वार्षिक प्रतिवेदन
Annual Report
2021

भाकृअनुप - केंद्रीय बारानी कृषि अनुसंधान संस्थान
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Preface

It is with great honor and privilege that I present the annual report of ICAR-CRIDA for the year 2021. During this year ICAR-CRIDA has made significant strides in research and technology development related to climate change and rainfed agriculture. ICAR-CRIDA is now at the forefront among the scientific institutes of India to successfully device effective strategies to combat climate-related threats to agriculture in rainfed areas of the country. This annual report gives an account of the salient achievements in research, technology development and other accomplishments.

The institute has taken major strides in cropping system research in drylands with recommendations of suitable technology for dryland farmers. In the area of water conservation, we have come up with technologies such as raised bed with modified furrow systems in maize crops that is effective in the conservation of soil moisture. Research on rainwater harvesting and resource characterization is moving towards the development of efficient and practicable package of practices that can directly benefit the dryland farmers of the country. We have been at the forefront in the development of district-based contingency plans for 648 districts in the country and district-level yield efficiency maps for 7 important rainfed crops.

In alternate land use and ecologically sustainable agriculture, we have taken innovative steps towards the evaluation of bamboo species suitable for Southern Telangana region for extending bamboo cultivation, its large-scale promotion and adoption. We have evaluated low-cost approaches for the management of Fall Army Worm (FAW), in maize moving closer towards the control of this pest in the country. We have also developed high productivity fodder-based cropping systems with less water loss, sediment loss and less pest and disease incidence through diverse crops and higher number of natural predators.

In drought and heat tolerance research, the institute has made considerable progress in identifying several traits and their genetic basis, which can be used to evolve climate-ready cultivars that are suited to the edaphic, climatic and management practices fitting in the dryland agriculture context. New designs and prototypes of implements for small farm mechanization were also developed and are being tested for efficient energy use and intercultural operations.

ICAR-CRIDA recognizes the importance of basic research which addresses fundamental questions and is the basis for the generation of new technologies and methodologies. In this respect, water stress tolerance mechanisms in maize stable Quantitative Trait Locis (QTLs) were identified for various drought-tolerant traits.

Various programmes like International Women's Day, Mahila Kisan Divas and events like Poshan Vatika were conducted by the institute for women in agriculture. During the year, 15 scientists, 5 technical and 2 finance staff participated in various training programmes as a part of human resource development. The scientists of the institute participated in about 100 different Conferences, Meetings, Workshops, Seminars and Symposia during this year.

Scientists of ICAR-CRIDA continued the tradition of excellence with fifteen scientists receiving awards, fellowships and recognitions from national academies, professional societies and other institutions. The institute's scientists published more than 60 research articles in international and national peer-reviewed journals and several books, bulletins, book chapters, popular articles, e-publications and participated in radio and television programmes. ICAR-CRIDA continues to work in collaboration with Ministries and Departments of the Government of India, State Governments, State Agricultural Universities, Non-Governmental Organizations and Private Industry for providing technological solutions to dryland agriculture in the country. I place on record my gratitude to the Indian Council of Agricultural Research for its continued support and guidance. I appreciate the work put in by the annual report committee for bringing out this report.

Hyderabad
March 2022

(Vinod Kumar Singh)
Director

प्रस्तावना

वर्ष 2021 के लिए भाकृअनुप-क्रीडा की वार्षिक रिपोर्ट प्रस्तुत करना मेरे लिए वास्तव में एक सम्मान और सौभाग्य की बात है। इस वर्ष के दौरान भाकृअनुप-क्रीडा ने जलवायु परिवर्तन और वर्षा आधारित कृषि से संबंधित अनुसंधान और प्रौद्योगिकी विकास में महत्वपूर्ण प्रगति की है। देश के बारानी क्षेत्रों में कृषि से संबंधित जलवायु खतरों से निपटने के लिए प्रभावी रणनीतियों को सफलतापूर्वक तैयार करने में देश के वैज्ञानिक संस्थानों में भाकृअनुप-क्रीडा सबसे आगे है। यह वार्षिक रिपोर्ट अनुसंधान, प्रौद्योगिकी विकास और अन्य गतिविधियों की प्रमुख उपलब्धियों का विवरण देती है।

संस्थान ने बारानी क्षेत्रों के किसानों के लिए उपयुक्त प्रौद्योगिकियों की सिफारिशों सहित बारानी क्षेत्रों के फसल प्रणाली अनुसंधान में विशेष ध्यान दिया है। जल संरक्षण के उपायों के क्षेत्र में, मक्का की फसलों में संशोधित कूंड प्रणालियों सहित उत्थित क्यारी प्रौद्योगिकियों को अपनाया है, जो मृदा नमी के संरक्षण में प्रभावी हैं। संस्थान की ओर से वर्षाजल संरक्षण एवं संसाधन लक्षण/वर्गीकरण पर किए गए अनुसंधान, उन्नत एवं अपनाने योग्य प्रक्रियाओं के पैकेज की ओर अग्रसर करते हैं, जो देश के बारानी क्षेत्रों के किसानों को सीधे लाभ पहुंचा सकते हैं। हम देश के 648 जिलों के लिए जिला आधारित आकस्मिक योजनाओं के विकास और सात महत्वपूर्ण वर्षा आधारित फसलों के लिए जिला-स्तरीय उपज दक्षता मानचित्रों के विकास में सबसे आगे हैं।

वैकल्पिक भूमि उपयोग एवं पारिस्थितिक संधारणीय कृषि में, हमने बड़े पैमाने पर दक्षिणी तेलंगाना के बारानी क्षेत्रों में बांस की खेती और उपयुक्त प्रजातियों को बढ़ावा देने तथा उन्हें अपनाने के लिए दक्षिणी तेलंगाना के बारानी क्षेत्रों के लिए दक्षिणी तेलंगाना क्षेत्र के लिए उपयुक्त बांस प्रजातियों के मूल्यांकन के साथ अभिनव कदम उठाए हैं। हमने मक्का में फॉल आर्मी वर्म (एफएडब्ल्यू) के प्रबंधन के लिए कम लागत वाले दृष्टिकोणों का मूल्यांकन किया है, जो देश में बडे पैमाने पर फैल रहे इस कीट के नियंत्रण में प्रभावी साबित हो रहे हैं।

हमने विविध फसलों और अधिक संख्या में प्राकृतिक परभक्षियों के कारण फसल प्रणालियों में होने वाली मृदा हानि, पानी की कमी, तलछट की हानि तथा कीट और रोग की आपतनों से फसल प्रणालियों की रक्षा करते हुए अधिकतम चारा उत्पादन प्राप्त किया है।

संस्थान ने सूखा और तापमान सहनशीलता अनुसंधान में, फसलों के कई लक्षणों और उनके अनुवांशिक आधार की पहचान करने में काफी प्रगति की है, जिसका उपयोग जलवायु-अनुकूल किस्मों को विकसित करने के लिए किया जा सकता है जो बारानी कृषि संदर्भ में उपयुक्त मृदीय, जलवायु और प्रबंधन प्रथाओं के अनुकूल हों। छोटे कृषि यंत्रीकरण के लिए उपकरणों के कई नए डिजाइन और प्रोटोटाइप विकसित किए गए तथा उन्नत ऊर्जा उपयोग और अंत:सस्यकर्षण प्राचलों के लिए और अधिक परीक्षण किए जा रहे हैं।

भाकृअनुप-क्रीडा बुनियादी अनुसंधान के महत्व को पहचानता है, जो मौलिक प्रश्नों को संबोधित करता है और प्रौद्योगिकी के निर्माण का आधार भी है। इस संबंध में, विभिन्न सूखा-सहिष्णु जांचों के लिए मक्का स्थिर क्वांटिटेटिव ट्रैट लोकिस (क्यूटीएल) में जल तनाव सहिष्णुता प्रक्रिया की पहचान की गई।

कृषि में महिलाओं के लिए संस्थान द्वारा अनेक कार्यक्रमों, जैसे कि अंतर्राष्ट्रीय महिला दिवस, महिला किसान दिवस एवं पोषण वाटिका जैसी गतिविधियों का आयोजन किया गया। वर्ष के दौरान, मानव विकास कार्यक्रम के भाग के रूप में 15 वैज्ञानिक, 5 तकनीकी एवं 2 वित्तीय कर्मचारियों ने विभिन्न प्रशिक्षण कार्यक्रमों में भाग लिया। इस वर्ष के दौरान संस्थान के वैज्ञानिकों ने लगभग 100 सम्मेलनों, बैठकों, कार्यशालाओं, संगोष्ठियों एवं परिसंवादों में भाग लिया।

भाकृअनुप-क्रीडा के वैज्ञानिकों ने राष्ट्रीय अकादमियों, वृत्तिक सोसाइटियों और अन्य संस्थानों से पुरस्कार, अध्येतावृत्ति और मान्यता प्राप्त करने वाले पंद्रह वैज्ञानिकों के साथ उत्कृष्टता की परंपरा को बनाए रखा। संस्थान के वैज्ञानिकों ने अंतर्राष्ट्रीय और अभिजात समीक्षित पत्रिकाओं में 60 से अधिक शोध लेख प्रकाशित किए और कई किताबें, बुलेटिन, पुस्तक अध्याय, लोकप्रिय लेख, ई-प्रकाशन और रेडियो और टेलीविजन कार्यक्रमों में भाग लिया। भाकृअनुप-क्रीडा देश में बारानी कृषि के लिए तकनीकी समस्याओं के समाधान के लिए भारत सरकार के मंत्रालयों और विभागों, राज्य सरकारों, राज्य कृषि विश्वविद्यालयों, गैर-सरकारी संगठनों और निजी उद्योग के सहयोग से निरंतर प्रयासरत है। इस संस्थान को भारतीय कृषि अनुसंधान परिषद की ओर से निरंतर समर्थन और मार्गदर्शन प्रदान करने के लिए मैं आभार व्यक्त करता हूं। मैं इस रिपोर्ट को प्रकाशित करने के लिए वार्षिक रिपोर्ट समिति द्वारा किए गए कार्य की भी सराहना करता हूं।

हैदराबाद
मार्च, 2022

(विनोद कुमार सिंह)
निदेशक

कार्यकारी सारांश

वर्ष 2021 के दौरान, संस्थान द्वारा राष्ट्रीय जलवायु समुत्थान कृषि में नवप्रवर्तन (निक्रा) एवं बाह्य वित्त पोषित परियोजनाओं के अंतर्गत अनेकानेक अनुसंधान कार्य किए गए हैं। इसके अलावा कई विस्तृत (आउटरीच) कार्यक्रम जैसे कि किसान प्रथम कार्यक्रम (एफएफपी), अनुसूचित जाति उप कार्यक्रम (एससीएसपी) एवं तेलंगाना के रंगा रेड्डी जिले में क्रीडा-कृषि विज्ञान केंद्र की गतिविधियों का भी आयोजन किया गया है।

संसाधन लक्षण

- जलवायु, मृदा एवं सिंचित क्षेत्र प्राचलों के आधार पर सात मुख्य वर्षा आधारित फसलों के लिए जिलावार पैदावार दक्षता मानचित्रों का विकास किया गया। 85 जिलों (10000 हेक्टेयर से अधिक वाले जिले) में से 14 कपास उगाने वाले जिलों की पैदावार दक्षता 50 प्रतिशत से भी कम पाई गई, जो यह सूचित करती हैं कि इन जिलों में कपास की पैदावार को दोगुना करने की संभावना है।
- पैदावार अंतराल निर्णायक सहायक प्रणाली (डीएसएस) के उन्नत रुपांतर (वी2) को http://www.icar-crida.res.in:8129/ पर उपलब्ध कराया गया है। यह पैदावार अंतराल निर्णायक सहायक प्रणाली (डीएसएस) उच्च उपज देने वाली किस्मों (एचवाईवी) और उर्वरक पोषक तत्वों के उपयोग की सीमा के अलावा लक्षित जिले की कम उपज दक्षता के लिए जिम्मेदार कारकों को खोजने के लिए प्राकृतिक संसाधनों और सामाजिक-आर्थिक विशेषताओं पर आंकड़े प्रदान करता है।
- देश 648 जिलों के लिए जिला आधारित आकस्मिक योजनाएं (डीएसीपी) तैयार की गई है और इन्हें भाकृअनुप तथा कृषि सहकारिता विभाग (डीएसी) की वेबसाइटों (http://agricoop.nic.in/acp.html, http://www.icar-crida.res.in/) पर उपलब्ध करनोपरांत सभी राज्य कृषि विश्वविद्यालयों को परिचालित कर दिया गया।
- खरीफ 2021 की साप्ताहिक वर्षा के आधार पर जिला स्तर पर भूजल पुनर्भरण की संभावना का गुणात्मक अनुमान लगाया गया। जब भी 65 प्रतिशत से अधिक सप्ताह में, कम वर्षा होती है या संचयी आधार पर 80 प्रतिशत से अधिक सप्ताह में, कम वर्षा होती है तो भूजल पुनर्भरण की संभावना बहुत कम होती है।

वर्षा जल प्रबंधन

- 695 जिलों में वर्षा के निष्क्रमण, शुष्क दौर और मौसम के दौरान अधिकतम शुष्क दौर के लिए मानसून के मौसम की निगरानी की गई। एक सौ बासठ (162) जिलों में वर्षा सामान्य से भी 75 प्रतिशत कम हुई। 1000 मिमी से अधिक वर्षा वाले क्षेत्र के लगभग 30 प्रतिशत जिलों में मौसम के दौरान कम वर्षा हुई।
- वर्षा आधारित पारिस्थितिक प्रणालियों के लिए कृषि तालाबों के प्रदर्शन और इसके निर्माण के लिए लगने वाले व्यव का अध्ययन किया गया। आंध्र प्रदेश में न्यूनतम वर्षा वाले क्षेत्र (रायलसीमा) में सीमेंट + मिट्टी की परत (6:1) के साथ कृषि तालाब प्रभावी पाया गया, उच्च घनत्व पॉलीथीन (एचडीपीई) (250 माइक्रोन) शीट परत वाले कृषि तालाब पूर्वी शुष्क क्षेत्र में उपयोगी पाए गए। एचडीपीई (500 माइक्रोन) शीट परत वाले कृषि तालाब राजस्थान में अर्ध-शुष्क काली मृदाओं सहित दक्षिणी क्षेत्र में प्रभावी पाए गए।

