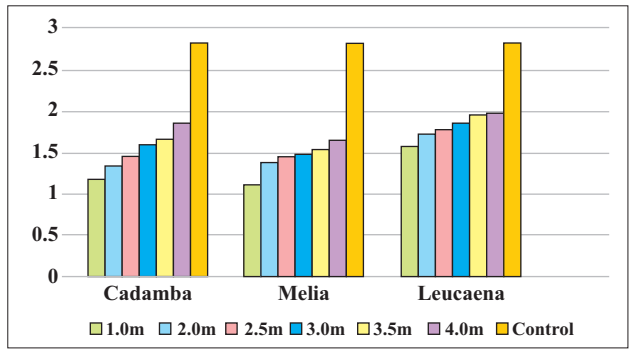


Fig. 11: Blackgram yield (g/m^2) under 8 x 2.5 m spacing

2. Research Achievements

2.2: Natural Resource & Environment Management Programme

NRMACAFRISIL201300100091

Agroforestry based conservation agriculture for sustainable land use and improved productivity

(Inder Dev, Asha Ram, Ramesh Singh, Naresh Kumar, Dhiraj Kumar, Lal Chand, Sushil Kumar, Y N Venkatesh and Priyanka Singh)

The project entitled "Agroforestry based conservation agriculture for sustainable landuse and improved productivity project" was initiated during July, 2014 having 03 experiments *viz.* Bael based Agroforestry system; Teak based Agroforestry system and Bael + Teak based Agroforestry system with 04 main plot treatments *i.e.*, Min. tillage-Blackgram-Mustard (CS-1); Min. tillage-Greengram-Barley (CS-2); CT-Blackgram-Mustard (CS-1) and CT-Greengram-Barley (CS-2) and 03 subplot treatments (with crop residue; without crop residue and with leucaena residue). The experiments were conducted in split plot design with 03 replications.

Experimental results

During *rabi* 2019-20, mustard and barley and in *Kharif,* 2020 greengram and blackgram were sown as per the treatment details in all the three experiments, and the results in brief of the experiments are presented as under:

Experiment 1: Bael (*Aegle marmelos*) based conservation agriculture system

In bael based conservation agriculture system, during *rabi,*2018-19, the seed yield of mustard varied significantly among tillage treatments (Fig. 12). The highest seed yield was recorded in crop residue treatment followed by leucaena added treatment. The seed yield in the treatment of crop residue and leucaena based were statistically at par with each other and significantly higher over the no residue treatment. The addition of crop residue increased the seed yield of barley substantially over no residue treatment.

During *kharif* season (2020), the seed yield of blackgram in MT and CT plots were non-significant (Fig. 12). The residue addition resulted in significant increase in seed yield of blackgram. The yields of crop residue treatment and leucaena treatment were found statistically at par with each other.

Seed yields of greengram in both the tillage treatments were found statistically at par. Addition of crop residue recorded highest seed yield followed by leucaena residue addition and least yield was recorded in control.

Experiment II: Teak (*Tectona grandis*) based conservation agriculture system

In teak based conservation agriculture system (Fig. 13) during *rabi* season (2019-20) due to residue addition significant difference in seed yield of mustard was observed. The seed yield showed substantial increase with crop residue and leucaena addition residue addition over control. However, both the residue addition remained statistically at par with each other. The data indicated that the grain yield of barley was not influenced by tillage treatments in teak based conservation agriculture system. In sub plot treatments, crop residue and leucaena residue addition have increased the grain yield of barley substantially over no residue application treatment. Among the residue based treatments, the seed yield of blakcgram increased substantially in crop residue addition and in leucaena residue addition over no residue addition treatment (Fig. 16). Data indicated that tillage treatment did not bring significant change in seed yield of greengram (Fig. 17).

Fig. 12: Bael based conservation Agriculture

Fig. 13: Teak based conservation Agriculture

Experiment III: Bael + Teak based conservation agriculture system

Tillage treatments did not bring any significant changes in the seed yield of mustard during *rabi* season of 2019-20. However, the seed yield was recorded slightly higher in CT plots than MT plot (Fig. 14). The residue addition has resulted in significantly increase in the seed yield of mustard over control. Residue addition recorded substantial increase in seed yield in crop residue addition and in leucaena residue addition in sub plots over no residue addition treatment**.** The grain yield of barley ranged from 1318.8 kg/ha in MT to 1348.7 kg/ha in MT plots (Fig. 15).

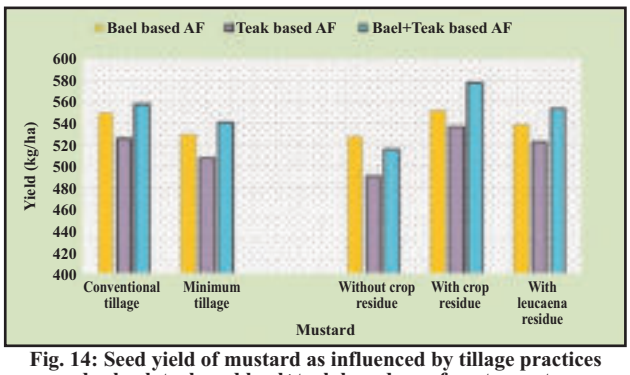


Fig. 14: Seed yield of mustard as influenced by tillage practices under bael, teak and bael+teak based agroforestry system

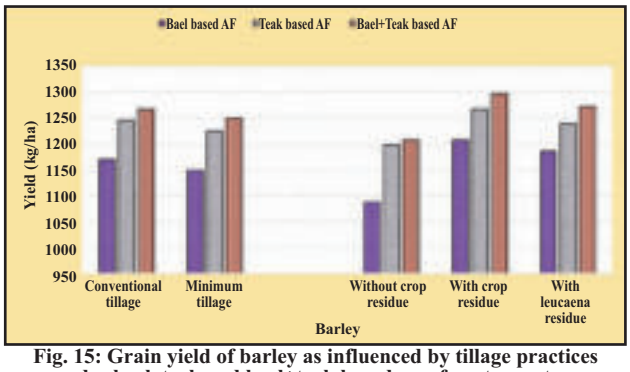


Fig. 15: Grain yield of barley as influenced by tillage practices under bael, teak and bael+teak based agroforestry system

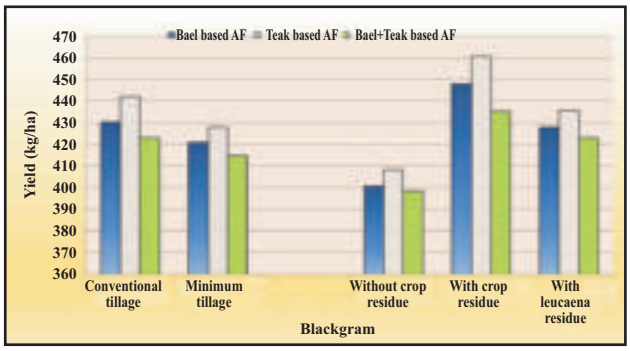


Fig. 16: Seed yield of blackgram as influenced by tillage practices under bael, teak and bael+teak based agroforestry system

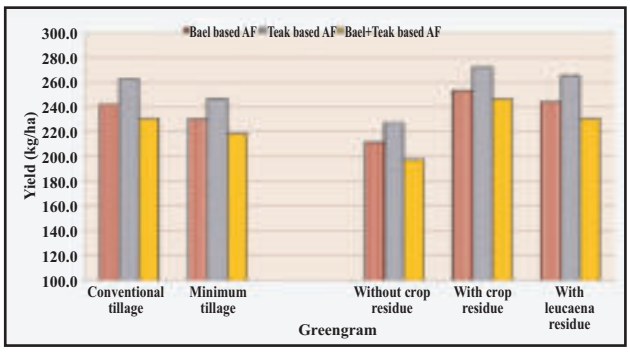


Fig. 17: Seed yield of green gram as influenced by tillage practices under bael, teak and bael+teak based agroforestry system

The data indicated that the seed yield of blackgram was observed statistically at par in both the tillage treatments. The data also indicated that the residue addition had influenced seed yield of blackgram significantly. The highest seed yield was recorded in crop residue added treatment followed by leucaena residue added plot and minimum in control. However, both the residue added treatments were found statistically at par with each other**.**

Data also indicated that seed yield level of greengram in MT and CT treatments were non-significant. Among the residue based treatments, the seed yield of greengram increased substantially in crop residue addition and in leucaena residue addition over no residue addition treatment**.**

Growth parameters of bael and teak in different AFS based conservation agriculture

The observations on growth parameters (DBH and Height) of bael and teak indicated that there was no significant difference between and among the systems for DBH and height of both the tree species.

Biology and life cycle of *Hyblaea puera* Cramer and *Eutectona machaeralis* Walker in Agroforestry based conservation agriculture

This study was conducted during July to October, 2020. Observations on the incidence of Teak Defoliator, *Hyblaea puera* Cramer (Lepidoptera: Hyblaeidae) and Teak skeletonizer, *Eutectona machaeralis* Walker (Lepidoptera: Pyralidae) were recorded. A laboratory experiment was conducted to study the biology, life cycle and observations were recorded on larval instars, larval duration, and pre pupal and pupal period, and fecundity, male and female adult longevity. Larvae of *H. puera and E. machaeralis* were collected from field and they were reared in laboratory on teak leaves up to pupation. After emergence of moths from pupae they were kept for oviposition, eggs laid by the moths were reared in the laboratory for study of life cycle and biology.

The incubation period of *H. purea* and *E. machaeralis* under laboratory condition varied from 1 to 2 days with an average 1.7±0.26 days and 2-3 days with an average 2.2±0.72, respectively. Total larval period ranged from 12 to 18 days with an average of 15±3.0 days in both the insect species. Pre-pupal period varied from 1 to 2 days with an average of 1.5±0.5 days in both the cases. Pupation occurred in webbed leaves inside the thin silken cocoon. In

H. purea pupal period lasted for 6 to 8 days with an average of 7.3±1.01 days and 6 to 7 days with an average of 6.5±0.5 in *E. machaeralis*.

The *H. purea* moth thorax was greyish red brown, abdomen black brown with orange segmental bands. Forewing was reddish brown and hind wing was dark brown with curved orange edged bands across the middle and anal angle (Fig. 18). *E. machaeralis* was greenish-white larva with a light brown head and adult moth with forewings having transverse markings and hindwings with bands (Fig. 19). Fecundity ranged from 460 to 480 eggs per female with a mean of 740±10 and 300 to 315 with a mean of 307.3±7.50 in *H. purea* and *E. machaeralis*, respectively. Male adult longevity ranged from 5 to 6 days with an average of 5.5±0.5 days and 6 to 7 days with an average of 6.5±0.4 in *H. purea* and *E. machaeralis*, respectively. While, female adult longevity ranged from 6 to 7 days with an average of 6.5±0.5 days and 8 to 9 days with an average of 8.5±0.5 respectively. Total life cycle of *H. purea* male and female was completed in about 26 to 37 and 26 to 38 days with an average of 32±5.56 and 32.6±6.1 days, respectively. Whereas, total life cycle of *E. machaeralis* male and female was completed in about 30 to 33 and 30 to 40 days with an average of 31.5±1.5 and 34.6±5.50 days, respectively.

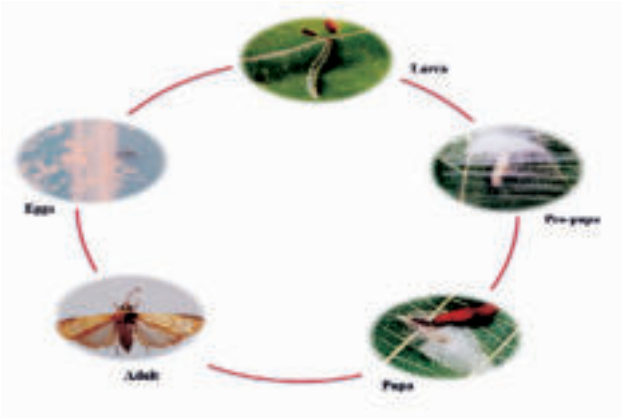


Fig. 18: Life cycle of Teak Defoliator, *Hyblaea puera* Cramer (Lepidoptera: Hyblaeidae)

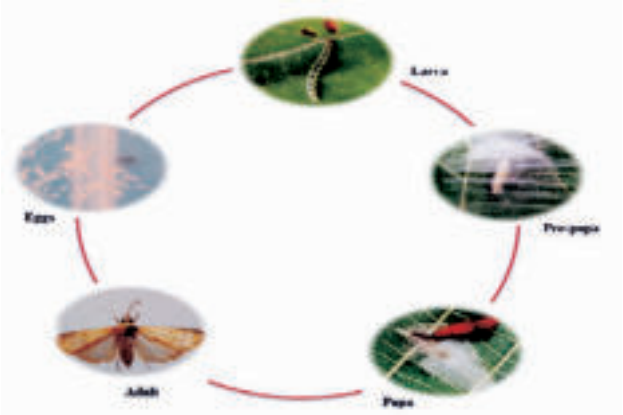


Fig. 19: Life cycle of Teak skeletonizer, *Eutectona machaeralis* Walker (Lepidoptera: Pyralidae)

NRMACAFRISIL201600400102

Agroforestry based integrated farming system for small and marginal farmers in semi-arid region

(Asha Ram, Sudhir Kumar, Naresh Kumar, Sushil Kumar, Lal Chand, Y N Venkatesh, R Vishnu, Priyanka Singh and Aswathy Chandrakumar)

Agroforestry based Integrated Farming System (AF-IFS) project was initiated during the year 2016. Among the new initiatives in the project, Melia and Teak were planted on outer boundary of the field. Melia plants were also planted along the fish pond as aqua-agroforestry. In *kharif* season, in low lying field direct seeded rice was grown. The guava production was recorded 25.15 kg/plant and about 1.0 tonne of guava was harvested. Custard apple was planted in between the guava in a row at 5m distance. Bunds of the field were utilized for pigeon pea production. From roadside Moringa plantation, about 150 kg moringa pods were harvested. After the moringa pod harvesting, to see the flowering time and pod bearing behaviour of the moringa plants, staggered pruning was done at 30 days interval (Pruning schedule was Unpruned, 30 April, 30 May and 30 June). In unpruned and plants pruned with 30 April recorded with 8- and 10-days earlier flowering as compared to plants pruned on 30 May and 30 June, respectively (Fig. 20 &21). During *rabi,* 2019-20, about 400 kg vegetable pea and 35 kg pea grains has been harvested from 0.3 ha area. About 800kg wheat, 80 kg chickpea have also been produced during *rabi*, 2019-20. During *kharif,* 2020, first time paddy crop was taken in fields which are more prone to water logging. From 0.4 ha area, about 800 kg rice grain was harvest. Blackgram and sweet corn were also grown during *kharif* season. Due to low water availability in *Zaid* season, only two crops (sweet corn and Bhindi) were produced in 0.2 ha area. In year 2020, from crop and fruit production about ₹ 81265 gross income has been generated.

Fig. 20: Fish production at IFS pond

Fig. 21:Paddy + Guava based agroforestry system

NRMACAFRISIL201600700104

Impact of watershed and agroforestry interventions on hydrology and nutrient loss at Garhkundar-Dabar watershed in Bundelkhand region of Central India

(Ramesh Singh/Inder Dev, R K Tewari and Asha Ram)

Monitoring of runoff and soil loss was done at four locations in Garhkundar-Dabar watershed (treated), however, untreated watershed was gauged for the same at the outlet. Datalogger based automatic stage level recorders were installed at five sites, including control watershed during 2020. Besides this, manual and self-recording rain gauges were also installed in the watershed to measure the rainfall. Total 776.1 mm rainfall, 11.5% deficit than normal, was received. It was observed that the runoff from the treated watershed was 9.8% of total recorded rainfall during the year. Soil loss from treated and untreated was also recorded and it was 81.5% lower in case of treated over untreated watershed. All open shallow dug wells in treated (116 nos.) and untreated (42 nos.) watershed were monitored monthly for water level. During the month of October average water column was 4.9 m which is 41% higher than the average water column of open wells situated in untreated watershed. The N and P loss were 3.9 and 1.98 kg/ha, respectively, from treated watershed.

NRMACAFRISIL201600700104

Relevance of soil and water conservation measures in enhancing productivity and sustainability of silvipastoral system in semi-arid conditions

(Asha Ram, Naresh Kumar and Inder Dev)

The survival of the teak and mahagoni after four year of transplanting was observed was 91 and 70%, respectively. After four year of planting, maximum growth parameters (DBH, Height) were recorded in treatment having Teak+ Mahagoni+ Pasture+ Contour staggered trenches. Grass cut

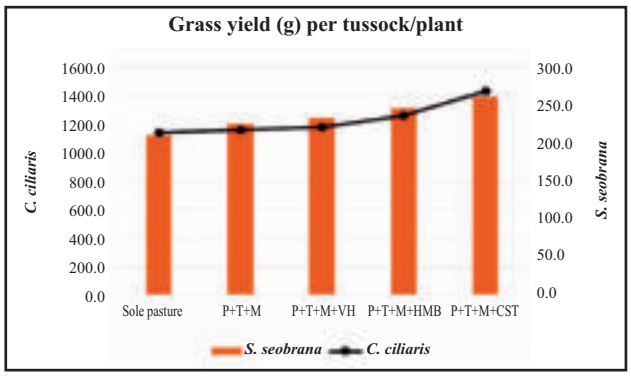


Fig. 22: Grass yield (fresh weight) of *C. ciliaris* and *S. seabrana*

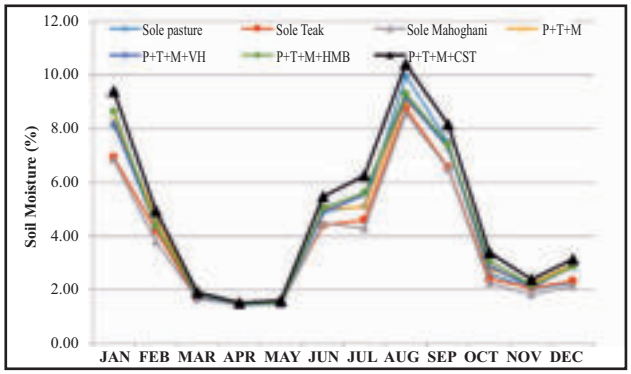


Fig. 23: Soil moisture dynamics in different treatments during year 2020

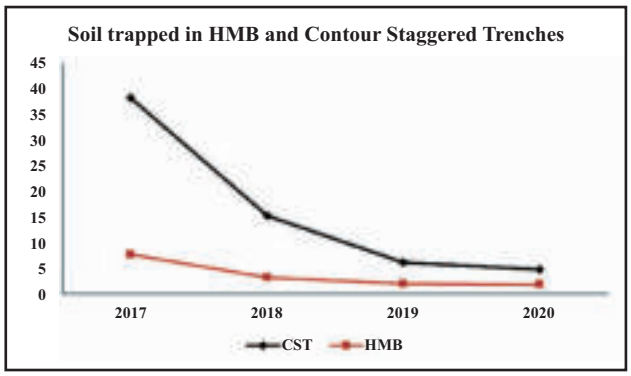


Fig. 24: Soil trapped in trenches and Half Moon Basin during 2017 to 2020

was taken in month of September and highest growth parameters and yield were recorded in T_7 - Teak+Mahagoni+ Pasture + Contour Staggered Trenches (CST) treatment followed by T_6- Teak+Mahagoni+ Pasture +HMB. All the soil and moisture conservation measures were observed to increase the grasses yields (Fig. 22). The root parameters of both the grasses were also found significantly higher in T_7 - Teak+Mahagoni+ Pasture + Contour Staggered Trenches (CST) treatment as compared to other treatments. Soil moisture dynamics in different treatments were studied through thermo-gravimetric method at 15 days interval and it was found that soil and moisture conservation measures increased the availability of soil moisture in soils. During March, April and May,

average soil moisture content was recorded below 2% in all the treatments and reaches upto 10.43% (in Teak+Mahagoni+Pasture+CST) in month of August (Fig. 23). Among all the treatments, highest moisture content was recorded in T_7 treatment during rainy season due to more conservation of water in the contour staggered trenches. Sole tree (Teak /mahagoni) plantation (without pasture component) observed with lowest moisture conservation due to direct exposure of soil surface to sunlight, wind etc. Improvement in soil biological properties was also observed in tree+ grass plots. After four years of experimentation, soil erosion was observed minimum as compared to previous years. After forth rainy season, the contour staggered trenches (CST) and half-moon basin (HMB) trapped soil sediments at the rate of 4.76 t / ha and 1.80 t/ ha, respectively (Fig. 24).

NRMACAFRISIL202000300121

Temporal evaluation of cropping systems under *Melia dubia* based agroforestry system

(Sushil Kumar, Asha Ram, Naresh Kumar, Sukumar Taria, Priyanka Singh and Rajendra Prasad)

A field experiment involving three spacing of *Melia dubia* (8x3, 8x4 and 8x5 m) in main plots and four *rabi* season crops (wheat, barley, chickpea and mustard) in subplots established (Fig. 25 &26) at the Institute experimental farm in a split-plot design with three replicates.

Fig. 25: Layout making for melia plantation

Fig. 26: Field view of the wheat

NRMACAFRISIL202000400122

Standardization of nursery practices for the production of quality planting material of Indian Sandalwood (*Santalum album* L.)