फसल एवं फसल प्रणालियां

- 22 कुलथी जीनरूपों में पैदावार एवं शरीर-क्रियात्मक लक्षणों का मूल्यांकन किया गया। जीनरूप सीआरएचजी-22 ने अधिकतम पैदावार दर्ज हुई एवं सीआरएचजी-4 ने न्यूनतम वितान तापमान एवं अधिकतम एसपीएडी मूल्य दर्ज किया। तीन विमोचित किस्मों में एथिल मीथेनसल्फोनेट (ईएमएस) का उपयोग कर उत्परिवर्तन किया गया और एम1 पीढ़ी की एकल पादप आधार पर कटाई की गई। कुलथी में 9 एफ1 और 12 एफ2 पीढ़ियों का विकास किया गया। इस साल लगभग 200 किलोग्राम मूल बीज का उत्पादन किया गया।
- मक्का में फॉल आर्मी वार्म (एफएडब्ल्यू), स्पोडोप्टेरा फ्रुगिपरडा के प्रबंधन के लिए कम लागत दृष्टिकोणों के मूल्यांकन ने यह स्पष्ट किया कि रसायन एवं एकीकृत उपचारों में औसत आपतन लारवा संख्या कम थी और मक्का की एकल फसल की तुलना में मक्का+लोबिया अंतर-फसल प्रणाली में यह संख्या अधिक देखी गई।
- पादप वृद्धि एवं फसल-क्रियात्मक प्राचलों के साथ-साथ मृदा सूक्ष्मजीवी पर नमी दबाव के विभिन्न स्तरों के मूल्यांकन के लिए किए गए एक प्रयोग में यह पाया गया कि मृदा में नमी का स्तर 20.6 प्रतिशत से घटकर 4.9 प्रतिशत होने के कारण फॉस्फोरस घुलनशील बैक्टीरिया, मुक्त रहने वाले नत्रजन-फिक्सिंग बैक्टीरिया और स्यूडोमोनास एसपीपी की संख्या में कमी आई है।
- फसल प्रणाली पर आधारित संधारणीय चारा की पहचान के लिए किए गए एक अध्ययन में ज्वार+अरहर/हेडगे ल्यूसेरने से 69445 किलोग्राम प्रति हेक्टेयर की अधिकतम प्रणाली उत्पादकता पाई गई, इसके बाद अरंड+हेडगे ल्यूसेरने (62762 किलोग्राम प्रति हेक्टेयर) का स्थान था। इन प्रणालियों ने बिना किसी अतिरिक्त सिंचाई के कम से कम 8-9 महीनों के लिए हरा चारा प्रदान किया है।
- सूखा सहीष्णुता के लिए वर्षा आधारित परिस्थितियों के अंतर्गत मक्का की सत्रह संकरों एवं चार किस्मों का मूल्याकन किया गया। एसएनजे201126/आरजेआर385, एसएनजे201126/ज़ेड10115, एचकेI7660/एसएनजे201126, ज़ेड10115/एचकेI161, एचकेआई161/एसएनजे201126, जेड10115/एचकेआई7660 पैदावार के मामले में व्यावसायिक संकरों के समान पाई गई।
- कीट पर तीन चरणों में विषयपरक मानचित्र तैयार करने के लिए स्ट्रीमलिट का उपयोग कर, उपयोगकर्ता निवेश पर आधारित स्वचालित विषयपरक

मानचित्रण तैयार करने वाला वेब टूल टीमैपजेन+ (TmapGen+) का विकास किया गया।

- क्रीडा में अंतर फसल के रूप में रागी के साथ कृषि-वानिकी पर आधारित बारह विभिन्न बहुउद्देश्यीय पेड़ प्रजातियों की स्थापना की गई, शीशम (डल्बर्गिया लैटिफोलिया) में सांतरित खाइयों से रागी (केएमआर 301) के अनाज उत्पादन में वृद्धि हुई। वर्षा आधारित लाल मृदाओं में शीशम (डल्बर्गिया लैटिफोलिया) के अंतर्गत बिना सांतरित खाइयों के एकांतर में स्टाइलोस को उगाने से अधिकतम हरा चारा का उत्पादन प्राप्त हुआ।

मृदा एवं पोषक प्रबंधन

- अरंड की फसल में, 0,2,4 एवं 6 मैगा ग्राम प्रति हेक्टेयर की दर से मृदा में वर्मीकंपोस्ट एवं गिरीपुष्पा (ग्लैरीसिड़िया) की कर्तनों का उपयोग किया गया। 40 सेंटीमीटर की गहराई तक मृदाओं के कार्बन पृथक्करण की क्षमता को, <20 माइक्रोन मिट्टी के अंश में जैविक कार्बन (ओसी) के मापे हुए मूल्यों का उपयोग करके गणना की गई, जो देशी वन भूमि उपयोग प्रणाली में 5.73 किलोग्राम प्रति हेक्टेयर से लेकर फसल में 7.72 किलोग्राम प्रति मीटर तक पाई गई।
- संरक्षण कृषि एवं नत्रजन प्रबंधन प्रक्रियाओं पर मक्का-अरहर फसल चक्रण ने यह स्पष्ट किया कि पारंपरिक कर्षण की तुलना में कर्षण रहित एवं कम कर्षण से करीब 24.1 एवं 12.8 प्रतिशत अधिक अरहर बीज पैदावार दर्ज हुआ। विभिन्न समुच्चय आकार के अंशों में, पारंपरिक जुताई की तुलना में क्रमशः 12.2-22.9 और 5.6-10.6 प्रतिशत कुल कार्बन की वृद्धि, जुताई रहित और कम जुताई में देखी गई।
- मक्का फसल पर किए गए प्रयोगों ने स्पष्ट किया कि नियंत्रण की तुलना में जियोलाइट प्रयोग ने पादप पोषकतत्व मात्रा एवं पोषकतत्व उद्ग्रहण में वृद्धि की। 120 किलोग्राम प्रति हेक्टेयर की दर से नत्रजन के एकल प्रयोग की तुलना में 4 एवं 8 टन प्रति हेक्टेयर की दर से जियोलाइट और 120 किलोग्राम प्रति हेक्टेयर की दर से नत्रजन के साथ प्रयोग से नत्रजन का उद्ग्रहण में क्रमश: 46.2 एवं 57.9 प्रतिशत की वृद्धि हुई है।
- ज्वार-उड़द की फसल के चक्रण में ज्वार के अनाज पैदावार में फसल प्रतिधारण के साथ काफी अधिक देखा गया। उच्च फसल अवशेष प्रतिधारण के साथ उपचार से 27.5 प्रतिशत अधिक ज्वार अनाज की उपज और 24 प्रतिशत अधिक भूसा की पैदावार बिना अवशेष उपचार की तुलना में दर्ज की गई।
- बाजरा-अरहर (एवं अवशेष उर्वरक पर कुलथी) आधारित प्रणाली से शून्य कर्षण एवं पारंपरिक कर्षण की तुलना में न्यूनतम कर्षण (2361 किलोग्राम प्रति हेक्टेयर) में बाजरा अनाज की पैदावार दर्ज की गई। इसी प्रकार, अन्य सिफारिश किए गए उर्वरकों की मात्रा की तुलना में 125 प्रतिशत सिफारिश किए गए उर्वरकों (2348 किलोग्राम प्रति हेक्टेयर) के प्रयोग से अधिक उपज पाई गई। कपास-अरहर प्रणाली, के 5 वर्षों (2016-2020) के एकत्रित आंकड़ों ने स्पष्ट किया कि शून्य कर्षण की तुलना में 125 प्रतिशत सिफारिश किए गए उर्वरकों की मात्रा सहित न्यूनतम कर्षण से महत्वपूर्ण रूप से समतुल्य अधिक कपास की पैदावार दर्ज की गई थी।
- अरहर+सेटारिआ अंतरफसल प्रणाली के परिणामों ने स्पष्ट किया कि पारंपरिक एवं कम कर्षण की तुलना में शून्य कर्षण से क्रमश: 20 एवं 18 प्रतिशत के समतुल्य अधिक अरहर की पैदावार दर्ज की गई। बिना अवशेष प्रयोग की तुलना में 10 एवं 30 सेंटीमीटर की ऊंचाई तक अवशेष प्रयोग से 55 एवं 54 प्रतिशत अधिक उपज दर्ज की।
- मक्का फसल के परिणामों ने स्पष्ट किया कि नमी संरक्षण उपचार रहित पारंपरिक कर्षण की तुलना में स्थाई क्यारी एवं कूंड, स्थाई संरक्षण कूंड द्वारा स्व-स्थानी नमी संरक्षण के एकीकरण की प्रक्रियाओं से क्रमश: 19 एवं 10 प्रतिशत अधिक मक्का पैदावार दर्ज की। खरपतवार नियंत्रण उपचारों में, अन्य खरपतवार प्रबंधन प्रक्रियाओं की तुलना में खरपतवारों के निकलने से पहले और बाद में शाकनाशियों के प्रयोग से अधिक उपज दर्ज किया। पारंपरिक कर्षण की तुलना में शून्य कर्षण में गैर खरपतवार उपचार से फसल की पैदावार में कमी आई।

पशुधन प्रबंधन

- उत्थित तापमान, उत्थित कार्बन डाइआक्साइड एवं तापमान युक्त पर्यावरणीय परिस्थितियों में क्रूड प्रोटीन (सीपी) एवं पाचनयोग्य ऊर्जा, चयापचय ऊर्जा (डीई / एमई) के मामले में मक्का चारे की पोषक मूल्यों में कमी आएगी।
- गैर-नेल्लोर भेड़ों की तुलना में नेल्लोर भेड़ को 9 सप्ताह तक खिलाने के लिए उपयोग किए जाने वाले कुल मिश्रित राशन (टीएमआर) का कुल वजन के 30 प्रतिशत की दर से खिलाने से शरीर के वजन में सुधार हुआ। इससे पता चलता है कि इमली का खोल, जो खेत में अनुपयोगी है, का वैज्ञानिक रूप से स्वदेशी भेड़ों में बेहतर विकास दर के लिए उपयोग किया जा सकता है।

ऊर्जा प्रबंधन

- उत्थित क्यारी रोपण प्रणाली में प्रचालन करने के लिए ऑटोनोमस प्लेटफॉम की अभिकल्पना की गई, खेत में सभी भू-भागीय परिस्थितियों में काम करने के लिए बहुमुमखी संरचना की आवश्यकता होती है। इसके लिए, चार पहियों के साथ एक प्लेटफॉम तैयार किया गया, जो कि दो कूंडों के बीच में चलेंगे और फ्रेम के नीचे क्यारी आ जाएगा, ताकि फसलो को नुकसान से बचाया जा सके।
- फार्म मशीनरी रिसर्च वर्कशॉप (एफएमआरटब्ल्यू), क्रीडा में छोटी और झाड़ीदार फसलों की कटाई के लिए रीपर विकसित किया गया। मूंग की फसल पर कटाई तंत्र का प्रारंभिक परीक्षण किया गया। कटाई के समय मूंग फसल की औसत पौध घनत्व और ऊंचाई 35-42 पौधे प्रति वर्ग मीटर और 20-30 सेमी के बीच होती है। यह देखा गया कि विकसित तंत्र ने बेहतर कटाई दक्षता के साथ फसल के तनों को बहुत आसानी से काट दिया।
- खेत में सौर उर्जा एवं बैटरी से चलने वाले वीडर का परीक्षण किया गया। मशीन का निष्पादन (i) मृदा नमी (ii) मृदा प्रकार (iii) खरपतवार का घनत्व (iv) प्रचालन गति के आधार पर अलग-अलग था। पूरी तरह से चार्ज बैटरी से प्रचालन की गति 0.3 मीटर प्रति सेकेंड पाई गई। गैर-अनुकूल परिस्थितियों में 51-64 प्रतिशत की तुलना में अच्छी प्रचालन स्थितियों में मशीन ने 84-92 प्रतिशत निराई दर्शाई।
- एक खरपतवार पुष्पक्रम श्रेडिंग हाइड्रोलिक प्रणाली संचालित उपकरण विकसित किया और इसका प्रदर्शन संतोषजनक पाया गया। हाइड्रोलिक मोटर द्वारा संचालित 75 सेमी रोटरी शाफ्ट और एल-एंगल सपोर्ट स्ट्रक्चर के साथ अवतल से बनी खरपतवार पुष्पक्रम श्रेडिंग रोटरी मशीन शाफ्ट को पीछे से कवर करती है।