(R. Vishnu, Naresh Kumar, Rajendra Prasad, K. Rajarajan and Sukumar Taria)

Two seed sources, one from Kerala and another from Tamil Nadu were evaluated for its seed germination. Seeds from Kerala showed 65-70% germination and from Tamil Nadu it was 25-30%. 500 ppm Gibberellic acid for 48 hours was found to be the best pre-treatment for high germination. Among different potting media used for germination, coir pith media showed the highest seed germination percent followed by red soil. During pre-winter (October-November) the seeds took 24 days for the first germination. During the winter season (January-February) it took more than 40 days for the first germination. The seedlings raised on open seed bed showed root parasitism with nearby weeds and with nearby sandalwood seedlings also.

2. Research Achievements

2.3: Tree Improvement, Post-Harvest and Value Addition Programme

NRMACAFRISIL200700400071

Comparative studies on seedling and clonal plants of *Pongamia pinnata* with special reference to their adaptability to rainfed dry agroclimate

(Badre Alam, A K Handa, Sukumar Taria, Hirdayesh Anuragi & Alka Bharti)

Comparative physiological efficiency was observed in clonal and seedling plants in field with reference to the evaluation through physiological traits and indices. Remarkable differential responses were noted during peak summer conditions between clonal and seedling plants. Relatively better physiological efficiency was noticed in clonal plants than the seedling plants during summer conditions. The functional differences were in the rate of CO_2 assimilation (P_N max), electron transport rate (ETR) across PS2 and effective quantum yield of photosystem-2 which were relatively higher in clonal plants (Figs. 27, 28, 29). Clonal plants indicated its relatively higher physiological efficiency to maintain functional traits relating to photochemical activities / efficiency during dry hot summer season.

Comparative growth in canopy diameter was also estimated (Fig. 30). Indications were also noted in differential responses in water relation traits in leaves. Dynamics of leaf water relation in peak summer revealed that leaf water relation trend in clonal plants indicated its comparatively

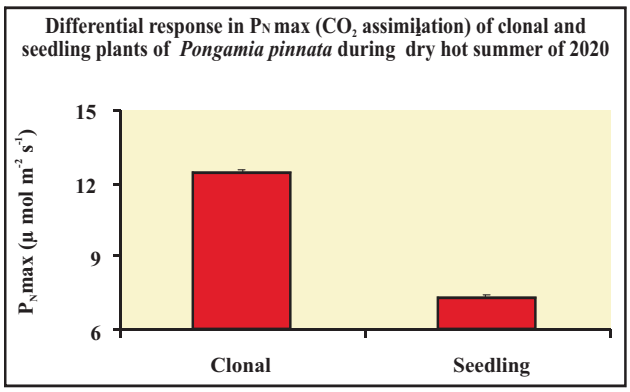


Fig. 27: Maximum rate of CO_2 assimilation (P_N max) of clonal and seedling plants of *Pongamia pinnata* under dry hot summer season

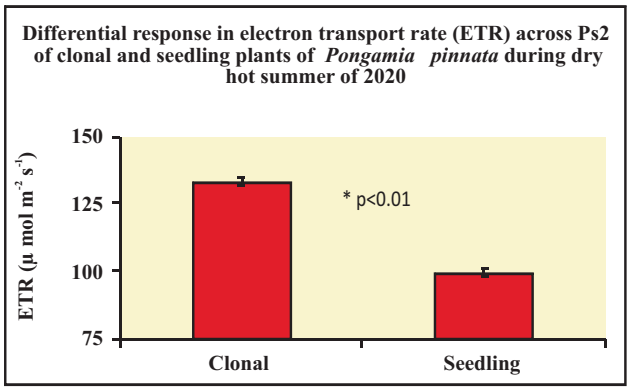


Fig. 28: Thylakoid electron transport rate (ETR) of clonal and seedling plants of *Pongamia pinnata* under dry hot summer season

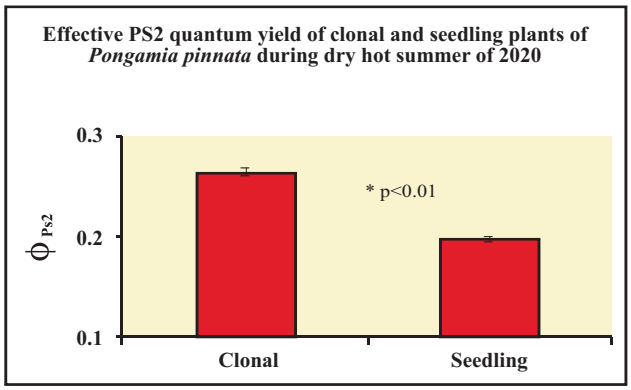


Fig. 29: Effective quantum yield of PS2 of clonal and seedling plants of *Pongamia pinnata* under dry hot summer season

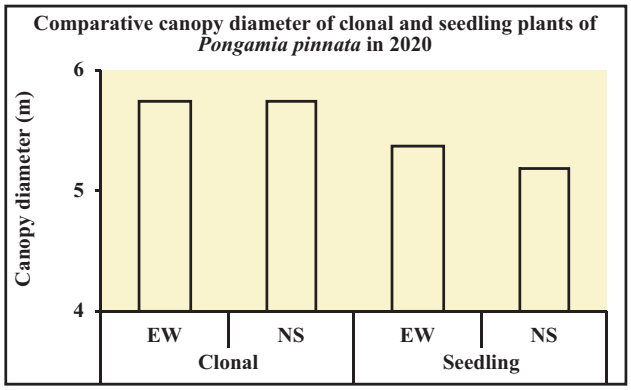


Fig. 30: Canopy diameter of clonal and seedling plants of *Pongamia pinnata* in east-west and north-south directions

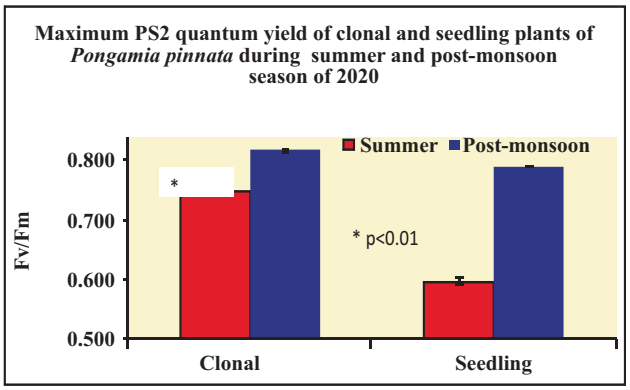


Fig. 31: Comparative maximum PS2 quantum yield of clonal and seedling plants of *Pongamia pinnata*

better adaptability than seedlings. Differential functional responses in enzyme activities have been deciphered associated with clonal and seedling plants in dry hot summer. Marginal difference in photochemical efficiency (Fv/Fm) traits in clonal and seedling plants was noted during conducive post-monsoon season (Fig. 31).

NRMACAFRISIL201500100092

Evaluation and characterization of different Leucaena germplasm at ICAR-CAFRI

(K Rajarajan, A K Handa, A K Singh (IGFRI), Maneet Rana (IGFRI) and R Vishnu)

In the proposed year we have optimized wood properties estimation parameters for different Leucaena species (*L. diversifolia*, *L. shanonii*, *L. lanceolata*, *L. collinsii* and *L. leucocephala*. We have also studied growth and biomass, physical properties (basic density, shrinkage parameters), chemical composition (α cellulose, holocellulose, lignin content, hot water solubility and NaOH solubility), fuelwood properties (moisture content, volatile matter, AB extractive, fixed carbon and calorific value) and wood anatomical parameters like fiber length and width (data not submitted). The great level of variation was observed among the species for wood properties (Fig. 32). Based on this study, the species *L. diversifolia* registered for superior fuelwood properties and *L. leucocephala* had superior pulpwood qualities with higher fiber length and width as compared to other species. Therefore, considering these species according to their wood properties may serve as an alternative species for bioenergy and pulpwood, respectively. In addition, these species could be useful in future inter-specific hybridization for wood properties improvement.

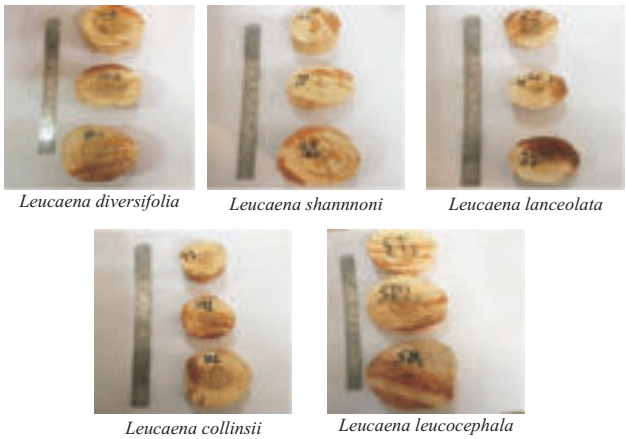


Fig. 32:Different leucaena species wood samples

NRMACAFRISIL201600900107

TBOs based agroforestry models

(R Vishnu, Inder Dev, Naresh Kumar and Sushil Kumar)

To demonstrate and promote TBO based agroforestry model, an experiment was laid out at the experimental farm of ICAR-CAFRI, Jhansi. Trees selected for the study are *Pongamia pinnata, Simarouba glauca* and *Azadirachta indica*. Development of irregular flowers were observed in *Pongamia pinnata* and *Azadirachta indica*. The average height and collar diameter of trees was found to be highest in *Azadirachta indica* (4.91 m and 14.05 cm) followed by *Pongamia pinnata* (3.42 m and 8.74 cm). Out of 36 trees of each species, 30 trees were flowered and fruited in *Azadirachta indica*, 10 trees flowered and 3 fruited in *Pongamia pinnata* and no flowering was observed in *Simarouba glauca.* Till the date *Pongamia pinnata* and *Azadirachta indica* showed 97% survival rate (1 tree in each species died) and *Simarouba glauca* showed 87 % (5 trees died) survival rate.

NRMACAFRISIL201801100114

Functional genomics for early drought tolerance in *Pongamia pinnata* genotypes

(K Rajarajan, A Radhakrishnan (IGFRI), Lal Chand, Sukumar Taria, Hirdayesh Anuragi and Alka Bharati)

In the previous study, we have screened eighteen genotypes into three early tolerant genotypes (NRCP-7, NRCP-9 and NRCP-25) and early susceptible genotypes (NRCP-6, NRCP-10 and NRCP-14) in both the seasons based on *per cent* reduction and mean performance of putative traits. Further, these genotypes were considered for physiological and biochemical characterization. In this proposed year, eleven morpho-physiological and biochemical traits were studied in these six genotypes under drought stress and control condition. Significant differences were observed for all the considered parameters under drought stress condition. The parameters *viz.* SPAD chlorophyll content, carotenoid, Fv/Fm, root length, dry root weight, peroxidase (PEX), catalase (CAT), total soluble protein, lipid peroxidation, and proline. Among the genotypes NRCP-9 were identified as tolerant genotype. In this study, the NRCP-9 genotype had superior antioxidant system, rood trait expression, increased photosynthetic pigments and proline accumulation as compared to other genotypes. Thus, involved in the tolerance mechanism of this genotype. Further, the genotype is subjected to molecular characterization by differential gene expression analysis by five known candidate genes.

NRMACAFRISIL201900200118

Collection, evaluation and hybridization of Moringa germplasms

(Hirdayesh Anuragi, Lal Chand, Sukumar Taria, K Rajarajan, Alka Bharati, Sushil Kumar and Y N Venkatesh)

Moringa oleifera Lam., popularly known as '*Moringa*', '*drumstick*', '*Sahjan*', or '*Ben oil*' is a member of moringaceae family. It has also been referred as '*superfood*', '*miracle tree*' and '*tree of life*' owing to its exceptionally high nutritive (minerals, vitamins, proteins, antioxidants) and

therapeutic values which can cure above 300 diseases. *Moringa* has Indian origin but is grown worldwide with a huge demand for its leaves and tender pods. India is a leading producer of *Moringa* with a global market of over US$ 8 billion worth *i.e.* 80% of total demand. *Moringa* being climate smart plant (fast growing, drought, high temperature and mild frost tolerant, and grown in wide range of climates), can be a potential agroforestry component which will ensure farmland ecosystem restoration, nutritional and livelihood security under current scenario. Looking at this, an experiment was planned to develop a collection of *Moringa* from possible nearby places followed by their characterization and attempting hybridization in order to develop superior genotypes. Identifying or developing superior genotypes with round the year fruiting habit under water scarce and hot climate will surely help the farmers of drought prone Bundelkhand and other semi-arid regions.

As a part of this, a total of fourteen *Moringa* germplasm with variable characteristics were collected from nearby districts of Madhya Pradesh and Uttar Pradesh *i.e.* Jhansi, Datia, Tikamgarh, Niwari, Chhatarpur, Lalitpur, Shivpuri, Gwalior, Mahoba, Rath, Sagar etc. While exploration, a considerable diversity for various traits has been observed and traits like tree morphology along with pod, seed and flower characteristics were recorded. On an average, after every 0.5 to 1 km distance, a moringa tree was observed either on the roadside or at the farm area. These plants were observed singly and no bulk plantation by any farmer was spotted during the visit. Plants with varied morphology, phenology and fruiting habits were observed. The plant growth habit was observed to be upright, and spreading type with light grey to dark colored stem bark. The shape of leaf blade varied from round to obtuse and leaf color with light to dark green. *Moringa* flowers were found to be medium (<2×3 cm) to large (>2×3 cm) in size with narrow to little bit broader petals. Pinkish pigmentation was also observed on flower bud, leaf petiole and pods in one accession. Pods with sweet and bitter taste, smooth and rough textured surface, light to dark grey color and different shapes were seen. Small to bold sized seeds with oval, triangular shape, light to dark brown color and white papery thin wings of various shapes were observed. The passport data of each germplasm was collected during the visit. In total, a considerable amount of variability was recorded in the quantitative (tree height, crown spread, number of primary branches, collar diameter, pod length, pod width, number of seeds per pod, seed length, seed width, approximate pod yield per plant) as well as qualitative traits like pod color, seed color, taste, fruiting habit *etc.* (Fig. 33, 34 &35) in the germplasm collected. These germplasm are under evaluation at ICAR-CAFRI, Jhansi.

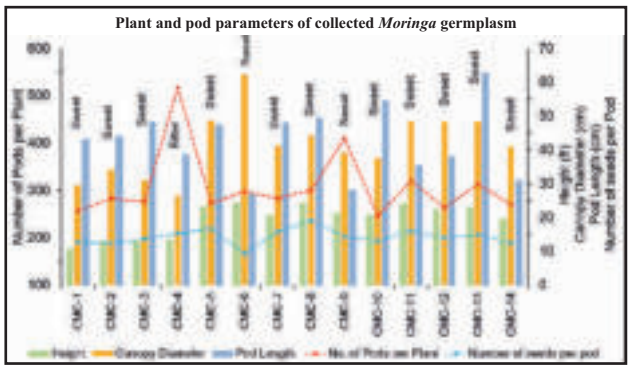


Fig. 33: Plant and pod characteristics of *Moringa* germplasm observed during exploration

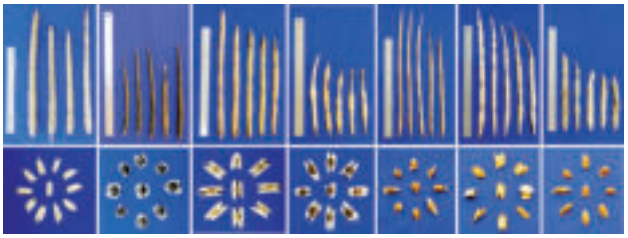


Fig. 34:Variation in pods and seed characteristics of *Moringa* germplasm collected

Fig. 35: Nursery raising and field plantation of collected *Moringa* germplasm at ICAR-CAFRI, Jhansi

OTHER RESEARCH ACTIVITIES

(A) Evaluation of bael (*Aegle marmelos* (L.) Corr.) varieties under semi-arid conditions of Bundelkhand

(Lal Chand, Sudhir Kumar and Asha Ram)

A bael block of six varieties *viz.* V_1: CISH-B-1, V_2: Goma Yashi, V_3: Kagazi Etawah, V_4: CISH-B-2, V_5: NB-5 and V_6: NB-9 was established during July-August, 2018 at CR Farm of ICAR-CAFRI, Jhansi to evaluate them under edapho-climatic conditions of Bundelkhand region. The experiment is setup in Randomized Block Design at 6x6m spacing with three replications having three plants of each variety in each replication. After two years of plantation, almost all the planted plants of different varieties established properly in the

field. The growth observations reveal that in the second year all the observed growth parameters (height, collar diameter and canopy spread) differed significantly among the varieties. Maximum height was found in CISH-B-2 (V_4) and minimum in NB-9 (V_6) and the trend was $V_4>V_3>V_5>V_1>V_2>V_6$. Similarly, collar diameter was also maximum in CISH-B-2 (V_4) and minimum in NB-9 (V_6) but the trend was $V_4>V_3>V_5>V_2>V_1>V_6$. As far as canopy spread is concern, it was maximum in NB-5 (V_5) for East-West direction and minimum in Kagazi Etawah (V_3) for North-South direction and the trend was observed in tune of $V_5>V_3>V_4>V_6>V_2>V_1$ for East-West spread & $V_3>V_4>V_5>V_6>V_1>V_2$ for North-South spread. On the basis of growth performance, in general, it can be summarized that varieties Kagazi Etawah (V_3), CISH-B-2 (V_4) and NB-5 (V_5) are in competition for their adaptation in this region.

Performance of newly planted fruit crops on raised bed planting system under edapho-climatic conditions of Jhansi

(Sudhir Kumar)

An orchard of different varieties of mandarin (5 Cvs.- Nagpur Mandarin, Nagpur Seedless, Clementine, Kinnow and Daisy), sweet orange (5 Cvs.- Mosambi, Blood Red, Jaffa, Pusa Sharad and Pusa Round), acid lime (8 Cvs.- AL 7, AL 8, Vikram, Premalini, Sai Sharbati, Pusa Udit, Pusa Abhinav and Balaji), Fig. (3 Cvs.- Deana, Poona Fig. and Black Ischia), guava (8 Cvs.- Arka Kiran, Arka Rashmi, Arka Mridula, L 49, Thai guava, Sweta, Lalit and CFRG 1), mango (8 Cvs.- Dashehari, Amrapali, Mallika, Ambika, Arunika, Baramasi, Chausa and Deshi), sapota (Cricket Ball and Khirni), pomegranate (Kandhari and Bhagwa) and ber (Thai Ber) was planted during February-March, 2018 on raised bed at 6m x 6m spacing to see the adaptability of different fruit crops/ varieties under Bundelkhand conditions. The data on growth performance were recorded in December, 2020 at the age of three years. The citrus groups included five varieties of mandarin, five varieties of sweet orange and eight varieties of acid lime. Growth performance data revealed that among citrus group; maximum height was observed in acid lime group (2.46m) followed by sweet orange (2.39m) and mandarin group (2.37m). Collar diameter was maximum in sweet orange group (8.10cm) followed by mandarin (7.18cm) and acid lime group (6.67cm). Canopy spread was maximum in acid lime group (2.37m) followed by sweet orange (1.93m) and mandarin group (1.72m) in East-West direction. Same trend was observed in North-South direction as well. Within the mandarin group, the height and collar diameter trend was observed as Nagpur Mandarin > Nagpur Seedless > Kinnow > Clementine > Daisy. Canopy spread trend was Kinnow > Clementine > Nagpur Mandarin > Nagpur Seedless > Daisy. Within the sweet orange group the trend was Pusa Round > Pusa Sharad > Mosambi > Jaffa > Blood Red for height, Jaffa > Pusa Sharad > Blood Red > Mosambi > Pusa Round for collar diameter, Mosambi > Blood Red > Pusa Sharad > Jaffa > Pusa Round for East-West direction of canopy spread and Mosambi > Jaffa > Blood Red > Pusa Sharad > Pusa Round for North-South direction of canopy spread. Within the acid lime group the height trend was noticed as Sai Sharbati > Premalini > Pusa Abhinav > Balaji > AL-8 > Vikram > Pusa Udit > AL-7, collar diameter trend was Sai Sharbati > Premalini > Balaji > Vikram > Pusa Abhinav > AL-7 > AL-8 > Pusa Udit. Canopy spread trend was Sai Sharbati > Balaj i> Vikram > Premalini > Pusa Abhinav > AL-7 > AL-8 > Pusa Udit for East-West direction and Sai Sharbati > Balaji > Premalin i> Vikram > Pusa Udit > Pusa Abhinav > AL-8 > AL-7 for North-South direction. Table 1 also reveals about fruit characters and availability of juice content in fruits. Among the citrus group average maximum fruit weight was recorded in sweet orange (170.78g) followed by mandarin (138.93g) and acid lime (36.84g). Similar trend was observed for fruit size, juice content and percent juice available in fruits.