सामाजिक आर्थिक अध्ययन एवं प्रौद्योगिकी का हस्तांतरण

- किसान प्रथम नामक परियोजना के हस्तक्षेपों के अंतर्गत तेलंगाना विकाराबाद के पूडूर मंडल के पांच गांव (गंगुपल्ली, राकमचर्ला, देवनोनीगुडा, मेडिकोंडा एवं पुडुगुर्ती) के 400 कृषक परिवारों शामिल किया गया। फसल मौसम के दौरान नौ विभिन्न प्रकार के नौ आवश्यकता आधारित उपकरणों की पहचान की गई और उनकी खरीदी की गई, इन्हें किसानों के लाभार्थ प्रदर्शित किया गया। पशु-पालन आधारित हस्तक्षेपों में घरेलु पौल्ट्री किस्मों का प्रोत्साहन, उन्नत चारा उत्पादन एवं प्रबंधन में सुधार, बकरियों को नमक चटाना, जुगाली करने वाले पशुओं के लिए खनिज मिश्रण शामिल हैं।
- कोरोमंडल फर्टिलाइजर्स लिमिटेड (सीएफएल) और जलग्रहण सहायक सेवाएं और गतिविधियों का नेटवर्क (वासन) की तुलना में राज्य विकास एजेंसियों के विस्तार प्रयासों को कम प्रभावी पाया गया। अध्ययन की गई तीनों एजेंसियों में विस्तार कर्मियों द्वारा अनुसरण किए जाने वाले प्रदर्शन और बैठकें अत्यधिक प्रभावी प्रसार पद्धति थी।
- नेल्लोर भेड़ को 9 सप्ताह तक खिलाने के लिए उपयोग किए जाने वाले कुल मिश्रित राशन (टीएमआर) के पौष्टीकरण वजन के 30 प्रतिशत की दर से इमली का खोल खिलाने से शरीर के वजन में महत्वपूर्ण ($p<0.05$) सुधार हुआ। पौष्टीकरण न देने वाले भेड़ों की वजन की तुलना पौष्टीकरण देने वाले भेड़ों का वजन एडीजी 53 ग्राम प्रति दिन की तुलना में यह 65 ग्राम प्रति दिन था। इससे पता चलता है कि इमली का खोल, जो खेत में अनुपयोगी है, का वैज्ञानिक रूप से स्वदेशी भेड़ों में बेहतर विकास दर के लिए उपयोग किया जा सकता है।
- दीर्घकालिक प्रयोगों में मूल्यांकन किए गए उपचारों/प्रक्रियाओं की संधारणीयता का मूल्याकन करने के लिए एक नया उपाय विकसित किया गया। सात महत्वपूर्ण वर्षा आधारित फसलों के लिए जिला स्तरीय उपज दक्षता मानचित्र विकसित किए गए। पैदावार अंतराल डीएसएस का उन्नत संस्करण http://www.icar-crida.res.in:8129/ पर उपलब्ध है।
- चावल, ज्वार, बाजरा, मक्का, अरहर, चना, उड़द और मूंग जैसी फसलों को शामिल कर वर्ष 1966-67 से 2017-18 के लिए बोए गए क्षेत्र, उत्पादन और पैदावार पर समय श्रृंखला आंकड़ों को शामिल करने वाला एक विभाजित जिला डेटाबेस बनाया गया।
- जिला स्तर पर वर्तमान और भविष्य की जलवायु का मूल्यांकन किया गया, जिसमें वर्ष 2030 के दशक में 24 जिलों और वर्ष 2050 में 32 जिलों में रेप्रसेंटेटिव कांसेंट्रेशन पाथवे पथ (आरसीपी 4.5) के अनुसार और आरसीपी 6.0 के अनुसार 2030 में 15 जिलों में और 2050 में 22 जिलों में जलवायु परिवर्तन देखा गया था। भविष्य में नमी की उपलब्धता में वृद्धि का संकेत देते हुए नमी सूचकांक, कुल मिलाकर बढ़ने का अनुमान है। भविष्य में जलवायु कम कठोर होने वाली है लेकिन जलवायु परिवर्तन न्यूनतम होगा।
- अंतर-में-अंतर मॉडल (डीआईडी) और स्टेपवाइज मल्टीपल लीनियर रिग्रेशन (एमएलआर) को जलवायु समुत्थान प्रौद्योगिकियों (सीआरटी) को अपनाने के प्रभाव और सूखे के दौरान कृषि आय को प्रभावित करने वाले कारकों को मापने के लिए नियोजित किया गया। किसानों ने बताया कि सूखे से फसलों से होने वाली आय में 54 प्रतिशत और पशुधन से होने वाली आय में 40 प्रतिशत की कमी आई है।

अनुसूचित जाति उप कार्यक्रम

- कृषि उपज की सुरक्षा और जैव उर्वरकों के उपयोग के बारे में किसानों के बीच दिनांक 28.01.2021 को तेलंगाना के मंचेरियल जिले के कोटपल्ली मंडल के मल्लमपेट गांव में जागरूकता कार्यक्रम आयोजित किया गया था।
- अरहर को छह गांवों के समूह में प्रस्तुत किया गया था और जून 2021 के दौरान 2000 किलोग्राम उन्नत किस्म के बीज (पीआरजी-176) वितरित किए गए और बीज भाकृअनुप-क्रीडा, कृषि विज्ञान केंद्र के बीज हब से खरीदे गए थे। पिछवाड़े में स्व-उपभोग के लिए और एक अंतरफसल के रूप में बोया गया बीज अच्छी स्थिति में पाया गया और इसे सभी किसानों द्वारा भली-भांति अपनाया गया।
- भारत के स्वतंत्रता 75 साल के आजादी का अमृत महस्तोव के हिस्से के रूप में दिनांक 18 अक्टूबर 2021 को भोगलिंगदहल्ली गांव, चिंचोली तालुआका, कालाबुरागी जिला, कर्नाटक में क्षेत्र दिवस आयोजित किया गया। इसमें भोगलिंगदहल्ली और कलाभवी गांवों के लगभग 150 किसानों ने भाग लिया।
- दिनांक 23-25 फरवरी, 2021, दिनांक 08-10 मार्च, 2021 और दिनांक 16-18 मार्च, 2021 के दौरान तीन समूहों में "सतत चावल उत्पादन प्रौद्योगिकी" पर तीन प्रशिक्षण कार्यक्रम आयोजित किए गए थे, जिससे भाकृअनुप-भारतीय चावल अनुसंधान संस्थान (आईआईआरआर), राजेंद्रनगर, हैदराबाद के मल्लमपेट और एडगट्टा गांव के 60 किसानों को लाभ हुआ।

अखिल भारतीय समन्वित बारानी कृषि अनुसंधान परियोजना

- अनंतपुरम में, अर्ध-शुष्क लाल मृदाओं में, सूक्ष्मजीव संघ2 (सी2: स्यूडोमोनास पुतिदा पी45 + बेसिलस एमिलोलिफेशियन्स बी17) एवं टीकाकरण रहित नियंत्रण को छोड अन्य उपचारों की तुलना में सूक्ष्मजीव संघ1 (सी 1: स्यूडोमोनास पुटिडा पी 7 + बैसिलस सबटिलिस बी 30) के मृदा के साथ प्रयोग से मूंगफली में महत्वपूर्ण रूप से अधिक मूंगफली की पैदावार (1595 किलोग्राम प्रति हेक्टेयर) दर्ज की गई। संघ2 सहित बीज उपचार + मृदा प्रयोग से उन्नत जैविक कार्बन (0.50 प्रतिशत) एवं उन्नत उपलब्ध नत्रजन (183 किलोग्राम प्रति हेक्टेयर) दर्ज किया गया। जबकि बीज उपचार+ संघ1 सहित मृदा प्रयोग से उन्नत मृदा उपलब्ध फासफोरस (66 किलोग्राम प्रति हेक्टेयर) दर्ज किया गया।
- जगदलपुर के उप-आर्द्र इनसेप्टीसोल मृदाओं में, सीधे बाए गए चावल क्षेत्र-मटर की मृदा उर्वरता एवं उत्पादकता पर अजैविक उर्वरकों एवं जैविक खादों पर किए गए लंबी अवधि के अध्ययन में, अन्य उपचारों की तुलना में नत्रजन फासफोरस एवं पोटाश (60:40:30 किलोग्राम नत्रजन फासफोरस एवं पोटाश प्रति हेक्टेयर) के पूरी मात्रा + 5 टन अहाता खाद + 25 किलोग्राम प्रति हेक्टेयर की दर से $ZnSO_4$ के प्रयोग से अधिक लाभ (60024/-रुपए प्रति हेक्टेयर) एवं वर्षाजल उपयोग दक्षता (3.68 किलोग्राम प्रति हेक्टेयर-मिमी) सहित महत्वपूर्ण रूप से अधिक चावल का पैदावार (4763 किलोग्राम प्रति हेक्टेयर) दर्ज किया गया। रबी के दौरान, सिफारिश किए गए नत्रजन फासफोरस एवं पोटाश की मात्रा (100 प्रतिशत नाइट्रोजन फासफोरस एवं पोटाश + 5

टन अहाता खाद + 25 किलोग्राम प्रति हेक्टेयर की दर से $ZnSO_4$) के प्रयोग से खरीफ के दौरान मटर का अधिक बीजोत्पादन (1147 किलोग्राम प्रति हेक्टेयर), शुद्ध प्रतिफल (36439/-रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (1.96) दर्ज किया गया था।

- परभनी के अर्ध-शुष्क काली मृदाओं में, सोयाबीन+अरहर(4:2) अंतरफसल प्रणाली में, कम कर्षण+शाकनाशी एवं कम कर्षण+निराई,गुडाई की तुलना में पारंपरिक कर्षण से महत्वपूर्ण रूप से सोयाबीन बीज समतुल्य पैदावार (1463 किलोग्राम प्रति हेक्टेयर), शुद्ध प्रतिफल (53284/-रुपए प्रति हेक्टेयर), बी:सी अनुपात (2.66) एवं वर्षाजल उपयोग दक्षता (2.10 किलोग्राम प्रति हेक्टेयर-मिमी) दर्ज हुई। पोषकतत्वों के स्रोतों में, अन्य पोषकतत्व स्रोतों की तुलना में सिफारिश की गई उर्वरक मात्रा (50 प्रतिशत) + वर्मीकंपोस्ट(1.5 टन प्रति हेक्टेयर) के प्रयोग से महत्वपूर्ण रूप से समतुल्य अधिक सोयाबीन बीज उत्पादन (1601 किलोग्राम प्रति हेक्टेयर), शुद्ध प्रतिफल (63097/-रुपए प्रति हेक्टेयर), बी:सी अनुपात (3.09) एवं वर्षाजल उपयोग दक्षता (2.15 किलोग्राम प्रति हेक्टेयर-मिमी) दर्ज किया गया।
- कृषि विज्ञान केंद्र कनकेर (जगदलपुर) में, कृषि तालाब में संचित वर्षाजल से क्षेत्रमटर में दो अतिरिक्त सिंचाइयों (स्प्रिंकलर) ने अधिक बीज उत्पादन दिया, लेकिन यह किसानों की प्रक्रिया (बाढ सिंचाई) (2281 किलोग्राम प्रति हेक्टेयर) के समान था। खेती की लागत किसानों के अभ्यास (24715/-रुपए प्रति हेक्टेयर) के साथ अधिक था, जबकि उच्च प्रतिफल, उच्च बी:सी अनुपात (2.97) और जल उपयोग दक्षता (4.27 किलोग्राम प्रति हेक्टेयर-मिमी) में दो पूरक सिंचाई के साथ दर्ज किया गया था।
- अक्लेरा में, सोयाबीन-अलसी प्रणाली (2214 किलोग्राम प्रति हेक्टेयर) की तुलना में सोयाबीन-चना प्रणाली ने महत्वपूर्ण रूप से अधिक सोयाबीन उत्पादकता (3450 किलोग्राम प्रति हेक्टेयर), शुद्ध प्रतिफल (77960/-रुपए प्रति हेक्टेयर) एवं बी:सी अनुपात (2.31) दर्ज किया गया। इसके बाद सोयाबीन-धनिया अनुक्रम (270 किलोग्राम प्रति हेक्टेयर) का स्थान था।
- भीलवाडा जिले (राजस्थान) के सुंदरपुरा एवं कोछरिआ गांवों में, वर्षा आधारित कृषि प्रणाली में, पारंपरिक कृषि प्रणाली की तुलना में उन्नत किस्मों का समावेश, समेकित पोषक प्रबंधन, स्व-स्थाने नमी संरक्षण, पशुओं को खनिज पोषण एवं मेंढ़ों पर चारा घास की खेती से सीमांत वर्ग के मामले में प्रणाली उत्पादकता में 22.9 प्रतिशत का सुधार हुआ एवं इसने अधिक शुद्ध प्रतिफल (77106/-रुपए प्रति हेक्टेयर) तथा रोज़गार (232 श्रम दिन प्रति वर्ष) दिया। छोटे किसानों के वर्ग में पारंपरिक कृषि प्रणाली की तुलना में इससे 31.2 प्रतिशत का सुधार हुआ एवं अधिक शुद्ध प्रतिफल 106365/-रुपए प्रति वर्ष) एवं रोजग़ार (286 श्रम दिवस प्रति वर्ष) दिया।