In guava cultivars maximum plant height was obtained in Lalit (2.52m) and minimum in Thai guava (0.85m) with the mean of 1.73m. Out of eight cultivars planted in the system, only four (Lalit, Arka Rashmi, L-49 and CFRG-1) shown height above the mean of all the cultivars. Collar diameter was more in CFRG-1 (6.37cm) however it was less in Thai guava (2.49cm). Canopy spread was maximum in CFRG-1 (3.00m) and minimum in Thai guava (1.05m) for East-West direction whereas for North-South direction, it was more in cv. Lalit (2.68m) and less in cv. Thai guava (1.05m). Among all the cultivars, poor performance was observed in Thai guava. Fruit study revealed that cv.. Arka Mridula produced maximum average fruit weight (233.33g) followed by Thai guava (208.34g), CFRG-1 (201.25g) and Sweta (187.5g). Minimum fruit weight was observed in cv. Arka Kiran (141.91). Fruit size was more in cv. Arka Mridula (7.90cm x 7.50cm) followed by Thai guava (7.30cm x 7.65cm), CFRG-1 (8.40cm x 6.27cm) and Arka Rashmi (7.17cm x 6.96cm). Minimum fruit size was measured in cv. Arka Kiran (6.58cm x 6.44cm). In fruit quality parameter only TSS (^{0}B) was seen which was maximum in cv. L-49 (17.40 ^{0}B) among all the cultivars. In Fig. cultivar, the growth performance was better in cv. Black Ischia than the cv. Deana and poona and also found more than the average of all the cultivars except collar diameter. As for as fruit characters are concerned, cv. Deana was better but taste wise cv. Poona was better. In case of the mango, all the cultivars showed poor performance with regards to growth. In sapota, Khirni (rootstock) was better in height and collar diameter but canopy spread (East-West and North-South direction) was better in cv. Cricket Ball. Among pomegranate cultivars, cv. Kandhari recoded better growth performance than the cv. Bhagwa. Thai ber planted in the system is performing well and bearing heavily.

2. Research Achievements

2.4. HRD, Technology Transfer & Refinement Programme

NRMACAFRWASIL201500200093

Socio-economic, energetic and environmental impact assessment of watershed and agroforestry interventions at Garhkundar-Dabar watershed in Tikamgarh district of Madhya Pradesh

(R P Dwivedi, R K Tewari, Priyanka Singh, Aswasthy Chandrakumar and R H Rizvi)

In village Dabar, about 51% of required fuelwood was collected from adjacent forest areas. The available tree species were Babul, Palash and Ber. The consumption of fuelwood was 5.5 kg/day during rainy, 6 kg/day during winter and 3.5 kg/day during summer season. Cow & Buffalo dung was also used @ 5-6 kg/day as per the requirement. There were about 20-25 LPG connections under Pradhan Mantri Ujjwala Yojana (PMUY) in the village. Around 65% women do the collection of fuel wood.

In village Rautiana, 68% of required fuel wood was collected from adjacent forest areas. The available tree species were Butea, Neem, Subabul and Dhaunkara. The consumption of fuel wood was 5 kg/day during rainy, 7 kg/day during winter and 4 kg/day during summer season. It was found that the collection of fuel wood was being performed mostly by women (85%). Cow & Buffalo dung cake was another important fuel being used for cooking at the rate of 5 to 6 kg/day as per requirement. There were 15-20 LPG connections under PMUY in the village.

In village Kundar, 43% of required fuel wood was collected from adjacent forest areas. The available tree species were Butea, Neem, Subabul and Dhaunkara. The consumption of fuelwood was 3 kg/day during rainy, 4 kg/day during winter and 3 kg/day during summer season. It was found that the collection of fuel wood was performed mostly by women (70%). Cow & Buffalo dung cake was another important fuel being used for cooking at the rate of 4 to 6 kg/day as per requirement. There were 50-60 LPG connections under PMUY in the village.

In village Sakuli, about 54% of required fuel wood was collected from adjacent forest areas. The available tree species were Butea, Neem, Kardhai, Babul, Chirol and Akola. The consumption of fuelwood was 5.5 kg/day during rainy, 7 kg/day during winter and 3.5 kg/day during summer season. Cow & Buffalo dung was also used @ 5-6 kg/day as per requirement. There were about 100-110 LPG connections under PMUY in Sakuli. Only 45% women do the collection of fuel wood.

In village Shivrampur, 79% required fuel wood was collected from adjacent forest areas. The available tree species were Butea, Kardhai and Besaram. The consumption of fuelwood was 7.5 kg/day during rainy, 10.5-12.5 kg/day during winter and 5.5 kg/day during summer season. Cow & Buffalo dung was also used @ 5-6 kg/day as per requirement. Average family size was 8 members in Shivrampur. There were about 30-35 LPG connections under PMUY in the village Shivrampur. In the village, 92% women were active in the collection of fuelwood.

Anna Pratha (stray animal) was a major constraint in adoption of agroforestry.

TRANSFER OF TECHNOLOGIES

The Institute organized a number of Farmers' activities for transfer of technologies of agroforestry and increased the awareness for speedy adoption of agroforestry during 2020. These were as below:

Kisan Gosthi

Kisan Gosthi was organized at village Rajapur, Block-Babina in Jhansi district on 29th February, 2020.

Mahila Kisan Gosthi

ICAR-Central Agroforestry Research Institute, Jhansi organized Mahila Kisan Gosthi at village Ganeshgarh, Block-Babina in Jhansi district on 15th October, 2020. The

village was a part of Mera Gaon Mera Gaurav (MGMG) programme of the Institute. The Gosthi was organized on the occasion of Mahila Kisan Diwas in the country. Farm women and farmers from village Ganeshgarh had participated in the programme.

Ber Pruning

Three days training programme on ber pruning was organized by ICAR-Central Agroforestry Research Institute, Jhansi at Village- Rajapur, Block-Babina in Jhansi district (U.P.) during 9th -11th June, 2020.

Ber Budding

Three days training programme on Ber budding was organized by ICAR-Central Agroforestry Research Institute, Jhansi at Village- Rajapur, Block-Babina, District-Jhansi (U.P.) during 23rd, 24th & 27th July, 2020.

Review of Doubling farmers' income (KISAN MITrA) project of Bundelkhand region

Shri Surya Pratap Shahi ji, the Hon'ble Minister for Agriculture, Agriculture Education and Research,

Government of Uttar Pradesh, reviewed the progress of the DFI (KISAN MITrA) project at Banda University of Agriculture and Technology (BUAT), Banda on 3rd July, 2020. The project was supported by Government of Uttar Pradesh and was being implemented by ICRWASAT, ICAR-CAFRI and other consortium partners in 22 villages of Bundelkhand, covering about one lakh population. Hon'ble Minister appreciated the efforts made by all the partners and suggested to scale up such initiatives.

Parthenium Awareness Week

Parthenium Awareness Week was observed during 16th-22nd August, 2020. All the Institute staff members participated in the program.

Vanamahotasava at DFI site (Sutta and Singar)

Vanamahotasava at DFI site *i.e.* Sutta and Singar (villages, Garontha Tehsil of Jhansi district) was jointly organized by ICAR-CAFRI and ICRISAT, Hyderabad on 18th August, 2020. Sh. Jawahar Rajput, Hon'ble Member of Legislative Assembly, Uttar Pradesh was the Chief Guest of the function. The programme received overwhelming response in the villages. Over 60 farmers participated along with the Hon'ble MLA, scientists and staff of CAFRI, IGFRI and ICRISAT. He also planted the tree saplings and visited various sites.

MERA GAON-MERA GAURAV (MGMG)

The plantation drive in the MGMG villages was carried out

by scientists of ICAR-CAFRI Jhansi in the selected MGMG villages. The scientists also interacted and created Awareness about Agroforestry among the farmers. Organized interface meetings with the farmers of MGMG villages during 2020. Total 3545 plants were distributed to the farmers. The last of clusters (5) and villages (16) were as below:

1. Hastinapur cluster (3 villages - Hastinapur, Karari, Rund Karari), Jhansi, U.P.
2. Domagor cluster (3 villages - Domagor, Dhikoli, Nayakhers), Jhansi, U.P.
3. Ganeshgarh cluster (3 villages - Ganeshgarh, Devgarh, Ramgarh), Jhansi, U.P.
4. Parasai cluster (3 villages - Parasai, Chhatpur, Bachhauni), Jhansi, U.P.
5. Garhkundar cluster (4 villages - Garhkundar, Dabar, Sakuli, Shivrampur), Niwari, M.P.

Exhibitions

ICAR-CAFRI, Jhansi participated and exhibited agroforestry stall in following programmes:

Date	Programme	Places
28th-30th January, 2020	Kisan Mela Krishi Vijay-2020	RVSKVV, Gwalior (M.P.)
03rd-05th February, 2020	National Conference on "Resource Conservation and Jalshakti: Farmers Perspective in Bundelkhand (RCSSJ-2020)"	ICAR-IWASWC, Regional Centre, Datia (MP)
14th February, 2020	Kisan Mela-2020	ICAR-IGFRI, Jhansi (UP)

2. Research Achievements

2.5: Externally Funded Projects

ICAR Network Project

NRMACAFRISOP200800100075

Harvest and post-harvest processing and value addition of natural resins, gums and gum resins

(Rajendra Prasad, A K Handa and Badre Alam)

The main objective of project is to develop agroforestry models integrating resins- and gum-yielding trees for livelihood security and horizontal dissemination of technologies. For conducting research at ICAR-CAFRI, Jhansi, the major themes are i) growth and productivity of gum-yielding tree based agroforestry models, ii) demonstration and development of gum-yielding tree based agroforestry models on farmers' fields, and iii) indigenous technical knowledge (ITK) on resin and gum tapping, applications and post harvest value addition. Data recorded during the year are summarized here:

A. GROWTH AND PRODUCTIVITY OF AGROFORESTRY MODELS

A.1. Agroforestry models on-farm

In agri-horti-silviculture model (Field no. 25), *Aegle marmelos* recorded maximum GBH, plant height and canopy spread, followed by *Acacia senegal*, *Citrus limon* and *Carissa carandas*. Total 19 plants of *A. marmelos* (814.00 kg), 14 of *C. limon* (179.00 kg) and 16 of *C. carandas* (53.00 kg)yielded fruits (Fig. 36), and *A. senegal* yielded average 61.76 g gum-arabic/tree. In silvi-herbal model-I (field no. 20), *A. senegal* recorded maximum growth, followed by *A. nilotica* and *T. arjuna*; and in silvi-herbal model-II (field no. 20), it was recorded maximum in *A. nilotica*. These models have been converted in to silvi-herbal models wherein lemongrass (*Cymbopogon citratus*) has been integrated as herbal component, due to complete damage of horticulture component. In *rainfed* agri-silviculture model (Field no. 40 & 41), maximum survival was recorded by *A. senegal* planted in 10 × 10 m spacing while in case of *A. nilotica,* it was recorded highest in 5 × 5 m spacing. After eight years, higher GBH and plant height were recorded in *A. nilotica* in all spacings, barring few exceptions.

During summer season, the natural exudation of gum in different fields of *A. senegal* was observed, which varied from 11.34 to 133.24 g (mean: 61.76 g/tree) in agri-horti-silviculture model, 1.51 to 110.0 g (mean: 33.15 g/tree) in rainfed agri-silviculture, 0.73 to 104.43 g (mean: 22.21 g/tree) in old gum garden, 1.92 to 177.39 g (mean: 33.52 g/tree) in new gum garden and 25.82 to 44.25 g (mean: 25.00 g/tree) in block plantation. While in case of *A. nilotica*, it varied from 8.25 to 26.59 g (mean: 17.57 g/tree) in silvi-herbal model and 0.43 to 83.23 g (mean: 14.78 g/tree) in rainfed agri-silviculture model.

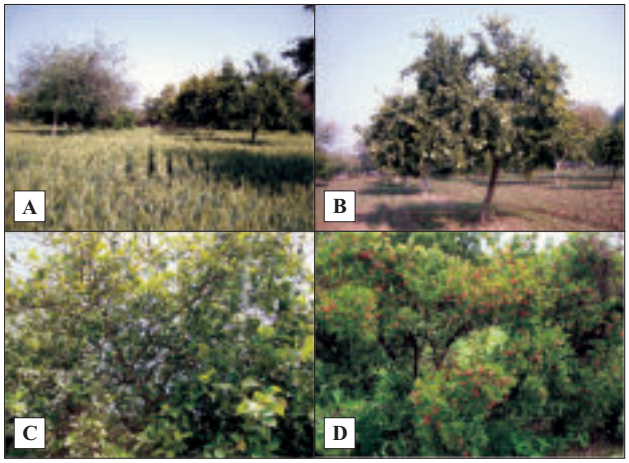


Fig. 36: *Acacia senegal* based agri-horti-silviculture model at research farm of ICAR-CAFRI, Jhansi. A- Wheat, B- *Aeglemarmelos*, C- *Citrus limon* and D- *Carissa carandas*

In agri-horti-silviculture model, wheat (var. HD 2967) and blackgram (var. KUG 479) were cultivated during *rabi,* 2019-20 and *kharif,* 2020 seasons, respectively. Observations on their growth and yield were measured at different distances (1.0, 2.5 and 4.5 m) from stem-base of woody perennials. Planted tree species and distances significantly affected the recorded parameters. All parameters were found to be increasing with increase in the distance from stem-base. Significantly higher yield of wheat and blackgram were recorded under *A. senegal* and *C. limon*, respectively, while their lowest values under *A. marmelos* (Fig. 37A). Two-way interactions between tree species and distance were found non-significant for studied parameters. In rainfed agri-silviculture model, taramira and til (var. RT-351) were cultivated during *rabi,* 2019-20 and *kharif*, 2020 seasons, respectively. Effect of *A. senegal* and *A. nilotica*, planted in different spacings (10 × 10m, 10 × 5m and 5 × 5 m), on growth and yield of understory crops were assessed. Results revealed that planted species did not show significant effect on yield of both crops, while it was recorded maximum in wider spacing and minimum in closer spacing (Fig. 37B). The two-way interaction between tree species and planting spacing were found non-significant.

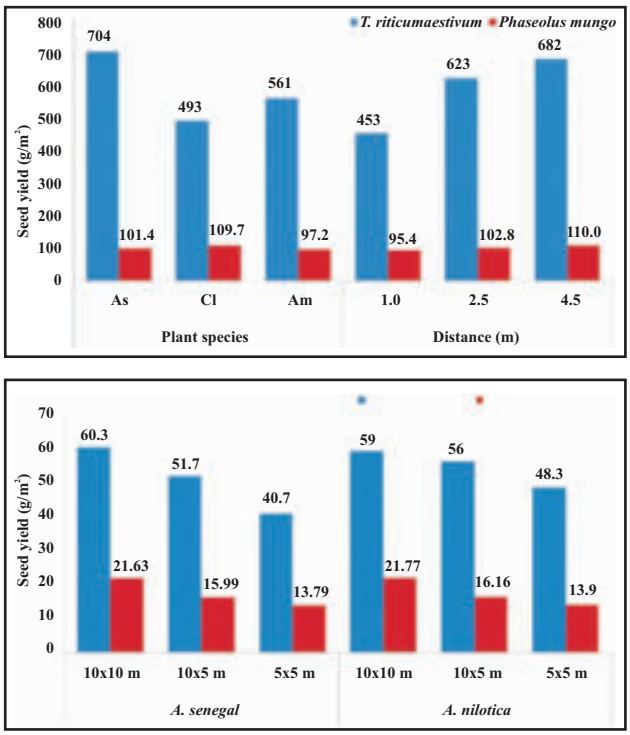


Fig. 37: Yield (g/m^2) of understory crops under agri-horti-silviculture (A) and rainfedagri-silviculture models (B)

Survival of lemongrass in silvi-herbal model

The horticulture components in horti-silviculture model-I and II (Field no. 20) have been replaced with lemongrass as herbal component and model renamed as silvi-herbal model. During rainy season of 2020, lemongrass was planted in space between two rows of *A. nilotica* (20 m apart), using randomized block design. To determine best planting spacing, lemongrass was planted by adopting four different spacing treatments *viz*., 100 × 50, 100 × 75, 100 × 100 and 100 × 125 cm, and each treatment was replicated four times. After six months of planting, survival (%) of lemongrass (Fig. 38) was maximum in 100 × 125 cm (76.38%), followed by 100 × 100 cm (69.88%), 100 × 75 cm (67.72%) and 100 × 50 cm (66.98%).

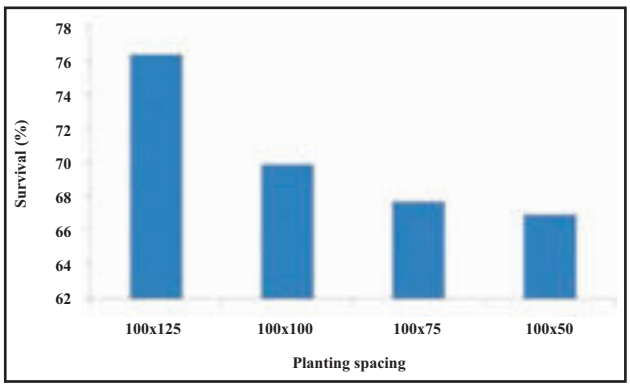


Fig. 38: Survival (%) of lemongrass in silvi-herbal model

Gum garden

The survival and annual growth data of *A. senegal* based gum gardens showed that *A. senegal* planted in new gum garden (during 2015) attained good girth with relatively higher survival (%) than that planted in old garden (during 2014). Out of 190 plants of *A. senegal* in old gum garden, 31 yielded *gum-arabic* and out of 268 trees in new gum garden, 23 yielded *gum-arabic*.

Growth of *Anogeissus* species

The growth of tissue culture raised five progenies of *Anogeissus pendula* (AP-12, AP-52, AP S-2, AP-28 and AP-35) revealed that the progeny AP S-2 recorded maximum GBH and minimum was recorded in AP-52. In plus tree trial of *A. pendula* consisting of seven progenies (AP-20, J-241, J-124, J-205, NRC-5, J-185 and J-62), maximum GBH was recorded in J-205 and minimum in J-241 progeny. In another plantation, consisting of *A. pendula* and *Anogeissus latifolia* planted in 5 × 5 m spacing (field no. 33 & 34), *A. pendula* recorded better survival (87.5%) while better GBH, height and canopy spread were recorded in *A. latifolia*.

A2. Agroforestry models on farmers' fields

After 11 years of planting, *A. senegal* recorded relatively more survival (up to 59.5%) than *A. nilotica* (up to 50%) at Garhkundar watershed area. At the farm of Shri Thakur Das, among planted species, *A. nilotica* recorded higher growth as well as survival, followed by *Psidium guajava* and *C. carandas*. In this field, many plants have been damaged by mechanized operations with tractor, as the farmer did not pay attention. On the farm of Shri Himmat, maximum growth and survival was recorded in *Emblica officinalis*, followed by *A. senegal* and *C. carandas*. At farm of Shri Ghanshyam, *A. senegal* planted during 2012 showed poor performance in terms of growth; however, survival was comparatively higher than the values recorded from other two fields. In village Ambabai, 37% survival of *A. senegal* with average height of 294.5 cm and average collar diameter of 17.5 cm was recorded.

B. DEMONSTRATION AND DEVELOPMENT OF GUM-YIELDING TREE BASED AGROFORESTRY MODELS

B1. At institute research farm

During rainy season of 2020, casualty replacement was done in bio-fence models established during 2018. In bio-fence model-1, *A. senegal* has attained 13.78 mm collar diameter with 113.6 cm height, and *C. carandas* recorded 3.27 mm collar diameter with 38.2 cm height. In bio-fence model-2, *A. senegal* has attained 13.43 mm collar diameter with 104.8 cm height, and *C. carandas* recorded 3.39 mm collar diameter with 28.3 cm height. In bio-fence model-3, comparatively higher collar diameter and height was recorded from *A. senegal* planted in inner row than that from outer row. In bio-fence model-4, comparatively higher growth was recorded in inner row *A. senegal* than that in the outer rows.

B2. At farmer's fields

During the year, a total of 30,000 seedlings were provided to enable "Doubling Farmer's Income (DFI)" for planting in Jhansi (3000), Lalitpur (3000), Jalaun (3000), Hamirpur (3000), Mahoba (1500), Banda (3000), Chitrakut (3000) and Gursarain (10500). At these selected sites, *A. senegal* has been planted on field boundaries, as it acts as bio-fence. Survival (%) of seedlings planted in various villages/sites during rainy season of 2018 varied from 36.8 (Binwara) to 67.8% (Talbehat) for *A. senegal*, 26.8 (Parasai) to 50.0% (Dhikoli) for *C. carandas*, 29.2 (Parasai) to 41.0% (Binwara) for *C. limon*, 25.0 (Kotkhera) to 30.0% (Dhikoli) for *D. strictus*, and 52.0% in *P. guajava*. Survival of *A. senegal*, *C. limon*, *P. guajava* and *P. granatum*, planted in the field of 14 farmers of village Parasai during 2017 varied from 46.0 to 86.7%, 25.0 to 54.0%, 33.3 to 56.4% and 28.0%, respectively.

C. GUM EXUDATION IN RELATION TO SOIL MOISTURE DYNAMICS

Observations on soil moisture content of various gum-yielding tree based agroforestry models (agri-horti-silviculture, silvi-herbal, ranifed agri-silviculture and gum gardens) were started during September, 2019 with the aim to assess its relationship with the natural exudation of gums from *A. senegal* and *A. nilotica.* For this purpose, soil samples were collected from two different depths (0-15 and 15-30 cm) of *A. senegal* and *A. nilotica* (within 0.5 m distance from tree trunk). Moisture content was determined by gravimetric method and converted in mm for 0-30 cm soil depth, and the data are presented in Fig. 39.