अखिल भारतीय समन्वित कृषिमौसम विज्ञान अनुसंधान परियोजना

- वर्ष 1971-2020 के दौरान महाराष्ट्र के विदर्भ क्षेत्र में स्थित 118 तहसीलों के लिए मान-केंडल परीक्षण का उपयोग करते हुए एक दिवसीय अत्यधिक वर्षा का रुझान विश्लेषण किया गया। परिणामों से पता चला कि वार्षिक आधार पर, दो तहसीलों (वाशिम और कोपरना गढ़चिरौली जिले में मंगरूपीर) ने महत्वपूर्ण सकारात्मक प्रवृत्ति दिखाई और 12 तहसीलों ने 75-100 मिमी की एक दिवसीय वर्षा की घटना में महत्वपूर्ण नकारात्मक प्रवृत्ति दिखाई।
- मानसून (जून-सितंबर) अवधि के दौरान मौसम संबंधी सूखे की घटनाओं में परिमाण और भिन्नता की गणना गुजरात राज्य (आनंद, भुज, जूनागढ़, नवसारी और एसके नगर) में चयनित स्थानों पर मानकीकृत वर्षा सूचकांक (एसपीआई) और मानकीकृत वर्षा वाष्पोत्सर्जन सूचकांक (एसपीईआई) जैसे सूखा सूचकांकों का उपयोग करके की गई थी। परिणामों ने संकेत दिया कि एसपीईआई या एसपीआई के उपयोग से राज्य के अधिकांश हिस्सों में सूखे की गंभीरता के मूल्यांकन में कोई उल्लेखनीय अंतर नहीं है और इसलिए गुजरात राज्य में, एसपीआई को प्राथमिकता दी जानी चाहिए क्योंकि इसमें एसपीईआई की तुलना में केवल वर्षा डेटा की आवश्यकता होती है।
- दक्षिण-पश्चिम मानसून के मौसम के दौरान, बटोटे, बनिहाल और राजौरी जिलों को छोड़कर, एल नीनो प्रकरणों के प्रभाव में जम्मू क्षेत्र के अधिकांश स्थानों में दर्ज की गई औसत वर्षा सामान्य से कम थी, जिसमें वर्षा में मामूली वृद्धि देखी गई। वर्षा में कमी कठुआ जिले में सर्वाधिक (25.1 प्रतिशत) रही।
- तीन बुवाई के वातावरण (10 जून, 25 जून और 10 जुलाई) और तीन बासमती चावल की किस्मों (पूसा-1121, एसजेआर-129, बासमती 370) के प्रभाव के बीच फसल मौसम संबंध जम्मू के छठा में आयोजित किया गया था। 10 जून को बोई गई फसल में और बासमती 370 किस्म खेती के लिए अधिकतम वर्षा उपयोग दक्षता (0.73 ग्राम प्रति MJ^{-1} वर्ग मीटर) पाया गया था। परिणामों ने यह भी संकेत दिया कि दुग्धावस्था और हार्ड डफ चरण के दौरान वर्षा का संबंध महत्वपूर्ण रूप से सकारात्मक था।
- वर्ष 2013-14 से 2019-20 के प्रायोगिक आंकड़ों का उपयोग करके वर्षा, सर्दी और वसंत ऋतु के लिए अमरूद की उपज की भविष्यवाणी करने के लिए कई समाश्रयण मॉडलों का उपयोग किया गया और इसे वर्ष 2020-21 की में हुई उपज के साथ मान्य किया गया था। बरसात के मौसम के मॉडल ने अमरूद की उपज (-13.1 प्रतिशत) को कम करके आंका, जबकि, सर्दी और वसंत के मौसम के मॉडल ने उपज को क्रमशः 8.8 और 15.5 प्रतिशत अधिक का अनुमान लगाया।
- डीएसएसएटी (वी4.7) के एसयूबीएसटीओआर (सबस्टोर)-आलू मॉड्यूल का उपयोग हिसार में आलू के लिए अनुकूलतम बुवाई की तारीख खोजने के लिए किया गया था। मॉडल अनुकरण फीनोलॉजिकल घटनाओं और कंद उपज मनाया मूल्यों के साथ संतोषजनक था और यह पाया गया कि अक्टूबर का दूसरा पखवाड़ा उपोष्ण कटिबंधीय क्षेत्र में आलू रोपण के लिए अनकूलतम है।
- लुधियाना में सीईआरईएस-गेहूं मॉडल (पीबीडब्ल्यू 343 किस्म के लिए) का उपयोग करके एक अनुकरण (सिमुलेशन) अध्ययन किया गया था और परिणामों से पता चला है कि गेहूं की उत्पादकता पर लगातार गर्मी के दबाव के हानिकारक प्रभावों को देखते हुए 15 नवंबर तक गेहूं की फसल बोवाई को रोका जा सकता है और सिफारिश किए गए नत्रजन का अतिरिक्त प्रयोग यानि 150 प्रतिशत (188 किलोग्राम प्रति हेक्टेयर) दो समान भागों में बोवाई के आरंभ में एवं बोवाई के 30 दिनों के बाद प्रयोग किया जा सकता है।

- अनंतपुर केंद्र में मौसम के मापदंडों और अरहर के चित्तीदार बेधक आपतनों के बीच सहसंबंध का अध्ययन किया गया। यह देखा गया कि वेब और लार्वा प्रति वर्ग मीटर की संख्या ने औसत तापमान और धूप के घंटों के साथ नकारात्मक सहसंबंध और सापेक्ष आर्द्रता के साथ सकारात्मक सहसंबंध दिखाया।
- कपास पर्ण खुरलिका और मौसम के तत्वों के बीच सहसंबंध अध्ययन से पता चला है कि अधिकतम तापमान, धूप के घंटे, हवा की गति और वाष्पीकरण ने पर्ण खुरलिका की आबादी को नकारात्मक रूप से प्रभावित किया है। इसी समय, सापेक्षिक आर्द्रता (महत्वपूर्ण) और वर्षा (गैर-महत्वपूर्ण) का पर्ण खुरलिकाओं की व्याप्ति पर सकारात्मक प्रभाव पड़ा।
- राजस्थान राज्य के किसानों के लाभ के लिए कृषिमौसम विज्ञान सलाहकार बुलेटिन के प्रभावी प्रसार के लिए एक्रीपाम-उदयपुर केंद्र द्वारा नया मोबाइल एप्लिकेशन ‘मेवाड़ रितु’ विकसित किया गया।
- बिहार के विभिन्न जिलों में खरीफ मौसम के दौरान लगातार दो सप्ताह तक शुष्क रहने की संभावनाओं पर काम किया गया है। विश्लेषण से पता चला है कि जुलाई और अगस्त (1-6 प्रतिशत) के दौरान लगातार दो सप्ताह के शुष्क दौर की संभावना कम है और जून (1-30 प्रतिशत) और सितंबर (0-19 प्रतिशत) के दौरान अधिक है। पश्चिमी जिलों की तुलना में, बिहार के पूर्वी जिलों में सूखे की संभावना अधिक है।

भाकृअनुप-क्रीडा में राष्ट्रीय जलवायु समुत्थान कृषि में नवप्रवर्तन परियोजना (निक्रा)

- उत्थित तापमान में अध्ययन किए गए मक्का के चार जीनरूपों ने कुल नाइट्रोजन को कम कर दिया, हालांकि उत्थित CO_2 प्रभाव जीनरूपों के साथ भिन्न था। नाइट्रोजन कटाई सूचकांक (एनएचआई) को डीएचएम-117 और डीएचएम-121 में उत्थित तापमान के अंतर्गत कम किया गया, जबकि उत्थित CO_2 के साथ इसमें सुधार हुआ था।
- उत्थित तापमान एवं कार्बन डाइऑक्साइड की परिस्थितियों के अंतर्गत मक्का चारा के पोषक मूल्य में कच्चे प्रोटीन, पाचनयोग्य ऊर्जा का अनुपात एवं गतिशील ऊर्जा में कमी आई।
- भविष्य में एस लिटुरा की पीढ़ियों की संख्या बेसलाइन से अधिक प्रतिशत वृद्धि की भविष्यवाणी बहुत पहले की गई थी, इसके बाद दूर के भविष्य और निकट भविष्य की अवधि में चार प्रतिनिधि एकाग्रता पथ परिदृश्यों में पीढ़ी के समय में कमी की भविष्यवाणी की गई थी। विरुधाचलम और तिरुपति में कम पीढ़ी के समय के साथ एस लिटुरा की अधिक संख्या में पीढ़ियों की संभावना है।
- कार्बन डाइऑक्साइड और ताप प्रवणता कक्ष में बाजरा के पौधों में उच्च तापमान पर फोटो कैमिस्ट्री की मात्रा में गिरावट देखी गई, जो फोटोसिस्टम II (पीएसII) के प्रोटीन में कनेक्टिविटी में कमी ऑक्सीजन के विघटन के कारण भी हो सकती है और आक्सीजन विकसित परिसर (ओईसी) जिसने फोटोसिस्टम II के इलेक्ट्रॉन परिवहन मार्ग (ट्रांसपोर्ट पाथवे) में इलेक्ट्रॉनों की आपूर्ति को कम कर दिया।
- मूंगफली पर स्पोडोप्टेरा लिटुरा के खिलाफ कीटनाशकों की प्रभावकारिता पर बढ़े उत्थित तापमान और उत्थित कार्बनडाइआक्साइड (CO_2) के परस्पर प्रभाव ने संकेत दिया कि कीटनाशकों की लगातार विषाक्तता में कमी का अवरोही क्रम डेल्टामेथ्रिन <क्विनालफोस <फ्लुबेंडियामाइड <एमेमेक्टिन बेंजोएट <स्पिनोसैड था और ये कीटनाशक उत्थित तापमान और उत्थित कार्बनडाइआक्साइड (CO_2) स्थितियों में कम अवधि के लिए बने रहे।
- मुक्त वायु तापमान उत्थित (एफएटीई) सुविधा पर परिवेशी परिस्थितियों के अंतर्गत यानि उत्थित तापमान (+3 डिग्री सेल्सियस), और (+3 डिग्री सेल्सियस) + ऊंचा CO_2 (550 पीपीएम) पर चार जीनरूपों अर्थात आईपीयू-06-02, पीएलयू-826, पीएसआरजे-95016 और आईपीयू-094-1 के ग्रंथियों से राइजोबियम विगलकों को अलग किया गया। विभिन्न जीनरूपों और पर्यावरणीय परिस्थितियों में ग्रंथियों के प्राचलों में भिन्नता पाई गई।
- जैविक, अजैविक एवं समेकित उत्पादन प्रणालियों के अंतर्गत विभिन्न फसलों के निष्पादन मूल्यांकन ने स्पष्ट किया कि अन्य उत्पादन प्रणालियों की तुलना में जैविक प्रबंधन के अंतर्गत सूरजमुखी (943 किलोग्राम प्रति हेक्टेयर) एवं मूंग (686 किलोग्राम प्रति हेक्टेयर) पैदावार अधिक थी। जबकि, विभिन्न उत्पादन प्रणालियों के अंतर्गत अरहर (348-375 किलोग्राम प्रति हेक्टैयर) का बीज उत्पादन समान था।
- कम एवं मध्यम चारा अवरोधों की तुलना में प्रयोग क्षेत्र पर अधिक चारा अवरोध के अंतर्गत नाइट्रस ऑक्साइड (N_2O) का उत्सर्जन महत्वपूर्ण रूप से कम था। वर्तमान अध्ययन से औसत अनुमानित उत्सर्जन कारक जलवायु परिवर्तन पर अंतर सरकारी पैनल (आईपीसीसी) (1996) मवेशियों के लिए आवश्यकता से कम था।
- वर्ष **1966-67** से **2017-18** के लिए बोए गए क्षेत्र, उत्पादन और उपज पर समय श्रृंखला डेटा को कवर करने वाला एक विभाजित जिला डेटाबेस बनाया गया था, जिसमें फसलें जैसे चावल, ज्वार, बाजरा, मक्का, अरहर, चना, उड़द और मूंग शामिल थे। **24** जिलों में वर्ष **2030** के दशक और में **32** जिलों में वर्ष **2050** के दशक में प्रतिनिधि एकाग्रता पथ **4.5** के अनुसार और **15** जिलों में वर्ष **2030** में और **22** जिलों में वर्ष **2050** में आरसीपी **6.0** के अनुसार जलवायु परिवर्तन देखे गए हैं।
- गहन शिक्षण-आधारित आर्टिफिशियल इंटेलिजेंस मॉडल का उपयोग करके फसल दबाव के बारे में पता लगाने के लिए क्षेत्र से तीन हजार दबावग्रस्त डिजिटल इमेजरी एकत्र किए गए थे।

प्रौद्योगिकी प्रदर्शन अवयव

- बिहार के बक्सर जिले के भितिहारा गांव में, किसानों की प्रक्रिया की तुलना में धान के लिए बांध की ऊंचाई में वृद्धि के परिणामस्वरूप अधिक जल अधिक दिनों तक भंडारण किया जा सका जिससे शुष्क अवधि के दौरान नमी के दबाव को कम करने में मदद मिली और इसके परिणामस्वरूप 12 प्रतिशत तक अतिरिक्त धान की पैदावार हुई। उसी गांव में किसानों की प्रक्रिया की तुलना में हैप्पी सीडर से गेहूं की बुवाई करने से पैदावार में 19 फीसदी तक की बढ़ोतरी हुई है।
- राजस्थान के भरतपुर जिले के सितारा, सेनहटी और मुकंदपुरा गाँवों में 82 ट्यूबवेल पुनर्भरण संरचनाओं के निर्माण से बोरवेलों के भूजल स्तर में 15 से 20 फीट तक बढ़ाने में मदद मिली, जिसके परिणामस्वरूप रबी फसलों के लिए अतिरिक्त 2 सिंचाई दिया जा सकी। किसानों की प्रक्रिया की तुलना में इस तकनीक कारण गेहूं में 1400 किलो ग्राम प्रति हेक्टेयर, जौ में 600 किलो ग्राम प्रति हेक्टेयर और सरसों की फसल में 530 किलो ग्राम प्रति हेक्टेयर की पैदावार में सुधार करने में मदद मिली।