To assess the effect of soil moisture dynamics on gum exudation, correlation matrix was worked out among all parameters of rainfall, soil moisture and gum exudation in *A. senegal* under both irrigated and rainfed conditions. Under irrigated field conditions, positive but non-significant correlation existed between soil moisture content and mean gum yield (g/tree) and number of trees exuding gum. Total annual rainfall in preceding year had direct influence on the number of trees with multiple exudations in a year (r = 0.763). For rainfed conditions, total gum yield exhibited better degree of positive correlation with soil moisture content (r = 0.559). Significant positive correlation also existed between total gum yield and number of trees with multiple exudations in a year (r = 0.957).

D. SOIL HEALTH OF AGROFORESTRY MODELS

Agri-horti-silviculture model: A factorial experiment on effect of woody perennials on soil properties (pH, EC, organic carbon, N, P, K, Fe, Mn, Zn and Cu) was carried out in agri-horti-silviculture model. Study consisted of three factors *viz*., plant species (*A. senegal*, *A. marmelos, C. limon* and *C. carandas*), distance from these plant species (0.5, 1.0, 2.0 and 4.0 m) and soil depth (0-15 and 15-30 cm).

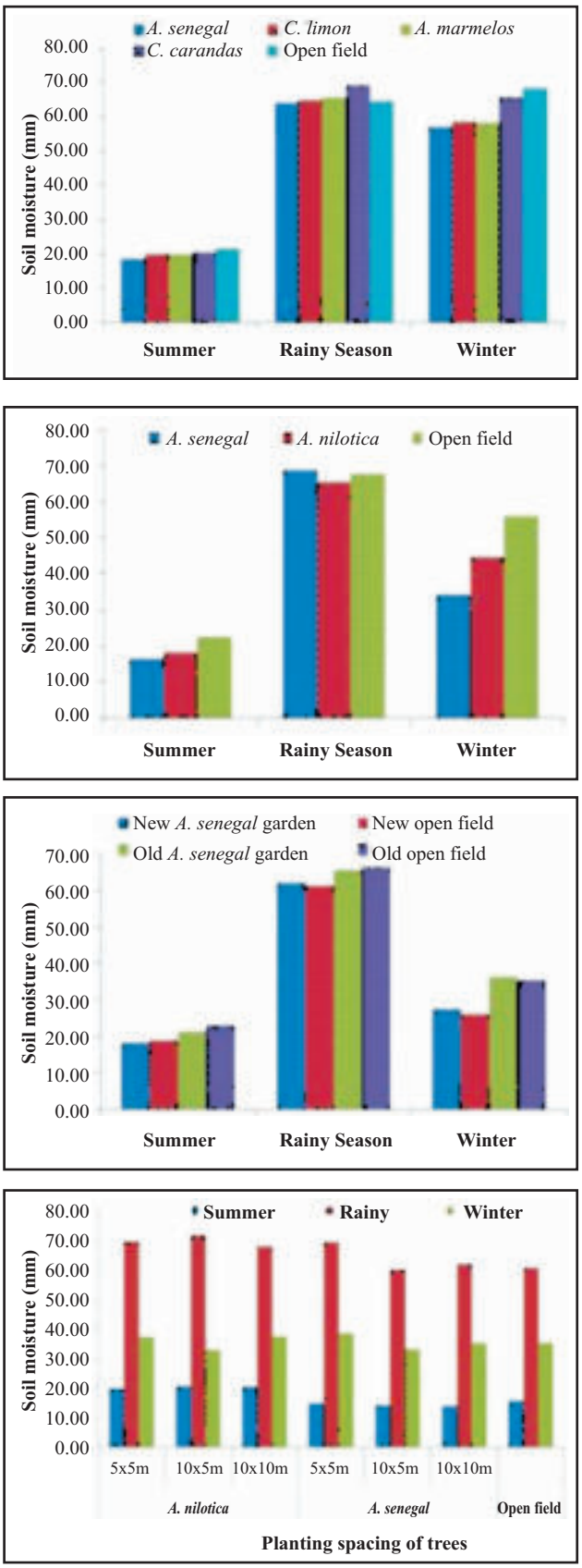


Fig. 39: Season-wise soil moisture dynamics (mm) in 0-30 cm soil depth in irrigated agri-horti-silviculture model (A), rainfedsilvi-herbal model (B), *A. senegal* based gum-gardens (C) and rainfedagri-silviculture model (D)

Various woody components exhibited variable effects on studied parameters. Soil depths significantly affected soil properties and relatively higher values of pH, organic carbon, N, P, K and Cu were recorded from surface soil while EC, Fe, Mn and Zn were recorded higher in sub-surface soil layer. Values of all studied parameters were significantly higher near the tree-base (0.5 m) and minimum at 4.0 m distance.

Rainfedagri-silviculture model: A factorial experiment consisting of three factors *viz*., plant species (*A. senegal* and *A. nilotica*), planting geometry (5×5, 10×5 and 10×10 m) and soil depth (0-15 and 15-30 cm) was carried out to assess the soil properties of a rainfed agri-silviculture model. Higher soil pH, EC, N, P, Fe and Mn contents were recorded from *A. senegal*, and Zn and Cu contents from *A. nilotica*. Planting geometry of trees and soil depths might have caused considerable variations in values of different soil properties. Values of all the parameters were significantly higher in close spacing (5×5 m), except Cu content. Soil organic carbon, N, P, K and Zn content were relatively higher in surface soil layer, while pH, EC, Fe, Mn and Cu contents were significantly higher in sub-surface soil layer.

ICRISAT, Hyderabad

NRMACAFRISOL 201800200114

Transforming rural livelihood through agroforestry based natural resource management in drought prone Bundelkhand region, UP (Sub Project of KISAN MITrA project for Doubling Farmers' Income in Bundelkahand region of Uttar Pradesh)

(InderDev, R K Tewari, Naresh Kumar, Asha Ram, Dheeraj Kumar and Lal Chand)

Dr. Ramesh Singh was PI of the DFI project till May, 2020, thereafter he joined ICRISAT

Bundelkhand region of Uttar Pradesh in Central India is a hotspot of water scarcity and land degradation, beset with poverty and poor socio economic conditions. A combination of poor groundwater recharge, high temperatures and low and erratic rainfall have together rendered agricultural productivity in the region to 0.5-1.5 t/ha. Most of the areas are single cropped and under rain fed conditions. Rainfall is highly erratic, both in terms of quantum and its distribution over time. Long-term weather data monitored by the India Meteorological Department (IMD) at 23 stations across Bundelkhand region has revealed a decline in annual average rainfall from 1000 mm in 1950 to 750 mm in 2017, clearly showing how changing climate has led to increased water scarcity.

Scaling up of agroforestry and water resources

Under the KISAN MITrA (consortium of ICAR-CAFRI and ICRISAT, Hyderabad) scaling up initiative, eight pilot sites covering about 40,000 ha area across seven districts of Bundelkhand are being developed. The emphasis has been on controlling land degradation through large-scale field bunding upstream and the construction of various *ex-situ* water harvesting structures downstream. Reviving and rejuvenating traditional water harvesting structures called *havelis* has been a high priority.

Upscaling of agroforestry for increasing the vegetation cover, improving livelihood and nutritional security is another most important objective being addressed.

Increasing water resource availability

ICAR-CAFRI and ICRISAT have introduced a novel core wall concept that has been introduced under the initiative to strengthen the earthen embankments that breach during heavy rains. Masonry outlets have been constructed for the safe disposal of excess water. These interventions have been undertaken in all the eight project locations across the seven districts of UP Bundelkhand region. A total of 16 such structures have been rejuvenated under this initiative during 2020-21. These interventions have created an additional storage capacity of about 0.5 Million Cubic Meter (MCM).

Apart from increasing storage capacity, the renovation of *havelis* has led to crop intensification. Two *haveli* structures with a total storage capacity of 50,000 m^3 were rejuvenated at Birdha village, Talbhet block of Lalitpur

Pilot Villages: Scaling up initiative

District	Block	Villages
Lalitpur	Talbehat	Pura-Khurdh, Birdha, Jhawar
Jhansi	Babina	Imiliya, Rajapur, Amarpur
	Bamour	Singa, Sutta
Jalaun	Mahiva	Noorpur, Naserpur, Hydalpur
Hamirpur	Sumerpur	Saukhar, Nazarpur, Karimati
Mahoba	Kabarai	Chandpura, Nathupura, Baniyatala
Banda	Thindwari	Benda, Amlikaur, Jauharpur
Chitrakoot	Karwi	Rowli-Kalyanpur, Rasin

district during last year. Harvested water in both the *havelis* greatly impacted groundwater availability. The structure filled up multiple times during the monsoon and recharged nearby wells to a distance of 1.0 km. About 30 ha of agricultural land which was previously left permanently fallow was put to crop cultivation (Fig. 40) and farmers are nowable to cultivate both *kharif* and *rabi* crops. Data obtained from different beneficiaries indicated a payback period of less than one year from such interventions.

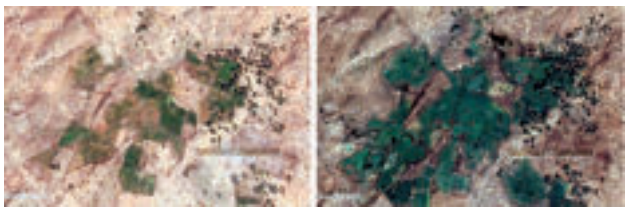


Fig. 40: Change in land use due to *haveli* renovation in Birdha village in Lalitpur district

Fig. 41: *Haveli* renovation in Rajapur village, Babina block, in 2020

Fig. 42: *Haveli* renovation and field bunding works in Sadhara village of Jalaun district

Fig. 43: *Haveli* structure from excavating foundation to various construction stages in Birdha village of Lalitpur district; Structure received good amount of runoff from the upstream hillock

Deepening of stream network

Widening and deepening of stream network is one of another important activities that have been undertaken in the project villages (Fig. 44). The streams with 5-8 m width have been widened by 2-5 m and silt was excavated to a depth of 1-1.2 m has which has created a large storage capacity in long stretches of the village (beginning from the ridge part to the downstream location).

Fig. 44: Deepening of stream network in Sutta village of Jhansi

Excavation of diversion drain/channel

In several sites, especially at the degraded landscape at the uppermost topo sequence, a significant surface runoff (ranging from 250-300 mm) was generated during monsoon season due to shallow and degraded lands use. The generated runoff was flooding agricultural lands, and farmers could not cultivate their fields during *kharif*. Further, due to poor groundwater recharge, these degraded uplands were also suffering from acute water scarcity and not cultivating lands in *rabi*. Farmers left these lands into permanent fallow and get migrated. These lands mostly belong to tribal, and their socio-economic conditions are in a deprived stage.

Diversion drainage channel (3-5 m wide and 1-1.2 m deep) from the uppermost part of the landscape to suitable downstream length was excavated. This drainage channel facilitated carrying runoff water without flooding the agricultural fields to the suitable sites where it could be harvested (partially) and dispose-off to the downstream sites (Fig. 45). Series of check walls at every 50-100 m distance along the channel was also constructed such that it also can reduce surface runoff and facilitate groundwater recharge. Nearly 10 km lengths of such channels at different villages were constructed in 2020, and nearly 50,000 cubic meter storage capacity was built within the channel itself. It also serves to control the flooding in agricultural fields.

Fig. 45: Diversion drain for safe disposal of excess runoff from uplands to stream network; top two pictures from Birdha village, Lalitpur; bottom pictures from Sutta/singar village, Jhansi

Agroforestry plantation

Large scale upscaling of agroforestry planation has been done in 22 villages covering eight locations in seven districts of Bundelkhand U.P. in a consortium of ICAR-CAFRI and ICRISAT. More than 1,50,000 plantation (bund plantation, boundary plantation, fruit based agroforestry system and plantation for nutritional security) have been done during 2020. Various fruit based agroforestry models and also high density orchards were developed in project villages. A large range of tree species along with its varieties and sources procured and planted in partnership with farmers and rural communities.

Productivity enhancement through ber budding

Ber which is a native tree (bush) species are available in most of pilot villages. There are thousands of such trees, which produce poor quality fruits and these trees hold opportunity to produce good quality ber through the process of ber budding. Nearly 2000 tree stems were cut and budded with improved quality shoots in the year 2020, which started producing good quality of ber fruits(Fig. 46)

Fig. 46: Improved quality of *ber* fruits after budding

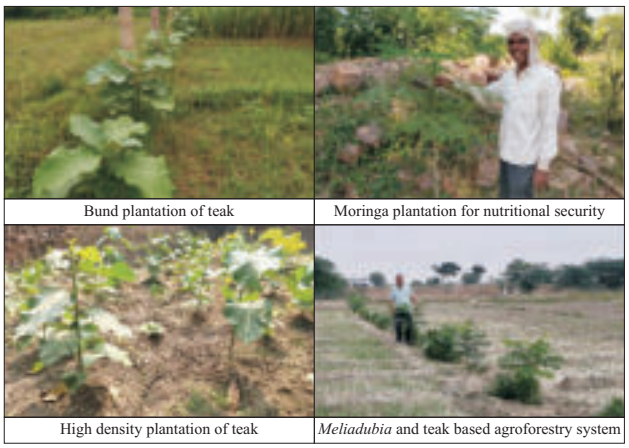


Fig. 47: Glimpses of plantation at DFI sites

Homestead garden for nutrition security

As baseline data clearly indicates that households in the region are suffering with poor dietary consumption than the recommended dose both for essential food, fruits and vegetables. In order to meet the daily dietary requirements, homestead garden is promoted by distributing trees of lemon, aonla (*Indian gooseberry*), moringa, and guava and also other fruit plants as per the farmers' choice. More than 2000 households have been benefited by this intervention in the project villages.

Livestock

Livestock is an integral part of farming system in the Bundelkhand region. Farmers in Bundelkhand have 1-2 cattle/HH; 2-5 buffalo/HH; and 3-6 goats/HH. The number of buffalos was found more with large farmers compared to small and marginal one, whereas cattle number were found almost same (~2 cattle/hh) for all category of farmers.

Productivity enhancement interventions

Farmers participatory field demonstrations is the one of the major activities of the DFI project in which various production technologies of agriculture were validated and demonstrated. More than 3000 farmers' participatory field demonstrations were undertaken covering a range of activities.

Impact of improved crop cultivars

Farmers in the region largely uses traditional varieties which has poor production potential. About 35 crop cultivars of *kharif* and *rabi* crops were tested and their performance was evaluated. All these cultivars were recommended by various premier research institutes for the Bundelkhand region; however, their performance was evaluated for different districts in the region. Sutable recommendations were provided for scaling up of the crop productivity.

Improved crop management interventions including integrated pest and weed management, seed treatment were followed along with various farmers' participatory field demonstrations. Organic fertilizer (Vardan) demonstrations, which characterized by a group of beneficial bacteria were also undertaken in all the seven districts. Nearly 300 field demonstrations were undertaken in each of the pilot districts during *kharif* and *rabi* seasons.

ICAR-ICRAF Work Plan

NRMACAFRISOL 202000400123

Assessment of area under agroforestry systems/species in agro-climatic zones of India

(R H Rizvi, A K Handa, R Vishnu, Suresh Ramanan S and K Shiran (ICAR-CAZRI, Jodhpur)

Mapping and Estimation of Agroforestry Area

The area under agroforestry in nine districts of ACZ-1

namly Kulgam, Budgam, Pulwama, Udhampur from Jammu & Kashmir and Pauri Garhwal, Champawat from Uttarakhand and Kullu, Kangra, Sirmaur from Himachal Pradesh was mapped using well established methodology (Fig. 48).Estimated agroforestry area was found highest in Kangra district (77159.9 ha) followed by PuariGarhwal district (58675.51 ha). However, as a percentage of geographical area, agroforestry area in these districts ranged from 9.0 to 20.7%. More than 90 percent accuracy was found in mapping agroforestry area in all nine districts of ACZ-1. Fig. 49(a) to 51(c)depicts the area under agroforestry in different districts of ACZ- I.

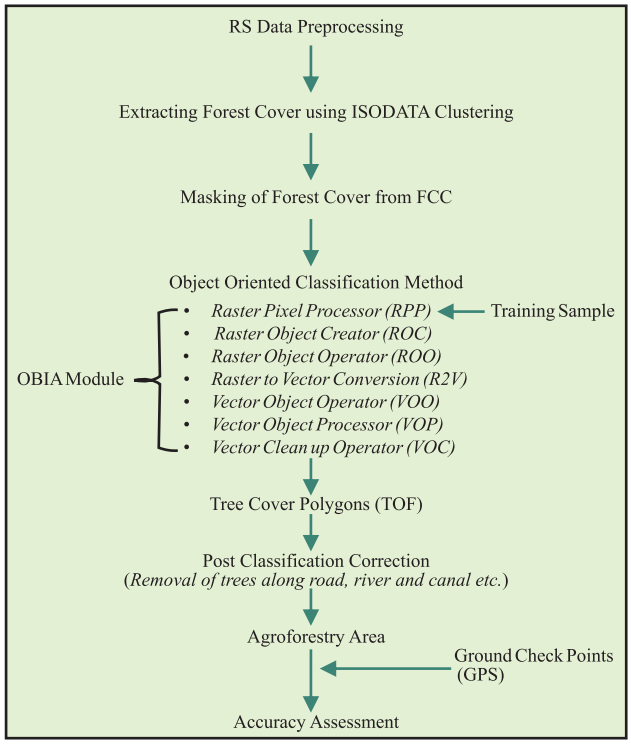


Fig. 48: Methodology adopted for agroforestry mapping (Source: Rizvi et al. 2020)

Remote Sensing Data and Forest Cover Maps

Resourcesat-2/LISS-4 data for nine selected districts of agro-climatic zone-1 (ACZ-1) has been procured from NRSC, Hyderabad. Total 27 multispectral LISS-4 scenes have been downloaded through 'ftp' for time period April to July, 2020. Besides this, Sentinel-2 data for selected districts of Rajasthan for three periods have been freely downloadedfrom earth explorer website (https://earthexplorer.usgs.gov/).

The Sentinel-2 satellites carry a single multi-spectral instrument (MSI) with 13 spectral channels in the visible/near infrared (VNIR) and short wave infrared spectral range (SWIR). Downloaded Sentinel data will be used for generation of spectral signatures for *P. cineraria* and *A.indica* species and their mapping on farmlands. Besides remote sensing data, forest cover maps of selected districts have also been purchased from Forest Survey of India, Dehradun.

District-level Agroforestry Mapping

For mapping of Agroforestry at district level, high resolution LISS-4 data (spatial resolution- 5.8m) has been used. Preprocessing of this data includes layer stacking, mosaicking and clipping of district area with the help of boundary. From district area, forest cover was then masked and remaining area was analyzed in ERDAS Imagine software. For identification of Agroforestry species, object-oriented classification technique was applied using IMAGINE Objective tool. Object based image analysis (OBIA) segments the pixels into different objects and groups them according to objects. This method utilizes the NDVI image and computes single feature probability (SFP). OBIA method was found better than pixel based classification methods.

Spectral signatures and mapping of tree species in Pali and Jodhpur districts

Sentinel- 2A/2B data was used for generating spectral signatures of Neem and Khejri for two seasons (April & September). These signatures were found different and reflectance values in Red Edge (B5) to Narrow NIR (B8A) bands were higher in the month of September than in the month of April. At this time, trees have new green leaves whereas in April trees are at flowering stage (Figs. 53(a) & 53(b)). Area under agroforestry, Neem and Khejri species in Pali district and only Khejri species in Jodhpur district of Rajasthan has been mapped and estimated using developed signatures (Fig. 54(a) to 54(d)). Estimated area under Neem and Khejri species come out to be 26493.05 ha (2.13%) and 13572.43 ha (1.1%), respectively in Pali district while 100584.05 ha (0.39%)in Jodhpur district of Rajasthan under Khejri species.