- राजस्थान के झुंझुनू जिले के चकवास गांव में गेहूं में मिनी स्प्रिंकलर और सब्जियों में ड्रिप सिंचाई से सिंचाई की सतही विधि की तुलना में 50 प्रतिशत तक पानी की बचत हुई और गेहूं में 18 प्रतिशत और ककड़ी की फसलों में 19 प्रतिशत की अतिरिक्त उपज प्राप्त करने में मदद मिली। इसके अलावा गेहूं की फसल से 16131/- रुपये प्रति हेक्टेयर एवं ककडी की फसलों से 23000/- रुपए प्रति हेक्टेयर का अतिरिक्त शुद्ध प्रतिफल प्राप्त हुआ।
- मध्य प्रदेश के रतलाम जिले के अंबा गांव में चौडी क्यारी कूंड और मेढ और कूंड के साथ सोयाबीन की बुवाई से किसानों की प्रक्रिया तुलना में क्रमश: 440 और 420 किग्रा प्रति हेक्टेयर की अतिरिक्त उत्पादकता प्राप्त हुई और 13440/-रुपए प्रति हेक्टेयर अतिरिक्त शुद्ध प्रतिफल प्राप्त करने में सहायता मिली।
- कर्नाटक के तुमकुर जिले के डी. नागेनहल्ली गांव में, खाई व मेंढ तकनीक ने किसानों की प्रक्रिया की तुलना में 360 किलोग्राम प्रति हेक्टेयर रागी का अतिरिक्त पैदावार प्राप्त करने में मदद की, जिससे 9540/- रुपए प्रति हेक्टेयर का अतिरिक्त शुद्ध प्रतिफल प्राप्त हुआ।
- बिहार के बक्सर जिले के भितिहारा गांव में, स्थानीय किस्मों की तुलना कम अवधि के सूखे से बचने वाले चावल (स्वर्ण श्रेया) और चना (बीजीएम - 547) से क्रमश: 830 किलोग्राम प्रति हेक्टेयर और 330 किलो ग्राम प्रति हेक्टेयर की अतिरिक्त उपज प्राप्त हुआ और इसके अलावा क्रमश: 12913/-रुपए और 13950/-रुपए प्रति हेक्टेयर का अतिरिक्त शुद्ध प्रतिफल प्राप्त हुआ।
- पश्चिम बंगाल के कूचबिहार जिले के खगरीबाड़ी गांव में, स्थानीय किस्मों की तुलना स्वर्ण उप-1 और गोल्ल विधान 1 ने क्रमशः 1005 और 800 किलोग्राम प्रति हेक्टेयर तक उपज में सुधार करने में योगदान दिया और इसके परिणामस्वरूप क्रमश: 17997/- रुपये एवं 15182/- रुपए का अतिरिक्त शुद्ध प्रतिफल प्रात हुआ।
- झारखंड के गोड्डा जिले के भेलवा गांव में मूंगफली (के-6), चावल (सहभागी और एमटीयू-7029) की उन्नत तनाव सहिष्णु किस्मों का प्रदर्शन किया गया, जिससे स्थानीय किस्मों की तुलना में 4 से 35 प्रतिशत अतिरिक्त उपज प्राप्त करने में मदद मिली। किसानों की प्रक्रिया की तुलना में 7150/- रुपये से 18400/- रुपए तक का अतिरिक्त शुद्ध प्रतिफल प्राप्त हुआ।
- आंध्र प्रदेश के कर्नूल जिले के यागंटीपल्ले गांव में, स्थानीय किस्मों की तुलना में अरहर (आशा) और चना (एनबीईजी-49) फसलों की सूखा सहिष्णु किस्मों से नमी की कमी के प्रभाव को कम करने में मदद मिली और क्रमश: 14 और 15 प्रतिशत अतिरिक्त उपज प्राप्त हुआ। इसके अलावा किसानों की प्रक्रिया की तुलना में क्रमश: 5870/- रुपए एवं 10560/- रुपए अतिरिक्त शुद्ध प्रतिफल प्राप्त हुआ।
- छत्तीसगढ़ के भाटापारा जिले के गुडेलिया गांव में 25 किसानों के लिए कुक्कुट (कड़कनाथ) और बत्तख (खाकी कैंपबेल) की नस्लों का प्रदर्शन किया गया, जिसके परिणामस्वरूप बत्तख और मुर्गी दोनों की मृत्यु दर में 30 प्रतिशत तक की कमी आई और स्थानीय नस्लों की तुलना में शरीर का अतिरिक्त वजन 1.5 और 0.95 प्रति पक्षी बढ़ गया और इसके अलावा क्रमश: मुर्गी और बत्तख में प्रति वर्ष अंडे के उत्पादन की संख्या में 35 और 103 प्रति पक्षी की वृद्धि हुई।
- महाराष्ट्र के अहमदनगर के पिंपरी लोकाई गांव में, साइलेज तैयारी, मल्टी कट चारा ज्वार (सीओएफएस-29) ने प्रति गाय की दर से दूध की पैदावार में 1.4 लीटर प्रतिदिन प्रति गाय की वृद्धि की और साइलेज न खिलाने वाले गायों की तुलना में 42/- रुपए प्रतिदिन प्रति गाय लाभ प्राप्त हुआ।

कृषि विज्ञान केंद्र

- तीन हज़ार दो किसानों, कृषि महिलाओं, ग्रामीण युवाओं और क्षेत्र स्तरीय प्रसार कार्यकर्ताओं के लिए उन्नत प्रौद्योगिकियों के विभिन्न पहलुओं पर आवश्यकता आधारित और कौशल उन्मुख पर पैंसठ प्रशिक्षण कार्यक्रम आयोजित किए गए।
- बीज हब परियोजना के अंतर्गत 2021-22 के दौरान, पीआरजी -176 किस्म के 107 क्विंटल अरहर फाउंडेशन बीज और सीआरएचजी-22 किस्म के 1.5 क्विंटल कुलथी बीज किसानों / हयातनगर अनुसंधान फार्म (एचआरएफ) से खरीदे गए और इन्हें बीज हब सुविधा में संसाधित किए गए। रबी 2021-22 में किसानों से डब्ल्यूजीजी किस्म के लगभग 10-15 क्विंटल प्रमाणित मूंग बीज की खरीद की जाएगी।
- राष्ट्रीय पादप स्वास्थ्य प्रबंधन संस्थान (एनआईपीएचएम), हैदराबाद ने दिनांक 28-30 अप्रैल, 2021 के दौरान ऑनलाइन माध्यम से फ्रूट फ्लाई सरवाईलेंस एंड मैनेजमेंट पर प्रायोजित सहयोगात्मक प्रशिक्षण कार्यक्रम आयोजित किया गया था जिसमें प्रसार क्षेत्र में काम करने वाले प्रशिक्षुओं का चयन (61 सदस्य) आंध्र प्रदेश और तेलंगाना से किया गया था।
- दिनांक 1 सितंबर, 2021 को हयातनगर अनुसंधान फार्म, क्रीडा में आज़ादी का अमृत महोत्सव और बागवानी ब्लॉक वृक्षारोपण कार्यक्रम आयोजित किया गया। इन फसलों के लिए आवश्यक मृदा एवं जलवायु आश्यकताओं को ध्यान रखते हुए 10 एकड़ के क्षेत्र में आम (मल्लिका, केसर, दशेरी, बनेशान), अमरूद (इलाहाबाद सफेदा, लखनऊ-49), ड्रैगन फ्रूट (गुलाबी गूदा), नींबू (बालाजी), सीताफल (बालानगर), सपोटा (कालीपट्टी, पाला), अनार (भगवा), कटहल (वरिका) जैसी उन्नत किस्मों के साथ व्यावसायिक रूप से उगाए जाने वाले फल के पेडों का रोपण किया गया।

मानव संसाधन विकास

- वर्ष के दौरान, मानव संसाधन विकास के भाग के रूप में 15 वैज्ञानिक, 5 तकनीकी एवं 2 वित्तीय कर्मचारियों ने विभिन्न प्रशिक्षण कार्यक्रमों में भाग लिया।
- इस वर्ष के दौरान संस्थान के वैज्ञानिकों ने करीब 100 विभिन्न सम्मेलनों, बैठकों, कार्यशालों, संगोष्ठियों एवं परिसंवादों में भाग लिया।

पुरस्कार एवं मान्यताएं

पंद्रह वैज्ञानिकों ने राष्ट्रीय अकादमियों, राष्ट्रीय एवं अंतर्राष्ट्रीय वृत्तिक सोसाइटियों और अन्य संस्थानों से पुरस्कार, अध्येतावृत्ति और मान्यताएं प्राप्त की। दस वैज्ञानिकों ने विभिन्न भारतीय एवं अंतर्राष्ट्रीय पत्रिकाओं में संपादकों के रूप में अपना योगदान दिया।

प्रकाशन/सॉफ्टवेअर/वेबसाइट/डेटाबेस

इस वर्ष संस्थान के वैज्ञानिकों द्वारा साठ से अधिक शोध लेख अंतर्राष्ट्रीय, राष्ट्रीय समकक्ष-समीक्षित पत्रिकाओं में एवं 50 से अधिक अन्य प्रकाशन प्रकाशित किए गए। इसके अलावा संस्थान के वैज्ञानिकों का योगदान कई नीति पत्रों, लोकप्रिय लेखों, सम्मेलनों में प्रस्तुतियों के रूप में भी सामने आया है।

Executive Summary

Executive Summary

During the year 2021, various experiments were conducted under Institute projects, National Innovations in Climate Resilient Agriculture (NICRA) and externally funded projects. There were outreach programmes such as Farmer First Programme (FFP), Schedule Caste Sub Programme (SCSP) and CRIDA-KVK activities. The achievements of all the above activities and others are briefly highlighted below.

Resource characterization

- District-level yield efficiency maps for seven important rainfed crops were developed based on climate, soil and irrigated area parameters. Out of 85 cotton-growing districts (Districts with >10000 ha) the yield efficiency of 14 districts were found less than 50 per cent indicating the scope for doubling the yield in these districts.
- An improved version (v2) of the Yield Gap Decision Support System (DSS) has been made available at http://www.icar-crida.res.in:8129/. This DSS provides statistics on natural resources and socio-economic features to find responsible factors for the low yield efficiency of the target district besides the extent of use of High Yielding Varieties (HYVs) and fertiliser nutrients.
- The district-based contingency plans (DACP) were prepared for 648 districts in the country and hosted on ICAR/DAC websites (http://agricoop.nic.in/acp.html, http://www.icar-crida.res.in/) and circulated to all state agriculture departments. During the year 2021, 67 plans have been updated with the support from SAUs thus totalling the updated DACPs to 502.
- Groundwater recharge prospect was estimated qualitatively at the district level based on the weekly rainfall of *kharif* 2021. Groundwater recharge possibility is extremely low whenever scanty rainfall is received in more than 65 per cent of weeks or deficit rainfall is received in more than 80 per cent of weeks on a cumulative basis.

Rainwater Management

- Monsoon season was monitored for rainfall departures, dry spells and maximum dry spell in 695 districts. One hundred and sixty-two districts received less than 75 per cent of their normal rainfall. About 30 per cent of districts in high rainfall zone (>1000mm) received deficient rainfall during the season.
- The performance and economics of farm ponds for rainfed ecosystems were studied. Farm pond with cement + soil lining (6:1) was found effective in scarce rainfall zone (Rayalaseema) in Andhra Pradesh, High-density polyethylene (HDPE) (250 micron) sheet lined farm ponds were found useful in eastern dry zone with semiarid alfisols of Karnataka and HDPE (500 micron) sheet lined farm ponds were found effective in southern zone with semiarid vertisols in Rajasthan.

Crops and cropping systems

- Yield and physiological characteristics were assessed in 22 horse gram genotypes. The genotype CRHG-22 recorded the highest yield and CRHG-4 recorded the lowest canopy temperature and highest SPAD value. Mutation was done using Ethyl methanesulfonate (EMS) in three released varieties and M1 generation is harvested on a single plant basis. Advancement of 9 F1 and 12 F2 generations were carried out in horse gram. About 200 kg of breeder seed was produced this year.
- Evaluation of low-cost approaches for the management of Fall Army Worm (FAW), *Spodoptera frugiperda* in maize indicated that the mean incidence larval population was lower in chemical and integrated treatments and was more evident in

maize +cowpea intercropping system than sole crop of maize.

- In an experiment, to assess the effect of different levels of moisture stress on soil microbial as well as plant growth and physiological parameter, it was found that population of phosphorus solubilizing bacteria, free-living nitrogen-fixing bacteria and *Pseudomonas* spp. decreased as the level of soil moisture content depleted from 20.6 to 4.9 per cent.
- In a study to identify the sustainable fodder based cropping system, the higher system productivity of 69445 kg/ha was obtained with sorghum + pigeon pea/hedge lucerne, followed by castor + hedge lucerne (62762 kg/ha). These systems provided green fodder for at least 8-9 months without any supplementary irrigation.
- Seventeen maize hybrids and four checks were evaluated under rainfed conditions for drought tolerance, out of which SNJ201126/RJR385, SNJ201126/Z10115, HKI7660/SNJ201126, Z10115/HKI161, HKI161/SNJ201126 and Z10115/HKI7660 performed at par in terms of yield compared to commercial hybrids.
- An automated thematic map-generating web tool TmapGen+ based on user input was developed using Streamlit to create thematic map in three steps on the fly.
- Among the twelve different multi-purpose tree species (MPTS) agroforestry-based systems with finger millet as intercrop established at CRIDA, *Dalbergia latifolia* with staggered trenches enhanced the finger millet (KMR 301) grain yield, and stylos grown under *Dalbergia latifolia* intra- spaces without trenches produced maximum green fodder yield under rainfed conditions.
- In an experiment on quantification and valuation of ecosystem services from agroforestry systems in different rainfed agro ecologies. The estimated amount of biomass kg/tree/year was (2.74), amount of carbon was (1.28) kg/year/tree and carbon dioxide absorption was (4.73) kg/year/tree in *Melia dubia* based agroforestry systems

Soil and nutrient management

- In castor crop, fresh vermicompost and gliricidia loppings were applied to the soil at rates of 0, 2, 4 and 6 Mg C/ha. The carbon sequestration potential of the soils up to 40 cm depth calculated using measured values of Organic Carbon (OC) in < 20 µm soil fraction ranged from 5.73 kg/m^2 in native forest land-use system to 7.72 kg/m^2 in the cropping with large C input land-use system.
- In maize-pigeon pea crop rotation on conservation agriculture and nitrogen management practices revealed that about 24.1 and 12.8 per cent significantly higher pigeon pea seed yield was recorded in no-tillage and reduced tillage as compared to the conventional tillage. In different aggregate size fractions, 12.2-22.9 and 5.6-10.6 per cent aggregate total carbon increase was observed in no-tillage and reduced tillage, respectively as compared to the conventional tillage.
- Experiments on maize crop revealed that zeolite application increased the plant nutrient content and nutrient uptake as compared to control. The application of N @ 120 kg/ha along with zeolite application @ 4 and 8 t/ha improved the N uptake by 46.2 and 57.9 per cent over sole application of N @ 120 kg/ha.
- The grain yield of sorghum in sorghum-blackgram rotation was significantly higher with crop residue retention. The treatment with higher crop residue retention recorded 27.5 per cent higher sorghum grain yield and 24 per cent higher straw yield over no residue treatment.
- The pearl millet-pigeon pea (and horse gram on residual fertility) based system recorded significantly higher pearl millet grain yield in minimum tillage (2361 kg/ha) as compared to zero tillage and conventional tillage. Similarly, higher yield was observed in 125 per cent of the recommended dose of the fertilizers (2348 kg/ha) as compared to the other recommended dose of fertilizers. The cotton-pigeonpea system, pooled data of 5 years (2016-2020) revealed that significantly higher cotton

equivalent yield was obtained under minimum tillage with 125 per cent recommended dose of fertilizers as compared to zero tillage.

- In pigeon pea +setaria intercropping system, results revealed that zero tillage recorded 20 and 18 per cent higher pigeon pea equivalent yields as compared to conventional and reduced tillage respectively. The 10 and 30 cm height anchored residues recorded 55 and 54 per cent higher yield as compared to no residue.
- Results on maize crop revealed that integration of *in-situ* moisture conservation practices through permanent bed and furrow, permanent conservation furrow recorded 19 and 10 per cent higher maize yields as compared to conventional tillage without moisture conservation treatment. Among the weed control treatments, pre-emergence+post emergence herbicide application recorded higher yields as compared to other weed management practices. Reduction in crop yield in un-weeded treatment in zero tillage was higher than in conventional tillage.

Livestock management

- Nutritive value of maize fodder in terms of crude protein (CP) and digestible energy. metabolizable energy (DE/ME) would decrease under elevated temperature and elevated carbon dioxide and temperature environmental conditions.
- Fortification of Total Mixed Ration (TMR) by @ 30 per cent of the total weight when used for feeding Nellore sheep for 9 weeks, improved body weight over non- Nellore sheeps. This suggests that tamarind shell which is unutilized in the field can be scientifically used for improved growth rate in indigenous sheep.

Energy management

- As the autonomous platform was designed to operate in raised bed planting system, it requires structure versatility to attend to all the terrain situations in the field. For this application, a platform was designed with four wheels which will run in between two side by side furrows and the bed will come underneath the frame, so that crop damage can be avoided.
- Reaper for the harvesting of short and bushy crops was developed at Farm Machinery Research Workshop (FMRW), CRIDA. Initial testing of cutting mechanism was conducted on green gram crop. The average plant density varied between 35-42 plants per m and height of green gram ranged from 20-30 cm at the time of harvesting. It was observed that the developed mechanism can cut the crop stems very smoothly with better cutting efficiency.
- A Solar-cum-battery operated weeder was tested in the field. The performance of the machine was varied with (i) soil moisture (ii) soil type (iii) weed density and (iii) operating speed. With full charged batteries, operational speed obtained was 0.3 m/s. Performance in good operating conditions, the machine gave 84-92% weeding efficiency as against 51-64% in non-favourable conditions.
- A weed inflorescence shredding hydraulic system operated implement was developed and its performance was found satisfactory. The shredding rotary machine composed of 75 cm rotary shaft driven by hydraulic motor and a concave with L-angle support structure covers the shaft from rear.

Socio-Economic studies and Transfer of Technology

- Under Farmers FIRST project interventions, 400 farm families were covered in five villages of Pudur Mandal namely, Gangupally, Rakamcharla, Devanoniguda, Medikonda and Pudugurthy in Vikarabad, Telangana. Nine different types of need-based implements have been identified, procured and demonstrated to the farmers during crop season. Livestock based intervention included promotion of backyard poultry variety, improved fodder production and management, salt lick to goats, mineral mixture to ruminants.
- Extension efforts of state development agencies were observed to be less effective as compared to Coromandel Fertilizers Limited (CFL) and Watershed Support Services and Activities Network (WASSAN). Demonstrations and meetings were highly effective extension method followed by extension personnel in all the three agencies studied.

- Fortification of Total Mixed Ration (TMR) by tamarind shells @ 30 per cent of the total weight when used for feeding Nellore sheep for 9 weeks, a significantly ($p<0.05$) improved body weight over non-fortified group was observed (ADG @ 65g per day vs 53g per day). This suggests that tamarind shell which is unutilized in the field can be scientifically used for improved growth rate in indigenous sheep.
- A new measure for assessing the sustainability of treatments /practices evaluated in long term experiments was developed. A District level yield efficiency maps were developed for seven important rainfed crops. The improved version of the Yield Gap DSS is available at http://www.icar-crida.res.in:8129/.
- An apportioned district database covering time series data on area sown, production and yield of crops for years 1966-67 to 2017-18 was built by including rice, sorghum, pearl millet, maize, pigeon pea, chickpea, black gram and green gram crops.
- Current and future climate at district level were assessed and climatic shifts was observed in 24 districts in 2030s and 32 districts in 2050s as per Representative Concentration Pathway (RCP 4.5) and in 15 districts in 2030s and in 22 districts in 2050s as per RCP 6.0. Moisture index, by and large, is projected to rise indicating enhanced moisture availability in the future. The climate in the future is going to be less harsh but climatic shifts will be minimal.
- The difference-in-difference model (DID) and stepwise multiple linear regression (MLR) were employed to quantify the impact of adopting climate-resilient technologies (CRTs) and factors influencing farm incomes during drought. Farmers reported that droughts decreased the income from crops by 54 per cent and income from livestock rearing by 40 per cent.

Scheduled Caste Sub Programme

- An awareness programme was organized for farmers at Mallampet village of Kotapally Mandal, Mancherial district, Telangana on 28.01.2021 about safety of farm produce and use of biofertilizers.
- Red gram was introduced in a cluster of six villages and 2000 kg seeds of improved variety (PRG-176) was distributed during June 2021and the seeds were procured from ICAR-CRIDA, KVK seed hub. The seeds sown in the backyard for self-consumption and as an intercrop was found to be in good condition and received well by all the farmers.
- As part of Azadi ka Amrit Mahastov of 75 years of India's Independence field day was organised at Bhogalingadahalli village, Chincholi Taluaka, Kalaburagi district, Karnataka on 18th October 2021. About 150 farmers of Bhogalingadahalli and Kalabhavi villages participated.
- Three training programmes were organized on "Sustainable Rice Production Technology" during 23-25th February, 2021, 08-10th March, 2021 and 16-18th March, 2021 in three batches which benefitted 60 farmers from Mallampet and Edagatta village at ICAR-IIRR, Rajendranagar, Hyderabad.

All India Coordinated Research Project for Dryland Agriculture

- At Anantapuramu, in semiarid alfisols, groundnut recorded significantly higher pod yield (1595 kg/ha) with soil application of microbial consortia 1 (C_1: *Pseudomonas putida* P7 + *Bacillus subtilis* B 30) compared to other treatments except soil application of microbial consortia 2 (C2: *Pseudomonas putida* P45 + *Bacillus amiloliquefacians* B17) and uninoculated control. Seed treatment + soil application with consortia 2 recorded higher soil organic carbon (0.59 per cent) and higher available N (183 kg/ha). However, higher soil available P (66 kg/ha) was recorded with seed treatment + soil application with consortia 1.
- In subhumid Inceptisols at Jagdalpur, in a long-term study on the effect of inorganic fertilizers and organic manures on soil fertility and productivity of direct-seeded rice-field pea system, application of full dose of NPK (60:40:30 kg NPK/ha) + 5 t FYM/ha + ZnSO4 @ 25 kg/ha recorded significantly

higher rice grain yield (4763 kg/ha) with higher net returns (Rs.60024/ha) and RWUE (3.68 kg/ha-mm) as compared to other treatments. During *rabi*, higher seed yield (1147 kg/ha), net returns (Rs.36439/ha) and B:C ratio (1.96) of field pea were recorded application of rec. NPK during *Kharif* (100 per cent NPK+5 t FYM+ $ZnSO_4$@ 25 kg/ha).

- In semiarid Vertisols at Parbhani, in soybean + pigeon pea (4:2) intercropping system, conventional tillage recorded significantly higher soybean seed equivalent yield (1463 kg/ha), net returns (Rs.53284/ha), B:C ratio (2.66) and RWUE (2.10 kg/ha-mm) compared to reduced tillage + herbicide and reduced tillage + interculture. Among nutrient sources, application of RDF (50 per cent) + vermicompost (1.5 t/ha) recorded significantly higher soybean seed equivalent yield (1601 kg/ha), net returns (Rs.63097/ha), B:C ratio (3.09) and RWUE (2.15 kg/ha-mm) compared to other nutrient sources.
- At ARS Kanker (Jagdalpur), two supplemental irrigations (sprinkler) in field pea from harvested rainwater in farm pond gave higher seed yield (2417 kg/ha) but was on par with that of farmers' practice (flood irrigation) (2281 kg/ha). The cost of cultivation was higher with farmer's practice (Rs.24715/ha) whereas higher net returns was recorded with two supplemental irrigations in field pea (Rs.62642/ha) with higher B:C ratio (2.97), and WUE (4.27 kg/ha-mm).
- At Aklera, soybean-chickpea system recorded significantly higher system productivity (3450 kg/ha), net returns (Rs.77960/ha) and B:C ratio (2.31) followed by soybean-coriander sequence (270 kg/ha) compared to soybean-linseed system (2214 kg/ha).
- At Sunderpura and Kocharia villages in Bhilwara district (Rajasthan), in the rainfed farming system, the introduction of improved crop varieties, integrated nutrient management, *in-situ* moisture conservation, mineral nutrition to livestock and cultivation of fodder grass on bunds improved the system productivity in case of marginal category by 22.9 per cent compared to traditional farming system and gave higher net returns (Rs 77106/year) and employment generation (232 man-days/year) and in case of small farmers category by 31.2 per cent compared to the traditional farming system and gave higher net returns (Rs 106365/year) and employment generation (286 man-days/year).

All India Coordinated Research Project on Agrometeorology

- Trend analysis of one-day extreme rainfall using Mann-Kendall test for 118 tehsils located in the Vidarbha region, Maharashtra during 1971-2020 was carried out. Results showed that on annual basis, two tehsils (Mangrupir in Washim and Koparna Gadchiroli district) showed significant positive trend and 12 tehsils showed significant negative trend in one-day rainfall event of 75-100 mm.
- Magnitude and variation in meteorological drought incidence during the monsoon (June-September) period were computed using drought indices like Standardized Precipitation Index (SPI) and standardized precipitation evapotranspiration index (SPEI) at selected locations in the Gujarat state (Anand, Bhuj, Junagadh, Navsari and SK Nagar). Results indicated that the use of SPEI or SPI does not have a marked difference in the quantification of the severity of the drought at most parts of the state and hence in Gujarat state, SPI should be preferred as it requires only rainfall data than SPEI.
- During southwest monsoon season, the average rainfall recorded was below normal in most of the locations of Jammu region under the influence of El Niño episodes except Batote, Banihal and Rajouri districts, which showed a slight increase in rainfall. The decrease in rainfall was highest (25.1 per cent) in Kathua district.
- Crop weather relationship between the effect of three sowing environments (10 June, 25 June and 10 July) and three basmati rice cultivars (Pusa-1121, SJR-129, Basmati 370) was conducted at Chatha, Jammu. The maximum RUE (0.73 gm/ MJ^{-1} m^{-2}) was found in crop sown on 10 June and for Basmati

370 cultivar. Results also indicated that rainfall had significant positive relation during the milking and hard dough stage.

- Multiple regression models to predict the guava yield for rainy, winter and spring seasons using experimental data of 2013-14 to 2019-20 and the models were validated with observed yield of 2020-21. The model for rainy season underestimated (-13.1 per cent) the guava yield, whereas, the winter and spring season model overestimated the yield by 8.8 and 15.5 per cent, respectively.
- SUBSTOR-Potato module of DSSAT (v4.7) was used to find the optimum sowing date for potato at Hisar. The model simulated phenological events and tuber yield was in satisfactory with the observed values and it was found that the second fortnight of October is optimum for potato planting in the sub-tropical region.
- A simulation study was carried out at Ludhiana using the CERES-Wheat model (for PBW343 cultivar) and results showed that the harmful effects of continual heat stress on wheat productivity can be reduced by sowing the wheat crop by 15th November and with additional application of nitrogen i.e.150 per cent (188 kg/ha) of recommended N in two equal splits at 0 and 30 DAS.
- Correlation between weather parameters and pigeon pea spotted borer incidence were studied at Anantapuramu centre. It was noticed that the number of web and larvae/m^2 showed negative correlation with mean temperature and sunshine hours and positive correlation with relative humidity.
- The correlation study between cotton leafhopper and weather elements showed that maximum temperature, sunshine hours, wind velocity and evaporation had negatively influenced the leafhopper population significantly. At the same time, relative humidity (significant) and rainfall (non-significant) had a positive impact on population build-up.
- New mobile application 'Mewar Ritu' was developed by AICRPAM-Udaipur centre for effective dissemination of Agromet Advisory Bulletins for the benefit of farmers of Rajasthan state
- Probabilities of having a dry spell of successive two weeks during *Kharif* season in different districts of Bihar have been worked out. Analysis revealed that the probability for two consecutive weeks of dry spells are less during July and August (1-6 per cent) and higher during June (1-30 per cent) and September (0-19 per cent). Compared to the western districts, the probability for dry spells is higher in the eastern districts of Bihar.

National Innovations in Climate Resilient Agriculture (NICRA) Projects at ICAR-CRIDA

- Elevated temperature decreased the total Nitrogen uptake in four maize genotypes studied, however elevated CO_2 impact differed with genotype. The Nitrogen Harvest Index (NHI) was reduced under elevated temperature conditions in DHM-117 and DHM-121 while it improved with elevated CO_2.
- A higher per cent increase of the number of generations of *S. litura* was predicted to occur in the very distant future over baseline, followed by distant future and near future periods with a reduction of generation time across the four representative concentration pathways scenarios. Among locations, a greater number of generations of *S. litura* with reduced generation time are likely at Virudhachalam and Tirupathi locations.
- A decline was seen in quantum yield of photochemistry at high temperature in pearl millet plants in the Carbon dioxide and Temperature Gradient Chambers which could be due to loss in connectivity in the proteins of Photosystem II (PSII) and also due to disruption of Oxygen Evolving Complex (OEC) which in turn reduced the supply of electrons to the electron transport pathway of Photosystem II.
- Interactive effects of elevated temperature and elevated CO_2 on the efficacy of insecticides against *Spodoptera litura* on groundnut indicated that the descending order in reduction of Persistent Toxicity

of insecticides was deltamethrin < quinalphos < flubendiamide < emamectin benzoate < spinosad and these insecticides persisted for shorter period at elevated temperature and elevated CO_2 conditions over reference

- Rhizobium isolates were isolated from nodules of four black gram genotypes viz., IPU-06-02, PLU-826, PSRJ-95016 and IPU-094-1 grown under ambient conditions, elevated temperature (+3°C) and elevated temperature (+3°C) + elevated CO_2 (550 ppm) conditions at Free Air Temperature Elevation (FATE) facility. Variation in nodule parameters was observed across different genotypes and environmental conditions.
- Evaluation of the performance of different crops under organic, inorganic and integrated production systems showed that the seed yields of sunflower (943 kg/ha) and green gram 686 kg/ha) were higher under organic management compared to other production systems. However, the seed yield of pigeon pea (348-375 kg/ha) was similar under different production systems.
- Nitrous oxide (N_2O) emissions factor was significantly low under the high pasture block of the experimental field compared to the low and medium pasture blocks. The mean estimated emission factors from the present study were lower than the Intergovernmental Panel on Climate Change (IPCC) (1996) default value for cattle.
- Three thousand stress digital imageries were collected from the field to detect crop stress using deep learning-based Artificial Intelligence models.