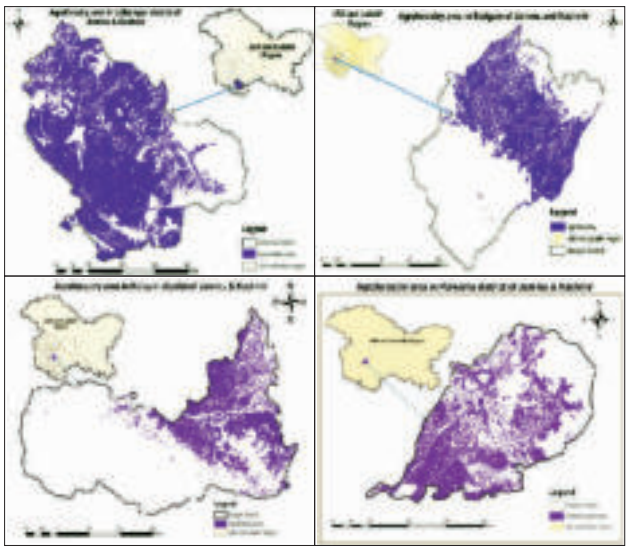


Fig. 49: Agroforestry area in (a) Udhampur, (b) Badgam, (c) Kulgam, (d) Pulwama districts

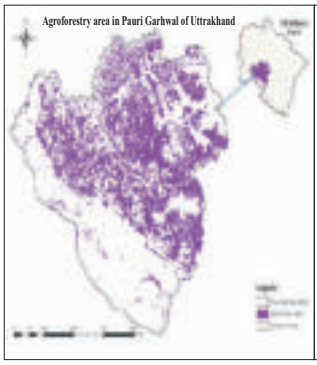


Fig. 50(a):Agroforestry area in Pauri Garhwal district

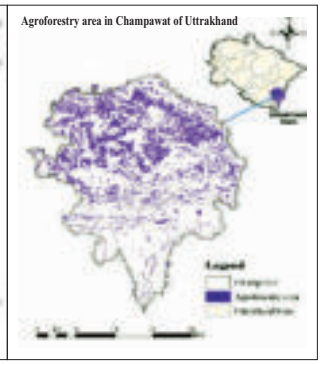


Fig. 50(b): Agroforestry area in Champawat district

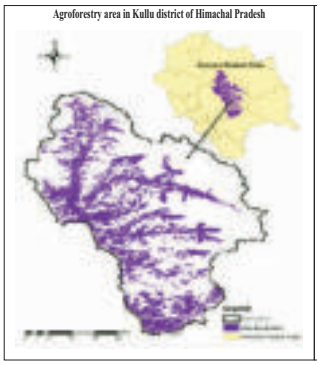


Fig. 51 (a): Agroforestry area in Kullu district

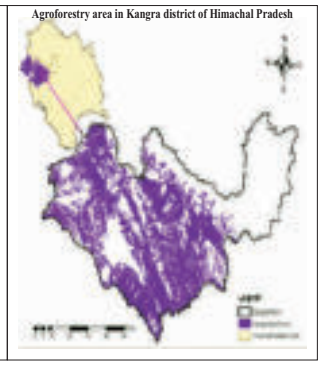


Fig. 51 (b): Agroforestry area in Kangra district

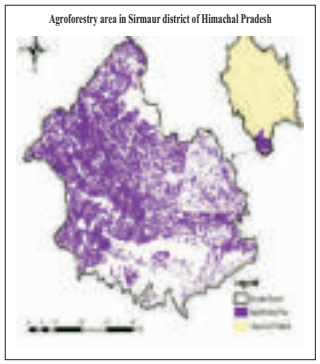


Fig. 51(c):Agroforestry area in Sirmaur district

Species in Pali District

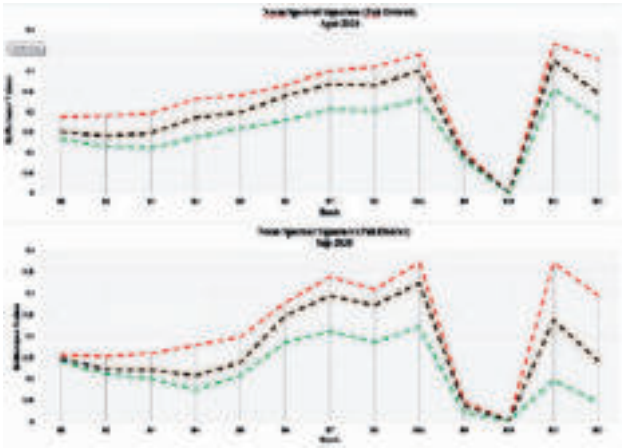


Fig. 52 (a): Spectral Signature Assessment for Neem

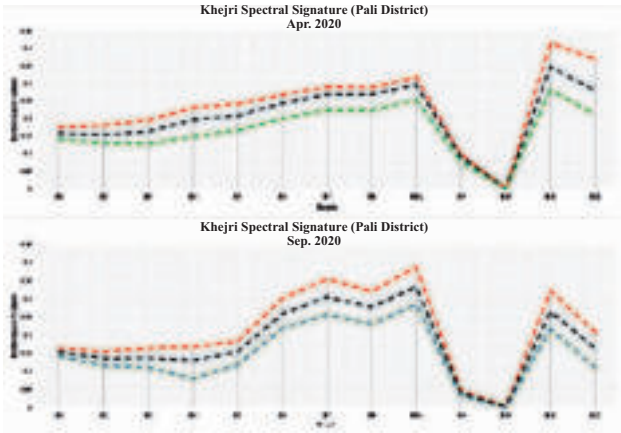


Fig. 52 (b): Spectral Signature Assessment for Khejri Species in Pali District

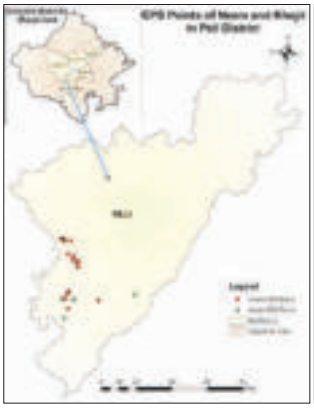


Fig. 53 (a): GPS points of neem and Khejri in Pali district

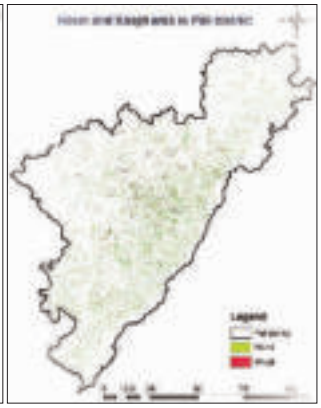
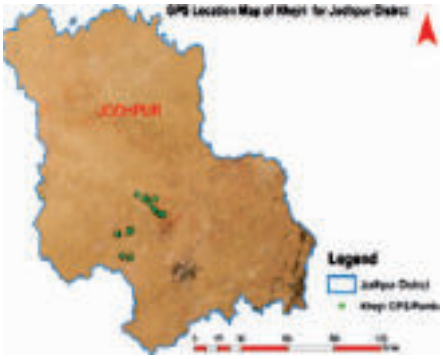


Fig. 53 (b): Neem and Khejri area in Pali district



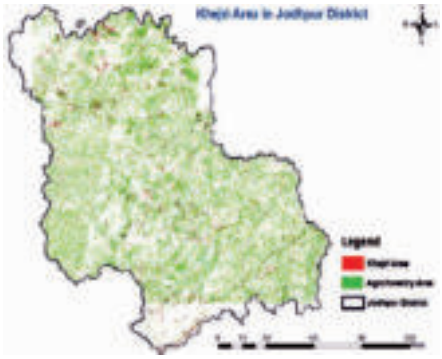


Fig. 53 (c):GPS points of Khejri in Jodhpur district &
Fig. 53 (d):Khejri area in Jodhpur district

Location Map (Zone–1 and Rajasthan)

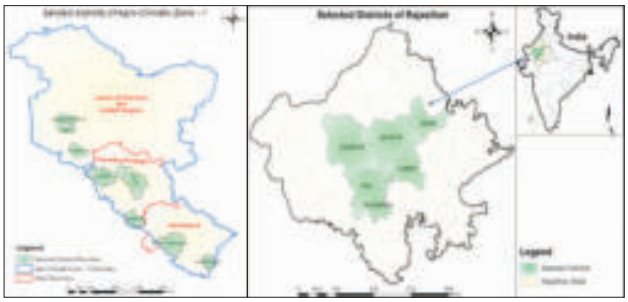


Fig. 54(a): Selected districts in agro-climatic zone-1

Fig. 54(b): Selected districts of Rajasthan

National Rainfed Area Authority (NRAA), Govt. of India, New Delhi

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

(K Rajarajan, H Anuragi and Alka Bharati)

The National Rainfed Area Authority (NRAA), New Delhi, is funded for pilot research project on neem. As a part of it, the evaluation of 170 neem germplasm for higher oil yield was initiated in the year 2020. The study aims to use morphological and molecular markers (SSR) to evaluate the diversified neem germplasm for higher seed, kernel, and oil yield. In this study, we estimated the fruit, seed, and kernel yield of 170 germplasm. Plant height and diameter at breast height (DBH) were calculated as individual tree morphological parameters. We've also initiated oil extraction from these germplasms using a soxhlet apparatus.

ICAR-ICRAF Work Plan

Whole Transcriptome Sequencing of *Pongamia pinnata* for Drought Stress Tolerance

(K Rajarajan, Alka Bharati, Ashajyothi, AK Handa, Suresh Ramanan S and Asha Ram)

This is an externally funded collaborative research project on *Pongamia pinnata* funded by the World Agroforestry Centre (ICRAF), New Delhi, as part of the ICAR-ICRAF work plan (2016-2020). Under drought stress and control conditions, two contrasting *P. pinnata* genotypes for drought tolerance were considered in this research. The morpho-physiological and biochemical traits of these genotypes were estimated under drought stress and control conditions. These genotypes were also to be investigated for their transcriptome profiles using RNAseq analysis on a HiSeq 4000 in order to better understand the molecular mechanisms of drought tolerance.

ICRISAT, Hyderabad

NRMACAFRISOP201100100085

Enhancing Groundwater Recharge and Water Use Efficiency in SAT Region through Watershed Interventions: Parasai-Sindh Watershed, Jhansi

(Ramesh Singh/InderDev, R K Tewari, R H Rizvi, R P Dwivedi and Dhiraj Kumar)

Ramesh Singh was PI till May, 2020

Background

Parasai-Sindh watershed has been developed by consortia of ICAR-CAFRI, Jhansi and ICRISAT, Hyderabad. The agroforestry based NRM interventions have been implemented in three villages *viz*., Parasai, Chhatpur and Bachhauni and located between 25^0 23' 56" to 25^0 27' 9.34" N and 78^0 19' 45.71" to 78^0 22' 42.57" E in Babina block of Jhansi district.

Runoff and groundwater recharge

Total rainfall during the year was 756.5 mm, 13.7% deficit over normal rainfall (877 mm). Total runoff recorded at the outlet of treated and untreated watersheds was 7.97 and 12.2% of annual rainfall recorded during 2020.

Open shallow dug wells (388 Nos.), were monitored for water table on monthly interval. The average water column during the year was 4.6 m which was 67% higher than the water column (2.75 m) recorded in untreated watershed. Landscape based NRM interventions in combination with field based interventions ensured water availability during entire *rabi* season in spite of continuous two years deficit rainfall.

Agroforestry Interventions

To bring more area under permanent vegetal cover, 120 (guava), 225 (lime), 400 (teak), 200 (*Melia dubia*) and 300 (*A. Senegal*) were planted in the fields of 15 farmers under various agroforestry systems.

Crop productivity enhancement (as per farmer practice)

The major crops grown by the farmers in the watershed area were groundnut, greengram and blackgram during kharif season and wheat, barley, chickpea and mustard during rabi season. Crop samples were taken from upper, middle and lower reaches of all the villages. 72 samples {3(lower, middle and upper reaches) x 3(villages) x 8 (replications)}were taken for groundnut and wheat. 27 samples {3(lower, middle and upper reaches) x 3(villages) x 3 (replications)}samples were taken for greengram, blackgram, chickpea and mustard. Each unit of sample was harvested from an area of 3m x 3m. The productivity of wheat, mustard and chickpea was 78, 46 and 45%, respectively, higher in treated watershed as compared to base line data (Fig.55).

Enhanced income of farmers through Integration of livestock at Parasai-Sindh watershed

Guava based agroforestry system at Parasai-Sindh watershed

Fig. 55: Glipmses of interventions at Parasai-Sindh Watershed

Capacity building of watershed dwellers

Farmers of the Parasai Sindh watershed were motivated to adopt agroforestry practices at their field by watershed team and scientists of the institute during MGMG programme. Farmers and farm women from watershed area participated in Workshop/field days, Kisan Mela and Gosthis organized by CAFRI on various occasions from time to time.

ICAR-ICRAF Work Plan

NRMACAFRISOL201800400116

Transforming rural livelihood and check migration through agroforestry in conjunction with natural resource management in Bolangir and Nuapada district of Odisha

(Ramesh Singh/InderDev, AK Handa and Asha Ram)

Background information

The project, "Transforming rural livelihood and check migration through agroforestry in conjunction with natural resource management in Bolangir andNuapada district of Odisha" is the sub project of "Enabling small holders in Bolangir and Nuapada districts of Odisha to produce nutritious food through agroforestry systems". The project was sponsored by Dept. of Soil Conservation and Watershed Development, Govt. of Odisha.

The project is being carried out with three main objectives *viz.*, *i)* to enhance groundwater recharge through suitable structures to facilitate agroforestry landuse; *ii)* to improve and optimize crop and livestock productivity to check the migration and *iii)* to develop model site of learning in Bolangir and Nuapada districts of Odisha.

Uplands of developed sites were suffering from land degradation and water scarcity especially during *rabi* and summer seasons despite receiving moderate to high rainfall. Rainfall in the villages ranges between 699 and 2555 mm with huge variability and 10-20 days long dry spells. Due to long dry spells, even *kharif* crops get affected with deficit soil moisture especially in Alfisols. Decentralized rainwater harvesting is the only option which offers concrete solutions. A significant amount of surface runoff is being generated which ranges from 350 to 700 mm/year. Even harvesting 10-20% generated runoff offers opportunities through small scale decentralised rainwater harvesting structures.

To improve the water availability both landscape based and field based natural resource management interventions were implemented at village Tara in Bolangir district and village Boirbhadi in Nuapada district of Odisha. To strengthen the life of earthen field bunding, masonry field drainage structures were constructed to dispose of excess runoff. To improve permanent vegetal cover and supports livelihoods, tree seedlings of fruits and timber species were planted on bunds. Besides, excavation of farm ponds for developing agroforestry based IFS, excavation of open shallow dug wells for life saving irrigation, plantation of identified tree species at field bunds, boundary and block plantation and introduction of new crops and round the year cultivation were the major activities undertaken in both the districts.

Diversion drainage channels (3-5 m wide and 1-3 m depth) with nala plugs at suitable intervals, deepening and widening of drainage networks, farms ponds along with masonry inlet and outlet with gauging facility, earthen field bunding with masonry surplusing arrangement were implemented at Tara and Boirbhadi sites in Bolangir and Nuapada districts, respectively (Fig. 56). The interventions implemented and benefits derived are listed below:

Interventions at village *Tara*, Bolangir

- Earthen field bunding with masonry surplusing arrangement was done in 80 ha

- Excavation of two farm ponds with capacity of 16000 cum and 5400 cum
- Widening and deepening of drainage network in 0.75 km length with earthen plugs at suitable intervals.

Interventions at village *Boirbadi*, Nuapada

- Earthen field bunding with masonry surplusing arrangement was done in five ha
- Excavation of farm pond with capacity of 6300 cum

These NRM interventions has led rainwater harvesting of 1.25 and 0.35 lakh cum at pilot sites of Bolangir and Nuapada districts, respectively. Water table rose by 2-3 meters at both the sites. Soils loss was reduced by 75% as compared to pre implementation phase.

At both the sites, mango, moringa, teak and bamboo based agroforestry systems have been developed at farmers' fields for improving the livelihood and nutritional security of the farmers.

Construction of outlet of the farm pond at *Tara* village

Fielillaged buding at *Tara* village

Ensuring watering through perforated pipe at village *Boirbhadi* in Nuapada district

Plantation at village *Boirbhadi* in Nuapada district

Fig. 56: Glimpses of interventions at *Tara* and *Boirbhadi villages* in Bolangir and Nuapada district of Odisha

ICAR-IGFRI, JHANSI

Farmer FIRST programme (FFP): Scaling up and integration of fodder technologies in existing farming system for sustainable livestock productivity in Bundelkhand

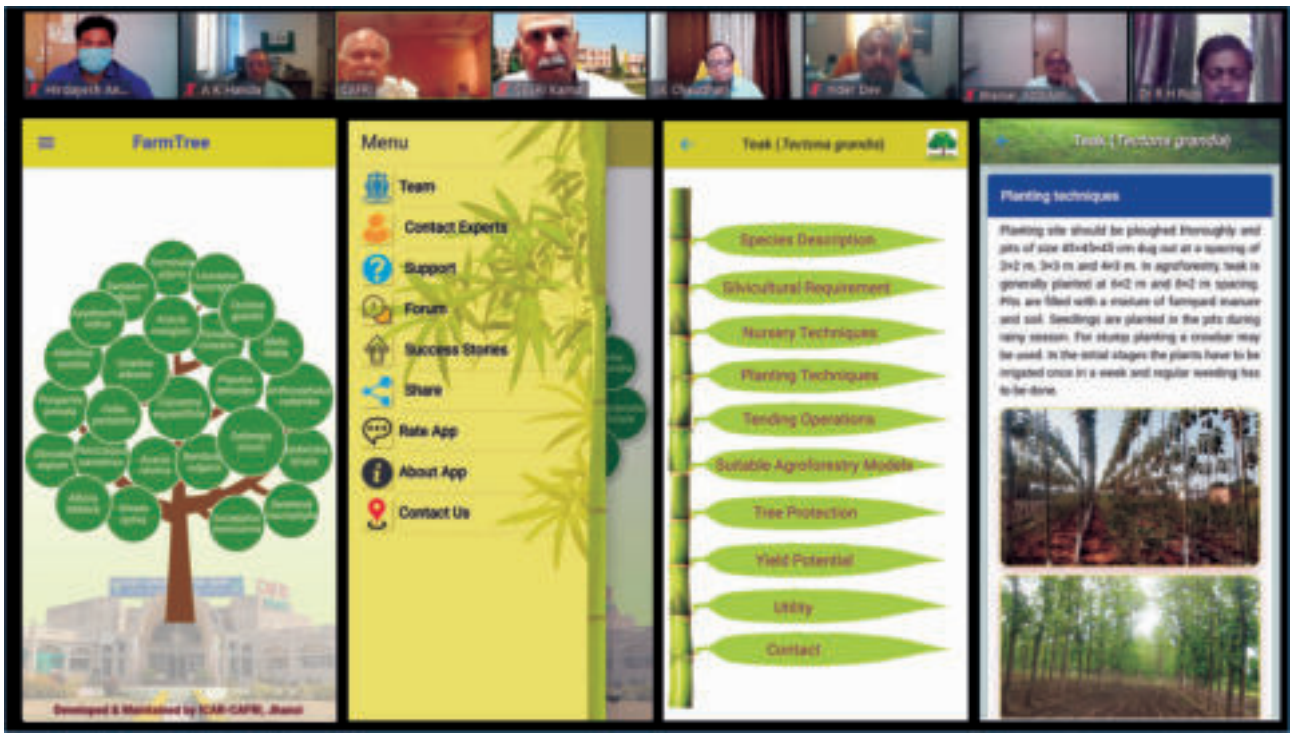
(Purshottam Sharma, Sunil Seth, S K Mahanta, Harsh Vardhan Singh, Mukesh Choudhary (IGFRI, Jhansi) and R P Dwivedi)

Actively associated in organizing the Livestock health camps to monitor and control health issues in animals. Motivated the farmers about participatory seed production in fodder crops. Created awareness among farmers towards introduction of improved variety of tomato, okra, bottle gourd, pumpkin and other cucurbits using capacity building module for capacity building and technology dissemination through trainings, livestock fodder-advisories and weather based agro advisory services. Total 10 Nos. training programmes were organized.

2. Research Achievements

2.6: 'FarmTree' Mobile *App* for Agroforestry

Launch of '*FarmTree*' Mobile App for Agroforestry Farmers of India FarmTree (English version)' an android based application developed by ICAR-CAFRI, Jhansi was virtually launched by Dr. S K Chaudhari, DDG (NRM), ICAR, New Delhi during the online Review Meeting of the institute on 23rd May, 2020. This App initially consisted of detailed information on 22 tree species of agroforestry importance along with supporting photographs. 'FarmTree' was developed by Dr. R H Rizvi, Dr. A K Handa, Dr. S B Chavan, Dr. H Anuragi, Dr. R Vishnu, Dr. Asha Ram and Mr. Abhishek Deb under the guidance of Dr. R K Tewari, Director, CAFRI. This App is freely available on our website: www.cafri.res.in', google play store and can be downloaded using the link: https://play.google.com/store/apps/details?id=com.cafri.farmtre



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.