Technology Demonstration Component (TDC)

- In Bhitihara village of Buxar district, Bihar, increase of bund height for paddy resulted in harvesting more water and storing for longer days, which helped to minimize the moisture stress during dry spells and resulted in additional paddy yield up to 12 per cent compared to farmers' practice. Sowing of wheat through happy seeder in the same village enhanced yields up to 19 per cent compared to farmers' practice.
- In Sitara, Senhti and Mukandpura villages of Bharatpur district, Rajasthan, construction of 82 tube well recharge structures helped to enhance the groundwater level by 15 to 20 feet in bore wells, resulting in additional 2 irrigations for *rabi* crops. This technology helped in improving yields by 1400 kg/ha in wheat, 600 kg/ha in barley and 530 kg/ha in mustard crop as compared to farmers' practice.
- Mini sprinkler in wheat and drip irrigation in vegetables in Chakwas village of Jhunjhunu district, Rajasthan saved up to 50 per cent water compared to the surface method of irrigation and helped to get an additional yield of 18 per cent in wheat and 19 per cent in cucurbitaceous crops with an additional net return of Rs. 16131 per ha from wheat and Rs. 23000 per ha from cucurbitaceous crops.
- In Amba village of Ratlam district, Madhya Pradesh sowing of soybean with broad bed furrow and ridges and furrow resulted in additional productivity of 440 and 420 kg/ha respectively, over the farmers' practice and helped to obtain additional net return up to Rs. 13440 per ha.
- In D. Nagenahalli village of Tumkur district, Karnataka, trench cum bund technology helped to get an additional yield of finger millet by 360/ha compared to farmers' practice with an additional net return of Rs. 9540 per ha.
- In Bhitihara village of Buxar district, Bihar, short duration, drought escaping varieties of rice (Swarna Shreya) and chickpea (BGM - 547) obtained an additional yield of 830 kg/ha and 330kg/ha, and an additional net return of Rs. 12913 and 13950 per ha compared to local varieties.
- In Khagribari village of Cooch Behar district, West Bengal, Swarna Sub-1 and Gotra Bidhan 1 contributed to yield improvement up to 1005 and 800 kg/ha respectively compared to local varieties and correspondingly resulted in additional net return of Rs. 17997 and Rs. 15182 per ha over the farmers' practice.

- Improved stress tolerant varieties of groundnut (K-6), rice (Sahbhagi and MTU-7029) were demonstrated in Bhelwa village of Godda district, Jharkhand which helped in realizing additional yield by 4 to 35 per cent compared to local varieties with an additional net return by Rs. 7150 to 18400 per ha over the farmers' practice.
- In Yagantipalle village of Kurnool district, Andhra Pradesh, drought tolerant variety of pigeon pea (Asha) and chickpea (NBeG-49) crops helped to minimize the effect of moisture stress and obtained additional yield by 14 and 15 per cent respectively, compared to local varieties and correspondingly helped to get addition net return of Rs. 5870 and 10560 per ha over the farmers' practice.
- Breeds of poultry (Kadaknath) and duck (Khaki campbell) were demonstrated for 25 farmers at Gudeliya village in Bhatapara district of Chhattisgarh resulted in reduction of mortality rate up to 30 per cent in both ducks and poultry and obtained additional body weight gain by 1.5 and 0.95 kg per bird and also increased the number of egg production by 35 and 103 per bird per year in poultry and ducks respectively compared to local breeds.
- In Pimpri Lokai village of Ahmednagar, Maharashtra, silage preparation, multi cut fodder sorghum (COFS-29) increased the milk yield by 1.4 l/day/cow and increased the return of Rs. 42 per day per cow compared to without feeding of silage.

Human Resource Development (HRD)

- During the year, 15 scientists, 5 technical and 2 finance staff participated in the various training programme as a part of human resource development.
- The scientists of the institute participated in about 100 different Conferences, Meetings, Workshops, Seminars and Symposia during this year.

Awards and Recognitions

- Twenty scientists received awards, fellowships and recognitions from national academies, national and international professional societies and other institutions. Ten scientists served as editors in various Indian and International journals.

Publications/Software/Websites/Database

- More than sixty research articles in international, national peer-reviewed journals and over 50 other publications were published. The contributions of scientists also appeared in the form of several policy papers, popular articles, presentations in conferences.

Contents

Introduction 1

Rainfed agriculture is the predominant form of agriculture in arid, semi-arid and sub-humid regions of the country. Rainfed agriculture constitutes a major part of Indian agriculture, necessitating a comprehensive approach and multi-disciplinary research for improving food and nutritional security while conserving and managing natural resources in the country. Food and Agriculture Organization (FAO) of the United Nations indicated the tremendous potential of rainfed agriculture which could feed the entire world by use of improved technology.

The geographic and demographic dimensions of rainfed agriculture warrant a continued priority for production systems in it, in general, and rainfed agricultural research and extension in particular. Short or long-term fluctuations in weather patterns, climate variability and climate change can influence production systems and in turn crop yields. The impending effects of climate change will further add the dimension of urgency to rainfed agriculture as the problems of poverty, hunger and resource degradation are likely to be exacerbated if appropriate measures are not initiated as 81 per cent of rural poor in India are engaged in rainfed agriculture. It was not until 1923 that the first systematic and scientific approach to the problem of dryland farming research was initiated. These were the earliest attempts made to improve the system and tackle the problems of rainfed areas (scarcity tracts) of the erstwhile Bombay State. During 1933-35, the then Imperial (now Indian) Council of Agricultural Research (ICAR) initiated a broad-based dryland farming research project at Solapur, Bijapur, Hagari, Raichur and Rohtak to formulate appropriate strategies. After independence, renewed efforts were made to improve the stability and productivity of rainfed agriculture through efforts on developing appropriate Soil and Water Conservation practices.

Recognizing the importance of rainfed agriculture, the Indian Council of Agricultural Research launched the All India Coordinated Research Project for Dryland Agriculture (AICRPDA) in 1970 at Hyderabad with 23 centres spread across the country and presently operating in 31 centres. The importance of weather and the science of Agrometeorology in agriculture was realized and on the recommendations of the National Commission on Agriculture, All India Coordinated Research Project on Agrometeorology (AICRPAM) was launched in 1983 by ICAR to strengthen research in Agrometeorology with 10 centres across the country and which has presently been increased to 25 centres.

Realizing the enormity and complexity of rainfed agriculture, the Central Research Institute for Dryland Agriculture (ICAR-CRIDA) was established at Hyderabad on April 12, 1985, to provide leadership in basic and strategic research in dryland agriculture and to address the location-specific problems in association with AICRPDA and AICRPAM centres. ICAR-CRIDA is a constituent organization of the Indian Council of Agricultural Research (ICAR) under the Natural Resource Management Division, an autonomous body of the Ministry of Agriculture and Farmers Welfare, Government of India.

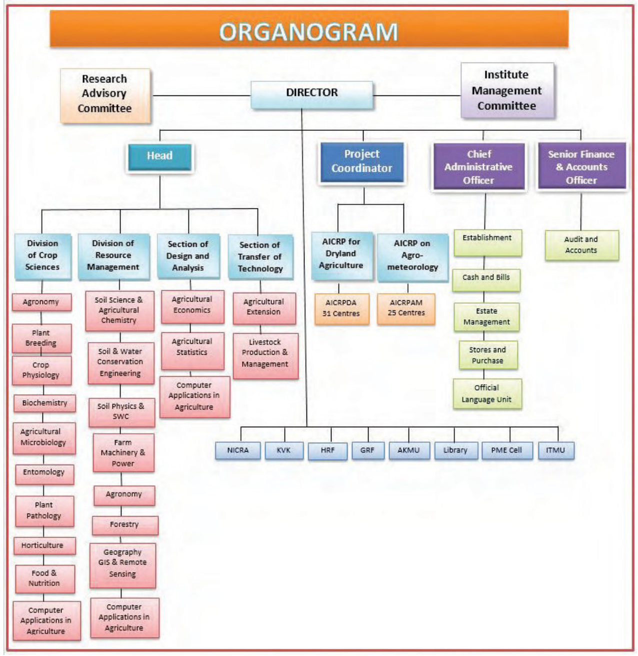
Mandate

- To undertake basic and applied research for sustainable and climate resilient agriculture in rainfed areas
- To Co-ordinate network research for generating location-specific technologies in rainfed areas
- To serve as a centre for capacity enhancement in natural resource management in drylands

Based on the work done under the National Project on Climate Change (NPCC), ICAR launched the National Innovations in Climate Resilient Agriculture (NICRA) in 2011 as a network project which is being coordinated by CRIDA. The project has four major components *viz.*, strategic research to address long-term climate change, technology demonstration in farmers' fields in the most vulnerable districts to cope with the current climate variability, competitive grant/sponsored research component and capacity building of stakeholders at different levels.

CRIDA's major research programmes and areas of research under the programmes:

Programme No.	Programmes	Areas of Research
I	Resource characterization	Rainfall and soil characteristics, length of the growing season, land capability-based potential and constraints, climatic analysis, crop weather modelling and geographic information system.
II	Climate change vulnerability assessment and adaptation	To understand the nature of climate change and its impact on rainfed agriculture. To evolve suitable adaptation and mitigation measures with special emphasis on small and marginal landholders.
III	Rainwater management	*In situ* moisture conservation, water harvesting and recycling, groundwater recharge studies, hydrological modelling, sustained management of surface and groundwater resources and efficient water-use strategies.
IV	Crops and cropping systems	Efficient crops and cropping systems, crop diversification for sustained water use and productivity, germplasm enhancement/ evaluation, stress physiology, horticulture and integrated farming systems.
V	Soil health and nutrient management	Soil physical condition management – tillage, crusting, drainage, soil fertility care, integrated and micro-nutrient management and supply systems (chemical fertilizers and natural nutrient sources including micro-organisms), sustenance of soil quality and sustainable agriculture.
VI	Land use diversification systems	Efficient utilization of different categories of lands through capability-based resource planning and generation of food, fodder and fuel, promotion of tree-borne oilseeds for non-arable lands, horticulture and livestock-based production system.
VII	Farm energy management with emphasis on small farm mechanization	Development of low-cost seeding and inter-cultural devices, solar and low lift pumps for lifting water from ponds.
VIII	Socio-economic aspects	Socio-economic and policy research studies, knowledge management, the impact of research, constraints and feedback, transfer of technology.
IX	Training	Training of primary and secondary stakeholders and use of modern tools like ICT.



Infrastructure

ICAR-CRIDA has a 9000 m^2 spacious building located at Santoshnagar in the eastern corner of Hyderabad city. The Institute has excellent laboratories, guest houses, trainee hostels, conference halls, dryland gallery, auditorium and two well laid out research farms. Over the years, the Institute has built modern facilities for conducting research, training and extension activities. A synoptic overview of the facilities is provided below.

Research Farms

The Institute has two research farms *viz.*, Hayathnagar Research Farm (HRF) of 280 ha at Hayathnagar and Gungal Research Farm (GRF) of 80 ha at Gungal and is about 15 and 45 km, respectively from the main campus. The mean annual rainfall received at Hayathnagar is 750 mm and that at Gungal is 690 mm. The research farms have well-equipped infrastructure and facilities for supporting field experiments and demonstrations including weather stations, maintenance workshops, tractors and farm equipment and fabrication facility for farm tools and implements.

Hayathnagar Research Farm (HRF)

Gunegal Research Farm (GRF)

Bio-resource centre: A bio-resource centre for the production and sale of biological pesticides and bio-fertilizers was set up at Hayathnagar Research Farm (HRF).

Farmers' service laboratory: A research and farmer's service laboratory was set up at HRF to cater to the analytical needs of experiments at HRF as well as of the farmers.

CRIDA Annexe building

CRIDA Annexe building

The Annexe building has the Director's office, Prioritisation, Monitoring and Evaluation (PME) cell and offices of administration. The unique feature of the building is that it is built by adopting the green building concept with lift facilities, firefighting and alarm systems. The building also has a well-furnished seminar hall (600 sq.mt.) with 120 seating capacity and a spacious cafeteria. The new Annex Building fulfils the long-cherished requirements of both the scientific and administrative staff of ICAR-CRIDA.

Conference hall in the Annexe building

State of art Climate Research Facilities

Climate Change Research Complex (CCRC): Free Air Temperature Elevation (FATE) facility, Carbon dioxide and Temperature Gradient Chamber (CTGC) facility, Supervisory Control and Data Acquisition (SCADA) based rainfall simulation facility and precision lysimeters with open type climate chambers a state of the art facilities to conduct climate change impact studies on crops, pests and natural resources were established at HRF, CRIDA.