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

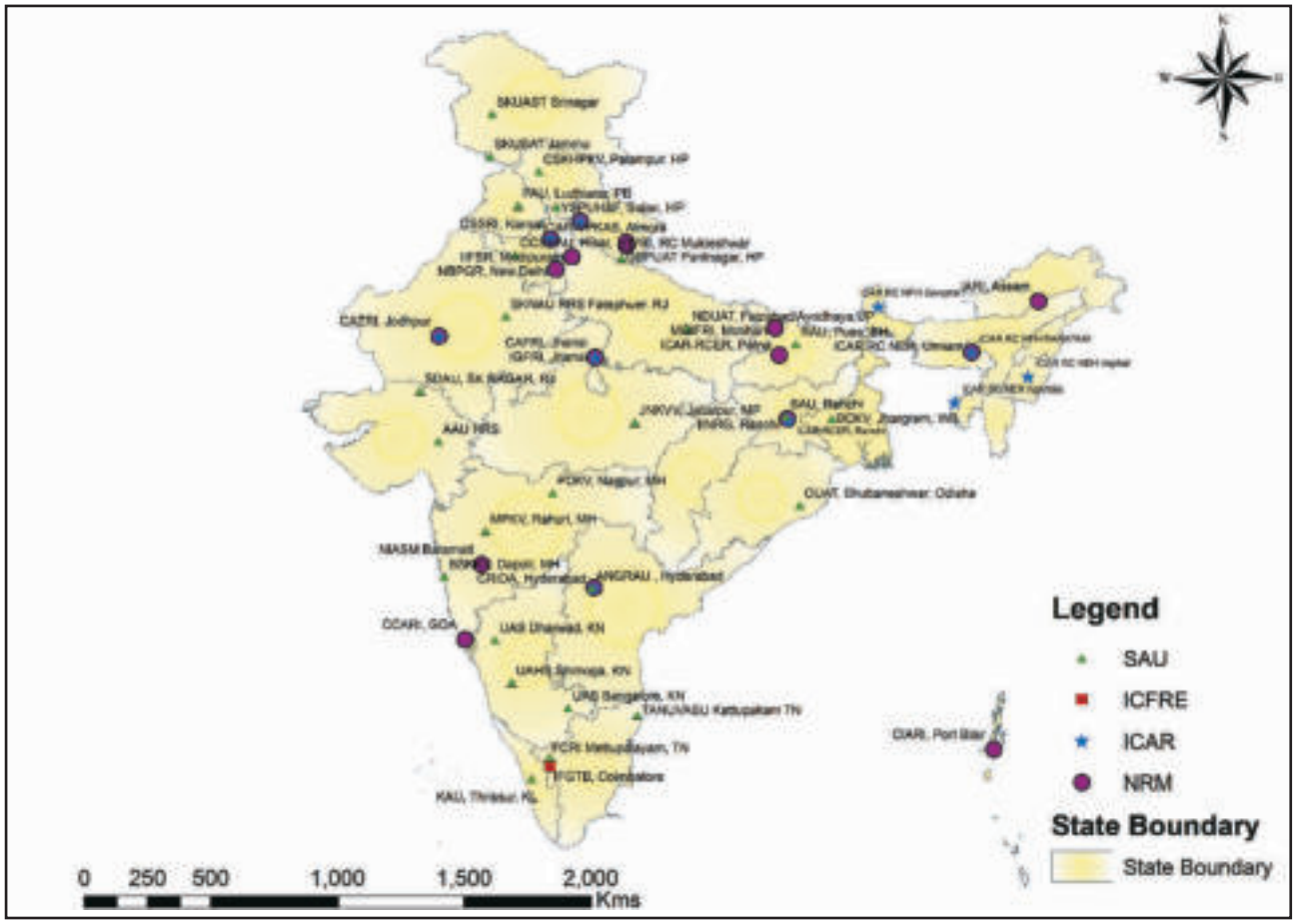


Figure 1. Showing the distribution of AICRP on Agroforestry Centres across the country

Diagnostic and Design survey

The Diagnosis and Design (D&D) survey is a continuous process in agroforestry research and the centers has been working on this objective. In the year 2019-2020, the OUAT centre conducted the D&D survey related to homestead agroforestry in 4 districts of Odisha (Khurda, Puri, Nayagarh & Dhenkanal) comprising 4 blocks and 8 villages. The BCKV centre conducted the Survey among farmers in different villages of Jhargram, Binpur II of Jhargram district; Salboni of Paschim Medinipore for extension of agroforestry systems in farmers' plots. The UAS, Dharwad centre has been undertaking on design and diagnostic survey for choice of perennial components in agroforestry on a regular basis in 7 districts of North-West Karnataka, PDKV centre in Nagpur district, and the GBPUAT in the Khatima block of the U.S. Nagar district of Uttarakhand.

Improvement of MPTs for Agroforestry Model Development

The AICRP-agroforestry has been working on tree breeding and improvement of selected woody perennials to quality their suitability for integration in agroforestry systems. During 2019-20, two of our Centres released prospective tree germplasm/varieties suitable for agroforestry *viz.,* UAS-Bengaluru centre released a Tamarind germplasm GKVK 17 for commercial cultivation; TNAU-FCRI released MPT-3 of *Melia dubia*. The complete germplasm assemblage of woody perennials in different centers is listed in Table 1. As part of developing management practices for agroforestry systems, the AICRP-Agroforestry centers are working on developing agroforestry models which are listed in Table 1.

Table 1. The germplasm assemblage of woody perennials and agroforestry models in different AICRP on Agroforestry Centres

Name of the centre/State	MPTS working upon	Agroforestry models under trial/ development
Assam Agricultural University HRS, Kahi-kuchi	*Acacia mangium* *Gmelina arborea* *Bambusa balcooa* *Bambusa tulda* *Melocanna baccifera*	*Gmelina arborea* based Agrisilvicultural system, Jackfruit based Agroforestry system, *Acacia mangium* based Agrisilvicultural system, *Bambusa balcooa* based Agrisilvicultural System
Professor Jayashankar Telangana State Agricultural University, Hyderabad	*Annona squamosa* *Azadirachta indica* *Melia dubia* *Simarouba glauca* *Pongamia pinnata*	*Melia dubia* based Agroforestry system, Custard apple based Hortipastoral system, Mango based in Agrihorticultural system
Bihar Agricultural University, Ranchi	*Acacia mangium* *Gmelina arborea*	*Gmelina arborea* based Agrisilvicultural System, Forage crops under Silvipastoral system, Perennial Medicinal Plants-bamboo alley cropping system
Bidhan Chandra Krishi Viswavidyalaya, West Bengal - Jhargram	*Gmelina arborea* *Acacia auriculiformis* *Leucaena leucocephala* *Dysoxylum binectariferum*	*Citrus sinensis* based agroforestry system, *Gmelina arborea* and Mango-based agroforestry system, *Eucalyptus tereticornis* and Mango based agroforestry system, *Anthocephalus cadamba* and mango agroforestry system
Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli	*Acacia auriculiformis* *Acacia mangium* *Gliricidia sepium* *Tectona grandis* *Melia dubia* *Garcina indica* *Pongamia pinnata* Bamboo	*Acacia mangium* based agroforestry system, Mango based horti-pastoral system, Sandal based horticultural system, *Bridelia retusa* based horticultural system, *Melia dubia* based medicinal agroforestry system, *Dendrocalamus stocksii,* Munro based agroforestry, Arecanut based plantation agroforestry system
Chaudhary Charan Singh Haryana Agricultural University, Hisar	*Populus deltoides* *Dalbergia sissoo* *Melia composita* Eucalyptus	Eucalyptus based agroforestry system, Poplar based agroforestry system, Kinnow and Eucalyptus agri-silvi-horticultural systems, Eucalyptus clone-based agroforestry system
Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur	*Toona ciliate* *Sapindus mukorossi* *Morus alba* *Terminalia chebula*	Harar based silvipastoral system, Horti-medicinal plant-based agroforestry system, *Leucaena leucocephala* silvipastoral agroforestry system

Forest College and Research Institute, Tamil Nadu Agricultural University, Mettupulayam	*Melia dubia* *Ceiba pentandra*	Silvipastoral system, Horticulture-based Integrated Farming System, Climate resilient agroforestry system, Silvihorticulture system, Alley cropping system, Tree fodder bank model, *Melia* based medicinal agroforestry model, Wind break model, Live Fence Model
G.B. Pant University of Agriculture and Technology, Pantnagar	*Populus deltoides* *Anthocephalus cadamba* *Dalbergia sissoo* Bamboo	Eucalyptus clone-based agroforestry, bamboo-based agroforestry
Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur	*Acacia nilotica* *Dalbergia sissoo*	*Gmelina arborea* based Agrisilvicultural system, *Dalbergia sissoo* based Agrisilvicultural system, Aonla based Agrihorticultural system
Kerala Agricultural University, Thrissur	*Acacia mangium* *Tectona* grandis	Homestead based dairy system; Bamboo based agroforestry
Mahatma Phule Krishi Vidyapeeth, Rahuri	*Acacia nilotica* *Azadirachta indica* *Simarouba glauca* *Pongamia pinnata*	Teak based Agroforestry system
Acharya Narendra Deva University of Agriculture and Technology, Ayodhya	*Casuarina equisetifolia* *Dalbergia sissoo*	Casuarina based agri-silvicultural system, Shisham based system, Eucalyptus based agroforestry system for Indo-Gangetic plains
Orissa University of Agriculture and Technology, Bhubaneshwar	*Acacia mangium* *Dalbergia sissoo*	Fruit based agrisilvihorticultural system (Jackfruit, Cashew, Mango), Silvipastoral system (*Acacia mangium, Acacia auriculiformis, Samanea saman*), Gambhar based Agrisilvicultural system, Mango + Pineapple Agrihorticultural system, Agrisilvicultural System (*Acacia mangium, Tectona grandis*)
Punjab Agricultural University, Ludhiana	*Populus deltoides* *Dalbergia sissoo* Melia spp., Eucalyptus	Poplar based agroforestry, *Melia composita* based agroforestry system, Eucalyptus based agroforestry system
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, College of Agriculture, Nagpur	*Tectona grandis* *Ailanthus excelsa* Bambusa spp.	Citrus based Agroforestry System, Bamboo based Agri-silviculture system, Teak based system
Dr. Rajendra Prasad Central Agricultural University, Pusa	*Bombax ceiba*	*Bombax ceiba* based Agrisilvicultural system
Sardarkrushinagar Dantiwada Agricultural University, SK Nagar	*Ailanthus excelsa* *Azadirachta indica*	*Melia dubia*-legume crops based Agrisilvicultural system, Neem and *Ailanthus* - boundary plantation based Agroforestry system, Ardusa (*Ailanthus excelsa*) based agroforestry system
Sri Karan Narendra Agriculture University, Regional Research Station, Fatehpur-Shekhawati	*Dalbergia sissoo* *Prosopis cineraria*	*Hardwickia* based system, *Prosopis* based system
Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Jammu (J & K)	*Terminalia* *Celtis* *Toona*	*Terminalia* based Silvipastoral System
Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Srinagar	*Ulmus* spp. *Morus alba*	Apple based system, Apricot based agroforestry system, Walnut based agroforestry system, Salix based silvi-pastoral system
Tamil Nadu Veterinary and Animal Sciences University, Kattapukkam	*Azadirachta indica* *Gliricidia sepium*	Hortipasture in degraded wastelands, *Psidium guajava* based pasture system, *Gliricidia* based silvipastoral system, Agroforestry based Integrated Farming system, *Cocus nucifera* based Hortipastoral system, *Leucaena leucocephala* based silvipasture for livestock integration
The University of Agricultural and Horticultural Sciences, Shimoga	*Gmelina* *Garcinia*	*Dendrocalamus stocksii* based agroforestry system Litsea based agroforestry

University of Agricultural Sciences, Bengaluru	*Simarouba glauca* *Tamarindus indica*	*Melia dubia* based agroforestry system, Mango based agroforestry system, Jamun based agroforestry system and Cashew based agroforestry system, Agroforestry based Intergraded Farming System
University of Agricultural Sciences, Dharwad	*Azadirachta indica* *Tamarindus indica*	Neem based agroforestry system, Sapota-timber species-based agroforestry system, *Melia dubia* based agroforestry system, Tree Borne Oilseeds based agroforestry system
Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Solan	*Grewia optiva* *Morus alba*	*Grewia optiva* based agroforestry system, *Morus alba*-based agroforestry system, Bamboo based agroforestry systems

On Farm Trails

On-Farm Trials being vital for testing the validity of agroforestry systems developed, all centres do establish and demonstrate to farmers regularly. During 2019-20, SDAU, SK NAGAR centre organized agroforestry-based demonstrations in five farmers field at the Banaskantha district, Gujarat.

New Initiatives

- Development of Harar based silvipastoral system for North Western Himalayan region: Common Experiment for Solan, Palampur, Jammu Centers.
- Organic fertilizer-based experimentation on *Dalbergia sissoo* based agri-silviculture system at NDUAT, Ayodhya centre.
- PJTSAU, Hyderabad centre has established an agrobiodiversity park comprising a Ficus Garden, Medicinal tree garden, Palm block and Butterfly Garden.
- AAU, Kahikuchi has developed cultivation practices for 12 species which is included in the 'Package of Practices' of the Assam Agricultural University & State Department of Agriculture, Govt. of Assam, 2018.
- Evaluation of different fodder tree species under agroforestry system and clonal evaluation of *Emblica officinalis* in Hill Zone of Karnataka by UAS Dharwad Centers. It is also involved in the Carbon Stocking in Natural Forest of Agricultural Research Station, Prabhunagar, Dharwad.
- Application of *Bambusa balcooa* leaf litter for Bio-oil preparation by pyrolysis and chemical characterization of bamboo bio-oil for suitability as engine fuel.
- Mass awareness campaign on "*Har Med Per Ped*".

Quality Planting Materials

sissoo, Azadirachta indica, Melia azedarach, Pongamia pinnata, Toona ciliata, Grewia optiva, Celtis australis, Leucaena leucocephala, Robinia pseudocacia, Salix sp., *Sapindus mukorossi, Morus alba* and *Artocarpus heterophyllus* 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 10000 farmers during 2019-2020. In addition, our centres provide agroforestry/tree-centric agro-advisories to the agroforestry practitioners.

State Interface

All the centres are providing constant technical support to the implementation of the Sub-Mission on Agroforestry in different states and other state line departments. A few of our centres like TNAU and UAS-Bengaluru are involved in enabling activities regarding entrepreneuship in tree farming including nursery.

Monitoring Framework for AICRP-Agroforestry

All significant developments and achievements thereof are being regularly documented through periodical reports and research documents. Salient datasets and achievements have been highlighted in the exclusive website (https://aicrp.icar.gov.in/) in 2019-2020 as developed by the ICAR-Indian Agricultural Statistics Research Institute (IASRI). This portal shall help different centres to upload new datasets and achievements on a real-time basis and enable the AICRP Coordination Unit at ICAR-CAFRI to monitor the progress and workflow. During 2019-20, a Technical Consultation Meeting was organized by the AICRP Coordination Unit at ICAR-CAFRI on 9th January, 2020 where transformation solicited to enhance the productivity of the AICRP centres was discussed and several guidelines and proforma were formulated for adoption by all the AICRP centres.More than 100000 seedlings of *Populus deltoides*, *Melia dubia*, *Tectona grandis, Gmelina arborea, Dalbergia*

4. Awards and Recognitions

Taria, S, Rane, J, Alam, B, Kumar, M, Babar, R, Anuragi, H, Rajarajan, R and Singh, N P received the Best Research Paper Award entitled "Combining IR Imaging, Chlorophyll Fluorescence and Phenomics approach for Assessing Diurnal Temperature and Desiccation Stress Management in *Azadirachta indica* and *Terminalia mantaly* in Agroforestry Systems. 2020, 94:941-951. https://doi.org/10.1007/s10457-019-00461-w .

(2) Best Popular Article Awards

- Sh. Lal Chand, Dr. Dhiraj Kumar, Dr. Asha Ram, Dr. Naresh Kumar, Sh. Sukumar Taria and Dr. Hirdayesh Anuragi received Best Popular Article Award (Institute Award) for 2019-2020 at ICAR-CAFRI, Jhansi.
- Sh. Lal Chand, Scientist received Best Popular Article Awards on his article entitled "Innovative techniques for successful establishment of new plantation in Bundelkhand region" published in Agri-life: Transforming Agriculture in Bundelkhand region through rainbow revolution 1(2):23-36. Published by RLBCU, Jhansi.

(3) Best Poster Award Awards

- Sh. Pradyuman Singh, Sh. Anand Kumar Singh, Sh. Prakash Rathod, Dr. Kaushal K Garg, Dr. Dhiraj Kumar, Shishupal Singh, Rajendra Singh and Dr. R K Tewari received Best Poster Award on KISAN MITrA Project: Biogas Plant Brought Smile on Dinesh Patel's Face". In: National Conference on "Resource Conservation for Soil Security and Jalshakti: Farmers Perspective in Bundelkhand (RCSSJ-2020)" during February 03-05, 2020 at ICAR-IISWC RC-Datia, Madhya Pradesh.
- Sh. Shankar Yadav, Sh. Sh. Sunil Kumar, Sh. Niranjan, Dr. Ramesh Singh, Dr. Inder Dev, Dr. Naresh Kumar, Dr. Dhiraj Kumar, Dr. R K Tewari, Dr. Anantha K H, Dr. Kaushal K. Garg received Best Poster Award for the poster presented on "Initial impact of Zero tillage at Farmers Field in Chandpura Village of Mahoba District in Bundelkhand Region". In: National Conference on "Resource conservation for Soil Security and Jalshakti: Farmers Perspective in Bundelkhand (RCSSJ-2020)" February 03-05, 2020 at ICAR-IISWC RC-Datia, Madhya Pradesh.
- Dr. Hirdayesh Anuragi Honored with "Best Poster Presentation Award" for poster entitled "Morpho-physiological, biochemical and molecular characterization for salt tolerance in Oat species" In: National Conference on "Resource Conservation for Soil Security and Jalshakti: Farmers Perspective in Bundelkhand (RCSSJ-2020)" February 03-05, 2020 at ICAR-IISWC RC-Datia, Madhya Pradesh.
- Dr. Asha Ram, Dr. Inder Dev, Dr. Ramesh Singh, Dr. Naresh Kumar, Dr. Dhiraj Kumar, Sh. Lal Chand and Dr. Sushil Kumar received Best Poster Award for the poster entitled "Effect of soil and water conservation measures in silvipastoral systems on productivity, water storage and soil erosion" during Hindi Saptah Celebration during 14-19 September 2020 at ICAR-CAFRI, Jhansi.
- Dr. Rajendra Prasad, Dr. Ramesh Singh, Dr. A K Handa, Dr. Badre Alam, Dr. Ashok Shukla, Sh. Prashant Singh, Sh. Anand Kumar Singh, Dr. R K Tewari, Dr. Sudhir Kumar evam Dr. Anil Kumar received 3rd prize for Best Poster Award 2020. Bundelkhand Kshetra Mein Anna Pashuon Se Fasal Suraksha Hetu Kumat (Gum Arabik) Ki Sajeev Baadh Ki Upyogita. Presented poster during Hindi Saptah (celebration during 14-19 September 2020 at ICAR-CAFRI, Jhansi.

(4) Institute Awards

- Dr. K Rajarajan, Scientist (Sr. Scale) received Best Worker Award (Science & Institution Development).

- Dr. Asha Ram, Scientist (Sr. Scale) received Best Worker Research Award (Field Operations).
- Dr. C K Bajpai, CTO and Sh. Kashi Ram, Sr. Tech. Asstt. (Driver) received Best Worker Award in Technical (Field/ Farm Lab. & Others).
- Sh. Mahendra Kumar, Assistant received Best Worker Award (Administration).
- Sh. Tridev Chaturvedi, Steno received Best Worker Award (Stenographer).

5. Research Projects (2020)

S.No.	Title of the Project	Leader	Associates
	(A) System Research Programme		
1	Nutrient management in ber based agri-horti. system	**Sudhir Kumar**	Rajendra Prasad, Inder Dev & Y N Venkatesh
2	Performance of pomegranate integrated with lemon grass under organic regime	**Sudhir Kumar**	Rajendra Prasad & Y N Venkatesh
3	Structural and functional analysis of short rotation tree based agroforestry system	**Naresh Kumar**	Asha Ram, Inder Dev, Kamini (ICAR-IGFRI, Jhansi) & Priyanka Singh
	(B) Natural Resource & Environment Management Programme		
1	Agroforestry based conservation agriculture for sustainable landuse and improved productivity	**Inder Dev**	Asha Ram, Naresh Kumar, Lal Chand* & Y N Venkatesh
2	Agroforestry based integrated farming system for small and marginal farmers in semi-arid region	**Asha Ram**	Sudhir Kumar, Naresh Kumar, Ramesh Singh, Dhiraj Kumar, R Vishnu, Y N Venkatesh, Sushil Kumar, Lal Chand*, Priyanka Singh & Aswathy Chandrakumar
3	Impact of watershed and agroforestry interventions on hydrology and nutrient loss at Garhkundar-Dabar watershed in Bundelkhand region of Central India	**Inder Dev**	Asha Ram & R K Tewari
4	Relevance of soil and water conservation sustainability measures in enhancing productivity and of silvipastoral system in semi-arid conditions	**Asha Ram**	Naresh Kumar & Inder Dev
5	Biomass modelling and area estimation in *Tectona grandis* based agroforestry systems in Central India	**S B Chawan* / R Vishnu**	Asha Ram & R H Rizvi
6	Temporal evaluation of cropping systems under *Melia dubia* based agroforestry system	**Sushil Kumar**	Asha Ram, Naresh Kumar, Sukumar Taria*, Rajendra Prasad & Priyanka Singh
7	Standardization of nursery practices for the production of quality planting material of Indian Sandalwood (*Santalum album* L.)	**R Vishnu**	Naresh Kumar, Rajendra Prasad, K Rajarajan & Sukumar Taria*
	(C) Tree Improvement, Post-Harvest & Value Addition Programme		
1	Comparative studies on seedling and clonal plants of *Pongamia pinnata* with special reference to their adaptability to rainfed dry agroclimate	**Badre Alam**	A K Handa, Sukumar Taria*, Hirdayesh Anuragi & Alka Bharati

2	Evaluation and characterisation of different Leucaena germplasm at CAFRI	**K Rajarajan**	A K Handa, A K Singh, (IGFRI), Maneet Rana (IGFRI) & R Vishnu
3	TBOs based agroforestry models	**R. Vishnu**	Inder Dev, Naresh Kumar, Sushil Kumar & R Vishnu
4	Functional genomics for early drought tolerance in *Pongamia pinnata* genotypes	**K Rajarajan**	Lal Chand*, A Radhakrishnan (IGFRI), Sukumar Taria, Hirdayesh Anuragi & Alka Bharati
5	Collection, evaluation and hybridization of Moringa germplasms	**Hirdayesh Anuragi**	Lal Chand*, S B Chavan*, Sukumar Taria*, Sushil Kumar, K Rajarajan, Alka Bharati & Y N Venkatesh
	(D) HRD, Technology Transfer & Refinement Programme		
1	Socio-economic, energetic and environmental impact assessment of watershed and agroforestry interventions at Garhkundar-Dabar watershed in Tikamgarh district of Madhya Pradesh Project concluded during 2020	**R P Dwivedi**	R K Tewari, R H Rizvi, Priyanka Singh & Aswathy Chandrakumar
1	Horizontal and vertical distribution of fine roots of tree and nutrients content in well-established Aonla and *Hardwickia binata* based agroforestry system	**Dhiraj Kumar***	Ram Newaj Rajendra Prasad & Asha Ram
	Externally Funded Project concluded in 31st March, 2020		
1.	DST, New Delhi — National Mission for Sustaining the Himalayan Ecosystems (NMSHE-Taskforce 6 for Himalayan Agriculture)	**A K Handa**	Inder Dev, Badre Alam & Asha Ram
2.	ICAR Network Project — Assessment of carbon sequestration potential of agroforestry systems (NICRA)	**Ram Newaj**	Rajendra Prasad, A K Handa, Badre Alam, R H Rizvi & S B Chavan
3.	ICAR- ICRAF Work Plan — Mapping and Estimation of Area under Poplar based Agroforestry Systems in Indo-Gangetic Plains of India	**R H Rizvi**	A K Handa & K B Sridhar

Externally Funded Projects

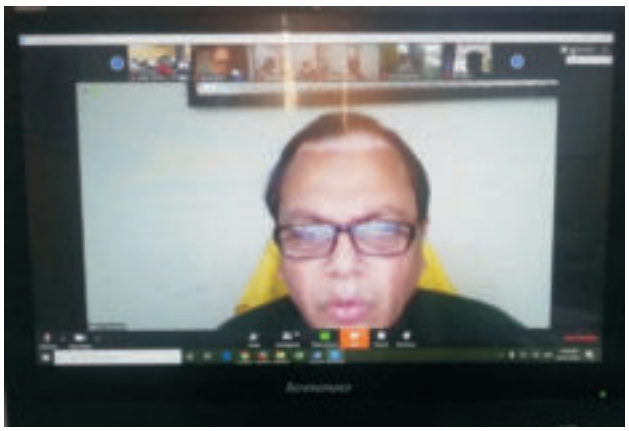
S.No.	Title of the Project	Leader	Associates	Funding Agency
1	Harvest and post-harvest processing and value addition of natural resins, gums and gum resins	**Rajendra Prasad**	A K Handa, Ramesh Singh & Badre Alam	ICAR, IINR&G Ranchi
2	Transforming rural livelihood through agroforestry based natural resource management in drought prone Bundelkhand region, UP (Sub Project of KISAN MITrA project for doubling farmers' income in Bundelkhand region of Uttar Pradesh)	**Inder Dev**	R K Tewari Naresh Kumar Asha Ram Dhiraj Kumar* & Lal Chand	ICRISAT, Hyderabad
3	Establishment of Hi-Tech nursery for the production of quality planting material U P Agroforestry Mission, Lucknow	**Lal Chand***	Naresh Kumar	

4	Transforming rural livelihood and checking migration through agroforestry in conjunction with natural resource management in Bolangir and Nuapada districts of Odisha	**Inder Dev**	A K Handa & Asha Ram	ICAR-ICRAF Work Plan
5	Assessment of genetic potential of neem germplasm for higher yield and oil content through molecular markers	**K Rajarajan**	H Anuragi & Alka Bharati	National Rainfed Area Authority (NRAA), Govt. of India, New Delhi
6	Assessment of area under agroforestry systems/species in agro-climatic zones of India	**R H Rizvi**	A K Handa, R. Vishnu, Suresh Ramanan S & K Shiran (ICAR-CAZRI, Jodhpur)	ICAR-ICRAF Work Plan
7	Whole Transcriptome Sequencing of *Pongamia piñata* genotypes for Drought Stress Tolerance	**K Rajarajan**	Alka Bharati, Ashajyothi, Suresh Ramanan S, Asha Ram & A K Handa	ICAR-ICRAF Work Plan
Inter Institutional and International Collaborative Project				
S.No.	**Title of the Project**	**Leader**	**Associates**	**Funding Agency**
1	Enhancing groundwater recharge and water use efficiency in SAT Region through watershed interventions-Parasai-Sindh Watershed, Jhansi	**Inder Dev**	R K Tewari, R H Rizvi & R P Dwivedi	ICRISAT, Hyderabad
2	Farmer FIRST programme (FFP): Scaling up and integration of fodder technologies in existing farming system for sustainable livestock productivity in Bundelkhand	**Purshottam Sharma**	Sunil Seth, S K Mahanta, Harsh Vardhan Singh, Mukesh Choudhary & R P Dwivedi	Inter-Institutional (IGFRI-Jhansi)

* Dr. S B Chavan, Scientist (Forestry) associated upto 7th August, 2020; Dr. Dhiraj Kumar, Scientist (Soil Science) associated upto 11th August, 2020; Sh. Lal Chand, Scientist (Fruit Science) associated upto 26th September, 2020 & Sh. Sukumar Taria, Scientist (Pl. Physiology) associated upto 26th December, 2020.

6. Important Meetings/Days Observed

Online Review Meeting



Online Review of CAFRI, Jhansi was conducted under the Chairmanship of Dr. S K Chaudhari, DDG (NRM), ICAR, New Delhi on 23rd May, 2020. Dr. R K Tewari, Director (A), CAFRI, Jhansi presented the achievements (2017- 2020) of the Institute and future line of work for 2020- 2025. Dr. A K Handa, Principal Scientist (Agroforestry) also presented the achievements of AICRP on Agroforestry and elucidated future plan. Dr. S K Chaudhari appreciated the work done by the Institute.

Research Advisory Committee (RAC)

The RAC meeting of ICAR-CAFRI, Jhansi was held virtually on 15th May, 2020 under the chairmanship of Hon'ble Dr. K Gurumurthi. Dr. S Bhaskar, ADG (AA & CC), NRM Division, ICAR, New Delhi; Dr. S K Dhyani, Senior Agroforestry Expert, World Agroforestry (ICRAF), New Delhi; Dr. S D Bhardwaj, Former Dean, Y S P University of Horti. & Forestry, Solan; Dr. A K Mandal, Former Director, TFRI, Jabalpur; Dr. P K Patnaik, Former Dean, OUAT, Bhuvneshwar; Dr. R C Dhiman, Former General Manager, WIMCO Seedling Limited, R&D Centre, Bagwala, Kashipur Road, Rudrapur; Dr. R K Tewari, Director (A), ICAR-CAFRI, Jhansi and Dr. Inder Dev, Pr. Scientist & Member secretary RAC participated in the meeting.

Annual IRC Meeting

The annual IRC meeting of, Jhansi was conducted on 19th -20th & 22nd June, 2020. All scientists of the institute participated and presented the progress of their research work.

हिन्दी सप्ताह

दिनाँक 14.09.2020 को हिन्दी सप्ताह का उद्घाटन सत्र संस्थान के निदेशक (कार्यवाहक) डॉ. आर.के. तिवारी की अध्यक्षता में

प्रारंम्भ हुआ। कार्यक्रम का प्रारम्भ आई.सी.ए.आर. कुलगीत से किया गया। उसके उपरान्त डॉ. इन्द्र देव, प्रधान वैज्ञानिक द्वारा मान्नीय कृषि मंत्री, भारत सरकार का हिन्दी दिवस पर संदेश पढ़कर सभी को उनके बहुमूल्य विचारों से अवगत कराया।

Days Observed

Women Day

On 8th March, 2020 a Women Day was observed at village Rajapur, Block-Babina in Jhansi district. Total 125 farm women from village Rajapur (District Jhansi) participated in the programme.

33rd Foundation Day

ICAR-CAFRI, Jhansi celebrated its 33rd Foundation Day on 8th May, 2020 virtually. Dr. S K Chaudhari, DDG (NRM) was the Chief Guest. Dr. S Bhaskar, ADG (Agronomy, Agroforestry and Climate Change) presided over the function. Dr. Javed Rizvi, Regional Director, South Asia Programme, ICRAF, New Delhi joined the celebration as the Guest of Honour. Dr. S K Dhyani, Former Director, CAFRI was also present on the occasion. At the outset, Dr.

R K Tewari, Director (A), CAFRI welcomed the dignitaries and briefed about the achievements of the Institute during the preceding year especially the work on agroforestry based watershed development, mapping of agroforestry area and carbon sequestration potential at all India level. He also highlighted about the international training conducted by ICAR-CAFRI in collaboration with ICRAF.

Dr. Javed Rizvi observed that CAFRI is one of the closest partner of ICRAF. He appreciated the linkages thereof. Dr. Rizvi told that during last year ICRAF has offered 31 life membership of Indian Society of Agroforestry for subscription of Indian Journal of Agroforestry. Dr. S Bhaskar commented the work done and achievements of ICAR-CAFRI. He also narrated the upscaling of agroforestry technologies and initiate research on agroforestry systems for their socio-economic imperatives. Dr. S K Chaudhari, Chief Guest of the function appreciated the efforts of CAFRI for its research achievements. He emphasized the role of agroforestry in reclaiming degraded wastelands and also in watershed management. He advised CAFRI to develop linkages with states. In the end, Dr. A K Handa thanked all the dignitaries of the 33rd Foundation Day of CAFRI, Jhansi. All participants observed prescribed preventive measures of COVID-19 during the function.

International Day of Yoga

6th International Day of Yoga on 21st June, 2020 as per the theme of IDY-2020 "Yoga at Home and Yoga with Family" was observed. Due to COVID-19 pandemic, the Yoga Day celebration was done in accordance with the social-distancing protocol.

Constitution Day

Constitution Day was observed on 26th November, 2020. The institute staffs were made aware of fundamental duties of Indian citizen at the Institute.

Republic Day and Independence Day

Republic Day (26th January, 2020) and Independence Day (15th August, 2020) were celebrated at ICAR-CAFRI, Jhansi. Flag hoisting ceremony was observed on both the occasions. Cultural programmes and sport events were organized for the staff along with their family members on the occasions.

7. Participation in Workshop/Webinars/Meetings/Symposia

- Dr A K Handa participated in ICAR-NRM Division Divisional Committee Meeting for Monitoring and Reviewing the Progress of Foreign Aided Projects on 29th January, 2020 organized by NASC Complex, New Delhi.
- Dr. Badre Alam participated in online workshop of Nodal Officer (HRD) of ICAR Institutes on 8th May 2020 organised by the HRM unit of ICAR, New Delhi.
- Dr. Badre Alam participated in the online review meeting of the Institutes on 23rd May, 2020 conducted/chaired by DDG (NRM), New Delhi.
- Dr. Badre Alam delivered invited lecture on the topic "Bridging the Carbon Sequestration with Climate Change Mitigation in Agro-Ecosystem: Future Perspectives" in virtual platform on 26th September, 2020 during the "Celebration of Innovation Week" organised by the Amity University, Gwalior (M.P.).
- Dr. Badre Alam participated in the webinar on "Developing grassroots level extension mechanism and capacity building of rural youth for Upscaling of agroforestry" on 9th November, 2020 organized by ICAR- CAFRI and AICRP on Agroforestry in collaboration with NRAA, New Delhi.
- Dr. R K Tewari, Dr. R P Dwivedi, Dr. (Er.) Ramesh Singh, Dr. Naresh Kumar, Dr. Asha Ram, Dr. Sushil Kumar, Dr. Dhiraj Kumar & Dr. Hirdayesh Anuragi participated in National conference on Resource Conservation for Soil Security and Jalshakti: Farmers perspective in Bundelkhand (RCSSJ-2020) from 03rd to 05th February, 2020 conducted by ICAR-IISWC RC, Datia (M.P.).
- Sh. S Suresh Ramanan participated in Webinar series on 'Post-COVID Era: Mainstreaming Biodiversity and Nature in Development Agenda' from 22nd May, 2020 organized by International Biodiversity Congress (IBC), Thiruvananthapuram; 'How to Work From Home Effectively as an Early Career Researcher' from 27th May, 2020 organized by Springer-Nature; 'From Volcanoes To Bicycles: Roles and Responsibilities for Inventing in Crisis Mode' from 28th May, 2020 organized by NCBS, Bengaluru - Bangalore Life Science Cluster; 'A Noon About The Online World Is Online' on 31st May, 2020 organized by College of Forestry, KAU, Thrissur, Kerala; 'Bamboo Resource Utilisation in Kerala: Prospects and Challenges' on 11th June, 2020 organized by KFRI, Peechi, Kerala; 'Agroforestry With Bamboos as A Means for Social Outreach And Business' Kerala on 23rd June, 2020 organized by KFRI, Peechi and National Webinar on Awareness and Use of CeRA Resources Through J-Gate Discovery Platform on 25th June, 2020 conducted by DKMA-ICAR, New Delhi; and Drone Remote Sensing in Agriculture on 9th September, 2020 organized by Indian Society of Agrophysics.
- Dr.(Ms.) Priyanka Singh attended the webinar series on 'Quantitative Methods for Social Sciences' organized by ICAR-NIAP, New Delhi on 1st to 23rd June, 2020 and lecture series on 'Agricultural Development' on 24th June, 2020 organized by ICAR-NIAP, New Delhi; Attended Webinar on "Farm Bill 2020: Understanding the Implications", organized by ICAR- Indian Agricultural Research Institute, New Delhi on 26th September, 2020.
- Dr. A K Handa participated in Work Plan meeting (virtual) of NABARD and ICAR on Successful Agroforestry Models on 6th July, 2020; A Talk on "Current Status and Future Roadmap of Agroforestry Research and Development" on 20th July, 2020 organized by Mettupalayam Agroforestry Business Incubation Forum, Forest College and Research Institute, Mettupalayam (TNAU).
- Dr. Sushil Kumar participated in the International Webinar on Soil Spectroscopy: An Emerging Technique for Rapid Soil Health Assessment on 01st October, 2020 organized by ICAR-Indian Institute of Soil Science, Bhopal & World Agroforestry (ICRAF), Nairobi.
- Dr. K Rajarajan attended webinar on Biological Diversity Act, 2002; Part II (The Biological Diversity Rule 2004) organized by National Biodiversity Authority and UNDP on 19th August, 2020; Peoples Biodiversity Register on 22nd December, 2020 organized by National Biodiversity Authority and UNDP. Participated in Young Scientist Conference organised during 22nd - 24th December, 2020 as a part of India International Science Festival-2020.
- Dr. A K Handa, Dr. K Rajarajan, Dr. Asha Ram, Dr. Sushil Kr Yadav, Mr. Sukumar Taria, Dr. J R Jat, Dr. S Gunasekaran, Dr. S Panda, Dr. Chhavi Sirohi, Dr. Vishnu, Aswathy Chandrakumar, Priyanka Singh, R P Dwivedi and Mr. Suresh Ramanan participated a Webinar on "Developing grassroots level extension mechanism and capacity building of rural youth for

upscaling of agroforestry" on 9th November, 2020 organized by ICAR-CAFRI, Jhansi.

- Mrs. Alka Bharati delivered lecture in International Webinar on "Recent Advances in Plant Biotechnology" on 19th December, 2020 organized by Pazhassi Raja College, Pulpally, Wayanad, Kerala.
- Dr. A Arunachalam, Dr. A K Handa and Dr. K Rajarajan and Dr. H Anuragi on 22nd December, 2020 attended a technical discussion on Microchip-based tagging of tree germplasm with World Agroforestry Centre (ICRAF), Kenya and ICAR-NBPGR, New Delhi.
- Mrs. Alka Bharati participated in the "Young Scientist Conference" from 22nd to 24th December, 2020 organised as a part of "India International Science Festival" by Ministry of science and technology, Ministry of Earth Sciences and Ministry of Health and Family Welfare in collaboration with Vijnana Bharati (VIBHA).

8. Publications

(A) Research Journals

Arunachalam, A, Handa, A K, Dev, I, Kaushal, R, Panwar, P and Dhyani, S K, 2020. Alternate Land Use and Agroforestry Systems for Resource Conservation and Enhanced Productivity in Hills. *Indian J. Hill Farming,* 33: 200–219.

Balamurugan, A, Kumar, A, Sakthivel, K, Ashajyothi, M, Sahu, KP, Karthikeyan, M, 2020. Characterization of Dickeya Fangzhongdai Causing Bacterial Soft Rot Disease on Dendrobium Nobile in India. *Eur. J. Plant Pathol,* 158: 773–780.

Chand, L, Singh, D B, Kumawat, K L, Rai, K M, Sharma, O C, Sharma, A, Saini, P and Handa, A K, 2020. Genetic Variability, Correlation and Path-Coefficient Studies for Nut and Kernel Traits Among the Persian Walnut (*Juglans Regia* L.) Genotypes. *Indian J. Agric. Sci,* 90: 868–873.

Chandra, A K, Kumar, A, Bharati, A, Joshi, R, Agrawal, A and Kumar, S, 2020. Microbial-Assisted and Genomic-Assisted Breeding: A Two Way Approach for the Improvement of Nutritional Quality Traits in Agricultural Crops. *3 Biotech,* 10(1): 1–15.

Chavan, S B, Armughum, K, Bhat, S, Handa, A K, Rajarajan, K, Ahmad, S, 2020. Poplar (*Populus deltoides*): Amalgam of Popular and Controversy in Jammu & Kashmir. *Curr. Sci,* 119: 910–911.

Chavan, S B, Newaj, R, Rizvi, RH, Ajit, Prasad, R, Alam, B, Handa, A K, Dhyani, S K, Jain, A, and Tripathi, D, 2021. Reduction of Global Warming Potential Vis-À-Vis Greenhouse Gases Through Traditional Agroforestry Systems in Rajasthan, India. Environ. *Dev. Sustain,* 23: 4573-4593. https://Doi.Org/10.1007/S10668-020-00788-w

Dev, Inder, Asha Ram, Ahlawat, Sudhir Pal, Palsaniya, Dana Ram, Singh, Ramesh, Dhyani ,Shiv Kumar, Kumar, Naresh, Tewari, Rama Kant, Singh, Mahendra, Sridhar, K Babanna, Ram Newaj, Dwivedi, Ragunandan Prasad, Kumar, Ram Vinod, Yadav, Ram Swaroop, Lal Chand, Kumar, Dhiraj and Prasad, Jasti, 2020. Bamboo-based Agroforestry System (*Dendrocalamus strictus* + sesame–chickpea) for Enhancing Productivity in Semi-Arid Tropics of Central India. *Agroforestry Systems*. DOI: https://doi.org/10.1007/s10457-020-00492-8.-volV)

Dev, R, Sureshkumar, M, Kumar, S, Venkatesan, V, Singh, T, Tetarwal, AS, Patidar, A, Dayal, D and Meghwal, PR, 2020. Collection, Characterization, Conservation and Utilization of *Cordia sinensis* Lam.: An Underexploited Multipurpose Fruit Species of Hot Arid Regions. *Plant Genet. Resour,* 18: 427-436.

Handa, AK, Sirohi, C, Arunachalam, A and Chavan, S B, 2020. Agroforestry Interventions for Carbon Sequestration and Improving Degraded Lands. Clim. Chang. *Environ. Sustain,* 8: 3. https://Doi.Org/10.5958/2320-642x.2020.00001.0

Handa, A K, Sirohi, C, Chavan, S B, Dhillon, R S, Ahlawat, K S and Rizvi, R H, 2020. Agroforestry in Haryana : Status and Way Forward Agroforestry in Haryana : Status and Way Forward. *Indian J. Agrofor,* 22: 1-10.

Khadatkar, A, Deb, R, Sah, R P, Basak, S, Sandeep, GM, Kumar, S, Singh, A and Jumrani, J, 2020a. Identification of Agricultural Problem through PRA Approach. *Indian J. Ext. Educ,* 56: 223–227.

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Kumar, Jitendra, Kalita, H, Angami, Thejangulie, Ramajayam, D, Anup Chandra, Kumar, Dhiraj, Sinha, Nishant K and Mohanty, M, 2020. Effect of Mulching on Growth and Quality of Tissue Culture Banana (Var. Grand Naine) and Soil Properties in Mid Hill Jhum Lands of Arunachal Pradesh. *Indian J. Agrofor.*, 22(2): 86-89.

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Kumar, S, Prasad, R, Kumar, V and Krishna, A K, 2021. Organic Source on Productivity of Pomegranate–Lemongrass-Based Agroforestry System in Central India. *Agrofor. Syst,* Https://Doi.Org/Https://Doi.Org/10.1007/S10457-021-00605-X)

Machiwal, D, Kumar, S, Islam, A, Kumar, S, Jat, S R, Vaishnav, M and Dayal, D, 2021. Evaluating Effect of Cover Crops on Runoff, Soil Loss and Soil Nutrients in an Indian Arid Region. *Commun. Soil Sci. Plant Anal,* Https://Doi.Org/1080/03650340.2021.1912324

Narkhede, S S, Handa, A K, Verma, K S and Bhave, SG, 2020. Wild Fruit Resources: Potential in Coastal Ecosystems of Konkan Maharashtra. *Adv. Agric. Res. Technol. Journal, 4 (1); 42-48.*

Patel, A, Kumar, A, Sheoran, N, Kumar, M, Sahu, K P, Ganeshan, P, Ashajyothi, M, Gopalakrishnan, S and Gogoi, R, 2020. Antifungal and Defense Elicitor Activities of Pyrazines Identified in Endophytic *Pseudomonas Putida* BP25 Against Fungal Blast Incited By *Magnaporthe oryzae* in Rice. *J. Plant Dis. Prot,* 128, : 1–12.

Prasad, Rajendra, Handa, A K, Alam, B, Singh, R, Shukla, A, Singh, P and Tripathi, VD, 2020. Growth and Biomass Studies of Fodder cum Gum Yielding Trees Under Different Spacing in Bundelkhand Region. *Indian For.,* 146 : 702–709.

Prasad, R, Singh, R, Alam, B, Handa, A K, Shukla, A, Singh, P, Tripathi, VD, Ajit and Tewari, R K, 2020. Benefit-Cost Analysis of *Acacia senegal* based Agri-Horti-Silviculture Model Suitable for Small Farmers. *Indian J. Agrofor.,* 22:7–15.

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Srinivasa, N, Chander, S, Sagar, D and Venkatesh, Y, 2020. Rice Brown Planthopper Prediction Model With Sweepnet Catches. *Indian J. Entomol,* 82:568–571.

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Veereshkumar, Kaushik, S K, Rajarajan, K, Kumaranag, K M, Uthappa, A R, Sridhar, K B, Alam, B and Handa, A K, 2021. Pollination Biology of *Pongamia Pinnata* (L.) Pierre: A Potential Biodiesel Plant. *Genet. Resour. Crop Evol,* 68: 59–67.

Veereshkumar, Kumaranag, K M, Uthappa, A R, Deb, D, Srivastava, M, Sridhar, K B, Handa and A K, 2020. Wild Bee Pollination in *Grewia flavescens* Juss. *Int. J. Trop. Insect Sci.,* 41(2): 1087-1093.

(B) Technical Journals

Mahanta, S K, Sharma, Purushottam, Kumar, Sunil, Choudhary, Mukesh, Dwivedi, R P, Manjunath, N, Upadhayay, J P, Chandra, Avinash, Saxena, A K, Gupta, Rajeev, Singh, Upendra and Kumar, Prashant. 2020. Subabul based Feed Pellets: As Strategic Supplements for Goats. *Indian Farming,* 70(12): 49–52; December, 2020.

Venkatesh, Y N, Sreedevi, K, Ashajothi, M, Kumar, Sudhir and Keerthi, MC (2020). Outbreak of White Grub Adults on Agroforestry Tree Species in Pre-Monsoon, *Agroforestry Newsletter,* Vol. 32 (2). Published by CAFRI, Jhansi.

(C) Popular Articles

Kumar, S and Misra, A K, 2020. Fodder Bank: A Source of Fodder to Livestock in Arid Kachchh during Drought Period. *Indian Farming*.

(D) Chapters in Book

Ambati S, Ramesh T, Anuragi H, Vidyadhar B and Lingaiah N, 2020. Biosphere, An Infinite Genepool to Combat Climate Change. *Organisms and environment* (ISBN: 978-93-89808-99-5): pp 26-35.

Bharati, Alka and Mandal, Pranab Kumar, 2020. Strategies for Identification of Genes toward Enhancing Nitrogen Utilization Efficiency in Cereals. *In:* Nutrient Dynamics for Sustainable Crop Production. (ed.) R S Meena. *Springer Nature Singapore Pte Ltd* :pp 157-187.

Bishwa Bhaskar, Choudhary, Singh, Priyanka, Gururaj, M, Kumar, Ranjit, Sirohi, Smita and Kumar, Sanjiv, (2020). Climate Change and Livestock Sector in India: Issues and Options. *In*: Climate Change and Indian Agriculture: Challenges and Adaptation Strategies. *Publisher: ICAR-NAARM, Hyderabad-500030*.

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(F) Book Authored

Rajarajan, K, Bharati, A, Anuragi, H, Handa, AK, Gaikwad, K, Singh, NK, Mohapatra, KP, Chandra, P, Chavan, SB, Chand L, Gupta V, Dhillon RS, Sirohi C, Shirin, F, Saravanan, S, Ravishankar, KV, Sankaran, M, Mehta, H, Venkatesh, G, Verma, A, Kalia, RK, Dasgupta, MG, Yasodha, R, Ginwal, HS, Deshmukh, R, Malik, SK, Bhaskar, S, Nadaf, A, Nayak, D, Dhyani ,SK, Hendre, PS and Rizvi, J, 2020. Status of Perennial Tree Germplasm Resources in India and their Utilization in the Context of Global Genome Sequencing Efforts. *Published by World Agroforestry, Nairobi, Kenya*. DOI http://dx.doi.org/10.5716/WP2020050.PDF.

(G) Edited Technical Book/Bulletins/Reports/ Extension Folders

Aswathy Chandrakumar, Priyanka Singh, R P Dwivedi and A K Handa, 2020. My meeting notes webinar "Developing grassroots level extension mechanism and capacity building of rural youth for upscaling of agroforestry" ICAR-Central Agroforestry Research Institute (ICAR-CAFRI) and AICRP on Agroforestry in collaboration with National Rainfed Area Authority (NRAA). No. 89/December 2020, AESA, Centre for Research on Innovation and Science Policy (CRISP), Hyderabad, India.

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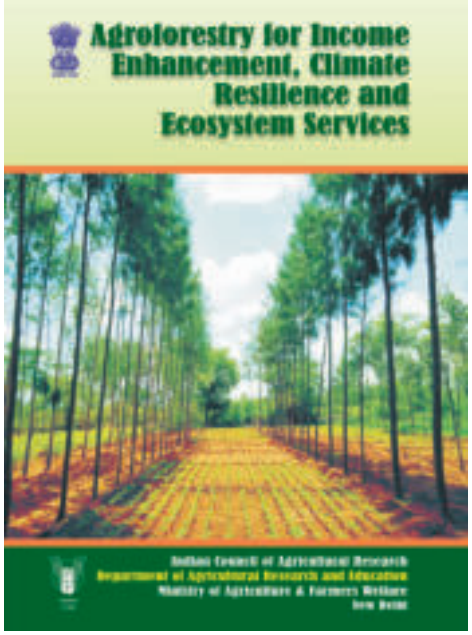
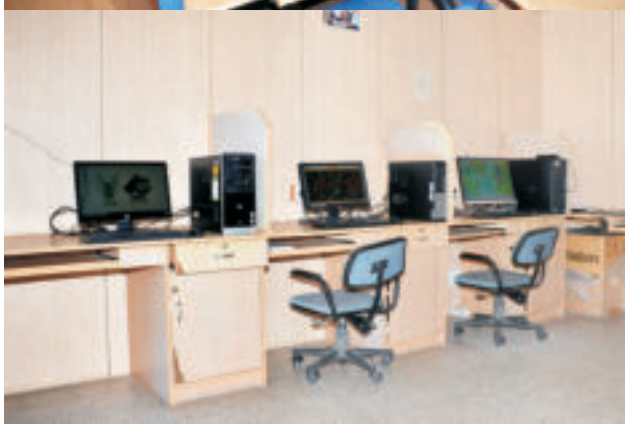


9. Trainings and Capacity Building

- Sh. Lal Chand participated in Winter School on Non-Conventional Approaches for Genetic Improvement of Perennial Horticultural Crops from 17th January to 6th February, 2020 organized by ICAR-IARI, New Delhi.
- Mrs. Alka Bharati attended the training on Climate change: challenges and response for women scientist from 10th to 14th February, 2020 at Lal Bahadur Shastri National Academy of Administration, Mussoorie.
- Dr. R Vishnu and Sh. S. Suresh Ramanan participated in online certificate course on 'Remote Sensing & GIS Technology and Applications' during 13th June to 1st July, 2020 organized by IIRS, Dehradun.
- Dr. Dhiraj Kumar and Mrs. Alka Bharati attended online lecture on NABL Accreditation of ICAR Laboratories on 22nd July, 2020 organized by NABL, New Delhi.
- Dr. H Anuragi, Dr. Sushil Yadav and Mr. Sukumar Taria participated in Online training programme on "Analysis of Experimental Data using R" from 5th to 11th August, 2020 organized by ICAR-NAARM, Hyderabad.
- Dr. (Ms.) Priyanka Singh attended Professional Attachment Training at ICAR-IGFRI, Jhansi from 6 August to 5th November, 2020; Regional workshop on "Startups and entrepreneurship" from 12th to 28th September, 2020 organized by Central Agricultural University, Imphal.
- Mrs. Aswathy Chandrakumar attended Professional Attachment Training from 1st August to 30th November, 2020 at ICAR-IISR, Calicut.
- Dr. Inder Dev attended Workshop cum training on Intellectual Property Rights in Agriculture and Education in India organized by NAHEP & IPTMU, ICAR, New Delhi from 12th to 28th September, 2020.
- Sh. S Suresh Ramanan, attended DST sponsored online national training programme "Empowerment and Entrepreneurship Development in Agriculture" from 9th to 13th November, 2020 organized by the Department of Agricultural Extension, UAS, Bangalore .
- Sh. S Suresh Ramanan, attended Professional Attachment Training from 10th December, 2020 to 10th March, 2021 at ICAR-CRIDA Hyderabad.



10. Scheduled Caste Sub Plan (SCSP)/TSP Progamme

ICAR-CAFRI is implementing SCSP schemes with the main objective to accelerate the pace of development of the SCs and bridge the socio-economic development indicators between SCs as compared to the advanced sections of the society. In this scheme, the quantifiable benefits and capacity building programmes are being organized for scheduled caste households. The schemes includes the enhancement of incomes of the target group and lead to the development of assets such as those related to sectors like agriculture sector.

Under the DFI Bundelkhand project, ICRISAT and ICAR-CAFRI are working together for the meeting the target of development of SC farmers in the selected 22 villages of different districts of Bundelkhand U.P. Till November 2020, more than 600 farm families of SC category have been benefitted under the convergence.

Distribution of sprayers and fertilizers to the SC farmers by the Chief Guest, Sh. Hargovind Kushwahaji at Pura Birdha

11. Swachh Bharat Abhiyan

150th Birth Anniversary of the Father of Nation Mahatma Gandhi

On the occasion of 150th Birth Anniversary celebration of the Father of Nation Mahatma Gandhi on 2nd October 2020 (from 26th September-2nd October 2020) following events were organized at the Institute:

- Inaugural session was organized on 26th September. During the program participants shared the anecdotes from Gandhi ji's life which were inspiration to all attendees in the hall and encouraged to think about the simple life style of Mahatma Gandhi.

- Yoga session was organized at campus on 27th September 2020. The main aim was to raise the awareness and ignite a passion for fitness and yoga among the participants.

- Painting competition was organized on 28th September for children of ICAR-CAFRI staff members. The participants shown their talent and creativity through painting. Amazingly, the enthusiasm among the participants was worth watching.

- Rangoli competition was organized for female participants of campus on 29th September at their residential colonies. They all participated very well and expressed their happiness through their rangolis. All female members were participated earnestly and with enthusiasm.

- Swachhta pledge was organized on 30th September. Staff members actively participated in Swachhta Pledge and they were conveyed the massage of cleanliness and importance of Swachhta.

- Swachhta abhiyan was organized at CAFRI campus in residential colonies on 1st October, 2020. They were highlighted with the importance of sanitation and the ongoing cleanliness drive "Swachh Bharat Abhiyan" started by our respected Prime Minister, Shri Narendra Modi.

- Birth anniversary of Father of Nation Mahatma Gandhi was celebrated on 2nd October, 2020.

12. Distinguished Visitors

Sh. Surya Pratap Sahi ji Hon'ble Minister for Agriculture, Agriculture Education and Agriculture Research, Govt. of UP visited Farmer site at Rauli Kalyanpur village, in Chitrakoot district, Uttar Pradesh and reviewed the progress of DFI project under KISAN MITrA, funded by ICRESAT, Hyderabad

Sh. Jawahar Rajput, Hon'ble Member of Legislative Assembly, Uttar Pradesh visited Sutta and Singar villages, Garontha Tehsil of Jhansi districtVisitors

Sh. Hargovind Kushwaha, Minister of State, Govt. of U.P. visited the Agroforestry planation of teak at Pura Birdha and project activities being explained at Birdha to Sh. Hargovind Kushwaha ji

13. Personnel Information

Dr. R K Tewari, Director (A), up to 08 December, 2020
Dr. A Arunacham, Director, w.e.f. 09 December, 2020
Scientific
1. Dr. R K Tewari, Pr. Scientist (Horticulture/ Fruit Science)
2. Dr. Rajendra Prasad, Pr. Scientist (Soil Science)
3. Dr. Sudhir Kumar, Pr. Scientist (Horticulture/ Fruit Science)
4. Dr. A K Handa, Pr. Scientist (Forestry/ Agroforestry)
5. Dr. R P Dwivedi, Pr. Scientist (Agriculture Extension)
6. Dr. Inder Dev, Pr. Scientist (Agronomy)
7. Dr. Badre Alam, Pr. Scientist (Plant Physiology)
8. Dr. R H Rizvi, Pr. Scientist (Computer Application)
9. Dr. Naresh Kumar, Pr. Scientist (Agroforestry)
10. Dr. K Rajarajan, Scientist, Sr. Scale (Genetics & Plant Breeding)
11. Dr. Asha Ram, Scientist, Sr. Scale (Agronomy)
12. Dr. Sushil Kumar, Scientist (Agronomy)
13. Dr. Hirdayesh Anuragi, Scientist (Genetics & Plant Breeding)
14. Sh. Sukumar Taria, Scientist (Pl. Physiology) (on Study Leave) w.e.f. 26/12/2020
15. Dr. R Vishnu, Scientist (Agroforestry)
16. Mrs. Alka Bharati, Scientist (Agril. Biotechnology)
17. Sh. Y N Venkatesh, Scientist (Agril. Entomology)
18. Sh. S. Suresh Ramanan, Scientist (Agroforestry)
19. Dr. (Ms.) Priyanka Singh, Scientist (Agricultural Economics)
20. Mrs. Aswathy Chandrakumar, Scientist (Agricultural Extension)
21. Mrs. M Ashajyothi, Scientist (Plant Pathology)
Technical
1. Dr. Rajeev Tiwari, Chief Technical Officer
2. Dr. C K Bajpai, Chief Technical Officer
3. Dr. A Datta, Chief Technical Officer
4. Sh. Sunil Kumar, Chief Technical Officer
5. Sh. Rajendra Singh, Chief Technical Officer
6. Sh. Rajesh Srivastava, Assit. Chief Technical Officer (Art & Photo)
7. Sh. R K Singh, Assit. Chief Technical Officer
8. Sh. S P Singh, Sr. Technical Officer
9. Sh. Ram Bahadur, Sr. Technical Officer
10. Sh. Ajay Kumar Pandey, Technical Officer (on Study Leave)
11. Mrs. Shelja Tamrakar, Sr. Technical Assistant (Library)
12. Sh. Het Ram, Sr. Technical Assistant (Driver)
13. Sh. Kashi Ram, Sr. Technical Assistant (Driver)
14. Sh. Prince, Technical Assistant, Mechanic

Administration
1. Sh. J L Sharma, A O
2. Sh. Birendra Singh, AAO& I/C AF& AO
3. Sh. A K Chaturvedi, Private Secretary
4. Sh. Hoob Lal, Personal Assistant
5. Sh. Om Prakash, Personal Assistant
6. Mrs. Kirti Chaturvedi, Personal Assistant
7. Sh. Mahendra Kumar, Assistant
8. Sh. Jai Janardan Singh, Assistant
9. Sh. Vir Singh Pal, Assistant
10. Sh. Deepak Vij, Stenographer (Grade-III)
11. Sh. Tridev Chaturvedi, Stenographer (Grade-III)
12. 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. Sh. S Suresh Ramanan, Scientist (Agroforestry)
2. Dr. Priyanka Singh, Scientist (Agricultural Economics)
3. Mrs. Aswathy Chandrakumar, Scientist (Agricultural Extension)
4. Mrs. M Ashajyothi, Scientist (Plant Pathology)
Transfer
• Dr. S B Chavan, Scientist (Forestry) transferred to ICAR-NIASM, Baramati.
• Dr. Dhiraj Kumar, Scientist (Soil Science) transferred to ICAR- IISS, Bhopal.
• Sh. Lal Chand, Scientist (Fruit Science) transferred to ICAR-CISH, Bikaner.
• Dr. A R Uthappa, Scientist (Agroforestry) transferred to ICAR-CCARI, Goa.
• Sh. S B Sharma, AF&AO promoted to the post of FAO at ICAR-DRMR, Bharatpur (Raj.).
Promotion
Dr. Naresh Kumar, Sr. Scientist (Agroforestry) promoted to the post of Pr. Scientist (Agroforestry) w.e.f. 9th November, 2018.
Retirement
• Dr. Ram Newaj, Pr. Scientist (Agronomy) retired on 31st January, 2020.
• Sh. Attar Singh, Skilled Support Staff retired on 31st May, 2020.
Obituary
• Sh. Ram Singh, Skilled Support Staff passed away on 24th October, 2020.

Annexure-I

Research Advisory Committee (RAC)

Dr. K Gurumurthi, Chairman Ex. Director, IFGTB 62/4, Leela Apartments, Ponnayarjapuram Coimbatore - 641 001 (TN)	**Dr. R K Patnaik** Ex. Dean, CoF, OUAT, Bhubaneshwar Flat Number 303, Gopal Residency Kalpana Road, B.J.B. Nagar Bhubaneswar - 751 014 (Odisha)
Dr. S K Dhyani Senior Agroforestry Expert World Agroforestry Centre (ICRAF), Regional Office for South Asia, C- Block, NASC Complex, DPS Marg New Delhi - 110 012	**Dr. S D Bhardwaj** Ex- Dean,COF, YSPUHF, Solan House No. 33, Scientist Colony, P.O. Shamti, Solan - 173 212 (H.P.)
Dr. A K Mandal Ex. Director, TFRI Srikrishna Apartment, New Area, Morabadi, Balihar Road, Ranchi - 834 008 (Jharkhand)	**Dr. B N Patel** Principal and Dean, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari - 396 450 (Gujarat)
Dr. S Bhaskar Assistant Director General (Agron./AF & CC) NRM Division, ICAR, Krishi Anushandhan Bhawan-II, New Delhi- 110 012	**Dr. R C Dhiman** General Manager WIMCO Seedling Limited, R&D Centre, Bagwala, Kashipur Road, Rudrapur - 263 153 (Uttrakhand)
Sh. Ashok Rajput Village- Nandsiya, Mooth, Post- Karjanva, Jhansi (U.P.)	**Sh. Pradeep Saravgi** House No. 165, Purani Nazai Jhansi (U.P.)
Dr. Inder Dev Pr. Scientist & Member Secretary, ICAR- CAFRI, Jhansi (U.P.)	

Annexure-II

Institute Management Committee (IMC) 2018-2021

Dr. R K Tewari (Chairman) Director (A) ICAR-CAFRI, Jhansi (U.P.)	**Dr. C B Pandey** Principal Scientist, ICAR-CAZRI, Jodhpur (Rajasthan)
Dr. K P Mohapatra Principal Scientist, ICAR-RC-NEHR, Barapani	**Dr. Harsh Mehta** Principal Scientist, ICAR- IISWC, Dehradun (Uttrakhand)
Dr. Jagdish Tamak HOD Plantations, ITC Limited, Paperboard and Specialty Paper Division, 106, Sardar Patel Road, Secunderabad - 500 003 (Telengana)	**Dr. Inder Dev** Principal Scientist, ICAR-CAFRI, Jhansi (Uttar Pradesh)
The Assistant Director General (A,AF&CC) NRM Division Indian Council of Agricultural Research, Krishi Anushandhan Bhawan-II New Delhi - 110 012	**Sh. Ashok Rajput** Village- Nandsiya, Mooth, Post- Karjanva, Jhansi (Uttar Pradesh)
Director Statistics and Crop Insurance, Government of Uttar Pradesh, Krishi Bhawan, Madan Mohan Malviya Marg, Lucknow (Uttar Pradesh)	**Sh. Pradeep Saravgi** House No. 165, Purani Nazai Jhansi (Uttar Pradesh)
Dean Krishi Vidyalaya, Raj Mata Vijyaraje Scindiya Krishi Vishwa Vidyalaya, Gwalior (Madhya Pradesh)	**Director Extension Services** Jawahar Lal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.)
Finance & Account Officer, ICAR- Indian Grassland & Fodder Research Institute, Jhansi (Uttar Pradesh)	**Sh. J L Sharma** A O & Member Secretary ICAR-CAFRI, Jhansi (Uttar Pradesh)

Annexure-III

Institute Joint Staff Council (IJSC) 2019-2022

Chairman : Dr. R K Tewari, Director (A)				
Category	**Staff Side**		**Office Side**	
Administration	**Sh. Birendra Singh** AAO	Member, CJSC	**Dr. R K Tewari** Pr. Scientist	Member
	Sh. Tridev Chaturvedi Stenographer	Secretary, IJSC	**Dr. Rajendra Prasad** Pr. Scientist	Member
Technical	**Smt. Shelja Tamrakar,** Sr. Technical Assistant	Member	**Dr. Inder Dev** Pr. Scientist	Member
	Sh. Kashi Ram Tech. Asstt. (Driver)	Member	**Dr. C K Bajpai** CTO	Member
Supporting	**Sh. Attar Singh** SSS	Member	**Sh. J L Sharma** A.O. & H.O.	Member Secretary
	Sh. Ram Singh SSS	Member	**Sh. S B Sharma** AF&AO	Member

Swachh Bharat Abhiyan

एक कदम स्वच्छता की ओर

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CENTRAL AGROFORESTRY RESEARCH INSTITUTE

"AGROFORESTRY PATHWAY FOR RESTORATION OF DEGRADED LANDS"

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झाँसी 284003, उत्तर प्रदेश

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