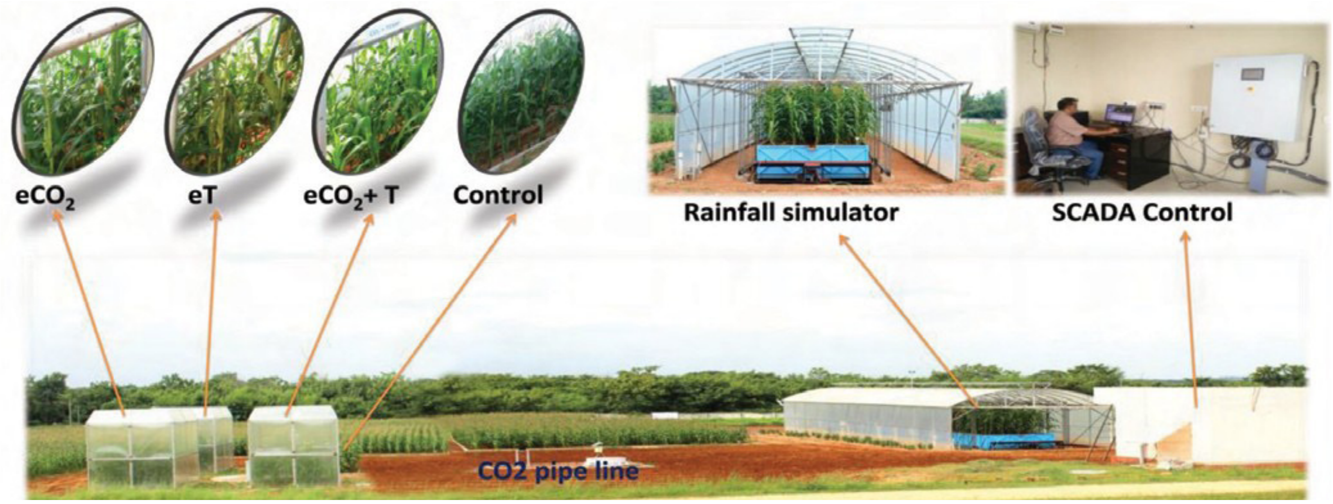
Free Air Temperature Elevation (FATE) facility: This research facility with elevated temperature conditions over ambient is intended to conduct controlled experiments with other manipulative parameters such as CO_2 enrichment and moisture deficit stress on intact ecosystems under natural environmental conditions was established at HRF, CRIDA.

FATE facility

Carbon dioxide and Temperature Gradient Chamber (CTGC) facility: The facility was established for measuring the individual and interactive impacts of elevated CO_2 and temperature on crops and pests. The elevated CO_2 condition (550 ppm) along with temperature gradient (+1°C to 5°C) will facilitate the assessment of the combined effects.

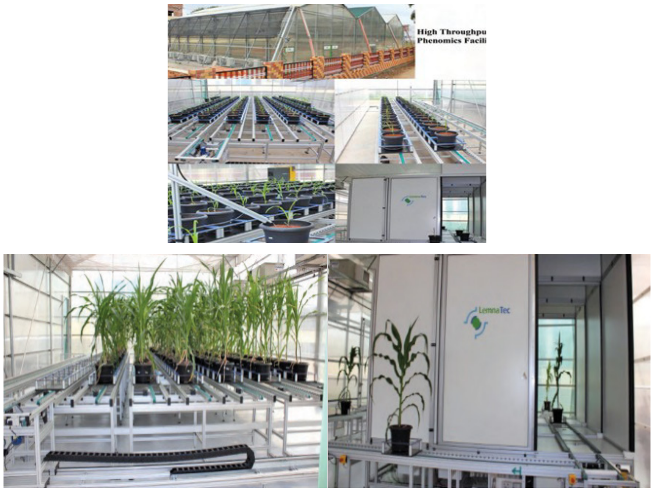
CTGC facility

SCADA based rainfall simulation facility and Precision type lysimeters with open type climate chambers: This system was established for assessing the climate change impact on resource losses.



SCADA based rainfall simulation and precision type lysimeters facility

Plant Phenomics Facility: The Phenotyping Platform with an automated non-destructive imaging-based scan analysis of crop growth and development has been developed during the XI plan to characterize genetic material with drought and other abiotic stress tolerances. This system consists of different imaging systems to collect data for quantitative studies of complex traits related to the growth, yield and adaptation to biotic or abiotic stress such as disease, insects, drought and salinity.



Phenomics facility

Open Top Chamber facility: Six Open Top Chambers were set up to assess the impact of elevated CO$_2$ concentration on crops and soils.

OTC facility

Transgenic glasshouse and greenhouse: A transgenic glasshouse conforming to containment standards for evaluating transgenic crops is available in the Institute. Apart from this, the Institute has a net house and climate-controlled glasshouse for conducting pot culture experiments.

Laboratories: ICAR-CRIDA has 15 well-equipped laboratories to support multi-disciplinary research on natural resource management and crop sciences and are well equipped with state-of-the-art facilities. In addition, Central laboratory, Agrometeorology and Data bank, and GIS laboratories cater to the needs of researchers across the divisions. Dedicated laboratories for root studies and estimation of greenhouse gases were added during XI plan.

Agroforestry: Agroforestry laboratory has facilities like soil and plant analysis, including a fully automated nitrogen analysis system and equipment for the estimation of GHGs.

Agrometeorology and databank: The Institute is the Coordinating centre for research and training in agro-meteorology since the VII Five Year Plan and has built up excellent equipment support. The centre has automatic weather stations, line quantum sensors, Bowen's ratio apparatus, spectro-radiometers and the relevant computer packages for processing historical weather data for agro-meteorological planning. State-of-the-art facilities for quality checking, storing of the meteorological data of all the AICRPAM centres and other weather stations of the country are also available. It also maintains a website *www.cropweatheroutlook.in* for providing agro-meteorological information, current weather status and contingency crop plans to aid the rainfed farmers across the country.

Agro-met data bank

Agronomy Laboratory: The laboratory is equipped with all basic instruments for soil and plant analyses, neutron moisture probes and root length measurement systems. It supports research activities in crop husbandry and soil and water management.

Animal Sciences Laboratory: Animal science laboratory was established during X-plan for estimation of proximate principles, fibre fractions, *in vitro* digestibility of feeds and fodders, *in vitro* gas production, deworming and vaccination of livestock, metabolic studies with small ruminants, clinical biochemistry parameters like serum, proteins, cholesterol, calcium, magnesium, albumin, etc.

Central Laboratory: The Institute has a central laboratory, which has state-of-the-art instruments, Inductivity Coupled Plasma (ICP) spectrometer, auto analyser, CNS analyzer, atomic absorption spectrophotometer, HPLC and TOC analyzer. This laboratory not only supports research at ICAR-CRIDA but also assists the entire research network on rainfed agriculture in the country and provides analytical services to institutions and individuals on payment.

Central laboratory

Entomology Laboratory: The Entomology laboratory is equipped with modern facilities and equipment relating to insect rearing, bio-pesticide evaluation, testing of pesticides, studies on pest development and assessing the effect of climate change on insect life cycles.

GIS Laboratory: The Geographical Information System (GIS) laboratory supports in-house digitization, mapping and analysis of watersheds, land use, land cover change analysis and mapping of soil erosion, drought incidence, and land degradation. The laboratory is also equipped with advanced software like ArcGIS (Ver.10.3.) with two add-on modules – ArcEngine and ArcPad, digital satellite data interpretation software - ERDAS Imagine (Ver.2015) with virtual and vector GIS add-on modules for analysis, Trimble DGPS, ASD Spectro radiometer and CropScan.

Horticulture Laboratory: A laboratory has been established during X five-year plan for analysis for soil, plant, fruit, leaf and other horticultural samples/products. There is also a cool chamber for storage of fruits and vegetables and their value-added products.

Hydrology Laboratory: ICAR-CRIDA has established excellent infrastructure with GIS and GPS facilities for conducting hydrology experiments. Computer controlled rainfall simulator and large tilting flume have been installed, which are useful in conducting micro plot experiments under controlled conditions.

Microbiology Laboratory: The laboratory is equipped with facilities to conduct research on agriculturally important micro-organisms including molecular characterization. Important equipment includes phase contrast and stereo microscopes, gas chromatograph, vacuum concentrators, PCR and electrophoresis systems.

Plant Molecular Biology Laboratory: The laboratory is well equipped with up-to-date facilities for carrying out research activities pertaining to the molecular biology of abiotic stress tolerance in rainfed crops such as PCR machines, Gel documentation system, Gene gun, Southern, Western and Northern blotting for achieving their objectives.

Plant molecular biology laboratory

Plant Pathology Laboratory: The laboratory is equipped with state-of-the-art facilities to pursue research in disease epidemiology in relation to weather, development of cost-effective and eco-friendly disease management options, integrated disease management and plant growth-promoting microbes.

Plant Physiology Laboratory: The laboratory has facilities to conduct research in stress physiology, plant nutrition, crop modelling and climate change. It is equipped with leaf area meter, UV-Visible spectrophotometer, osmometer, pressure chamber for measuring water potential, cold centrifuges, plant canopy analyzer and portable photosynthesis analyzer.

Soil Chemistry Laboratory: The laboratory is equipped with instruments for estimating essential nutrients required for plant growth. It supports research activities on integrated nutrient management, soil quality assessment, organic matter dynamics, carbon sequestration, etc.

Soil Physics Laboratory: The laboratory, besides basic facilities, has instruments to measure physical properties of soil and special equipment such as particle size analyzer, modulus of rupture apparatus, time-domain reflectometer, rainfall simulator, hysteresis apparatus, pressure plates and temperature data pads. The laboratory supports research and training in soil and water management and land degradation.

Agriculture Knowledge Management Unit: Agriculture Knowledge Management Unit (AKMU) successfully maintains IT infrastructure of ICAR-CRIDA and its services like Database, Application, website, Internet and network security and its related services. It also takes care need-based in-house Software and Database development. AKMU successfully runs all Internet-based service on National Knowledge Network (NKN) connectivity. ICAR-CRIDA has 10th generation desktops computers, Dell servers and Tyan GPU server with 4 teraflops speed. Three large size display panels were installed in the conference Director's committee room for presentations. Two sets of wireless collaboration devices were used for the seamless presentation from any device. AKMU successfully conducted 123 WebEx videoconference sessions during the year. All computers are connected to a Centralized uninterrupted power supply (80 + 80 KVA). Websites of CRIDA, NICRA, AICRPDA and ISDA hosted at ICAR-CRIDA servers and updated regularly time to time. Every Month, salary and IT database updated and generated salary slips, IT statements and other reports for disbursing salaries.

Dryland Gallery: The Institute maintains a Dryland Gallery where the history of dryland research and research achievements are highlighted through charts, photographs and models.

Dryland Gallery

Conference and training facilities: The Institute has four air-conditioned conference halls with a seating capacity of 30, 100, 20 and 120 besides an auditorium for accommodating 250 persons.

Auditorium

Library: The institute has a central library with a collection of over 9319 books and 5809 back volumes of periodicals. It subscribes to 117 Indian and 10 International Journals. The library extends online access to foreign journals through a subscription of Agroforestry Abstracts (CAB International). Under the National Agricultural Innovation Project (NAIP), ICAR established a Consortium for e-Resources in Agriculture (CeRA) to access 2000 plus scholarly peer-reviewed journals from the renowned publishers in the disciplines of agricultural and related sciences.

Institute Technology Management Unit (ITMU): The ITMU acts as a repository of Intellectual Properties (IPs) of ICAR-CRIDA and facilitates all scientists in protecting and commercialization of their IPs. The ITMU plays a key role in drafting MoUs, MoAs, technology licensing, filing of patents, copyrights and conducting awareness programs on IPR issues. It also liaises between the institute and ICAR in fostering public-private partnerships for knowledge generation and dissemination in the field of rainfed farming for the ultimate benefit of both the inventor and end-user.

Financial Statement for 2021 as on 31st March 2021 (Rupees in lakhs)

CRIDA		AICRPDA		AICRPDA	
Sanctioned	Utilized	Sanctioned	Utilized	Sanctioned	Utilized
3807.73	3807.69	2389.44	2389.44	741.67	741.67

Staff Position as on 31st December 2021

Staff	Positions	
	Sanctioned	Filled
Scientific	66	61*
Technical	79	35
Administrative	48	26
Supporting	22	12
TOTAL	215	123

* Including Director and two scientists on deputation

Research Highlights 2

2.1. Resource characterization

2.1.1. Weather conditions at Hayathnagar Research Farm (HRF)

At HRF, the total annual rainfall during 2021 was 1217.9 mm which was 73 per cent higher than normal (704 mm). During the winter season, very meagre rainfall was recorded in January, while 6.8 mm was received during February. During the summer season, no rainfall was recorded in March, while it was deficient during April (-24 per cent) and the rainfall was excess in May (181 per cent). During southwest monsoon season, above-normal rainfall was received in all the months to the tune of 5, 198, 46 and 114 per cent during June, July, August and September, respectively. The highest one-day rainfall of 158 mm was experienced on July 15, 2021. Dry weather was witnessed during the winter (Jan-Feb) season as only 7.6 mm rainfall was received which is a 21 per cent deficit when compared to normal (9.6 mm) (Fig. 2.1.1.1.). During the summer season (March-May) 107.8 mm rainfall was recorded which is 44 per cent higher than the normal rainfall of 75 mm. Excess rainfall received during southwest monsoon (June-September) season, i.e. 969.6 mm which is 96 per cent more than normal rainfall of 494 mm. 132.9 mm rainfall received during post-monsoon (October-December) season which was little higher than normal rainfall of 137.2 mm.

During post-monsoon season, below normal rainfall was received in October (98.6 mm) and December (2.5 mm) months when compared to normal rainfall of 107.6 mm and 5.5 mm, respectively. While 32 per cent excess rainfall was recorded during November month (31.8 mm) than the normal rainfall of 24.1 mm. The southwest monsoon (June-Sept) rainfall was distributed in 45 rainy days while the annual rainy days were 62. Within the southwest monsoon season, a dry spell with a duration of ≥7 days was observed 2 times. The longest duration of 22 days was observed between July 24 and August 14 and 9 days dry spell was noticed from June 17 to 25. The month-wise rainy days during southwest monsoon 2021 were June (9 days), July (11 days), August (12 days) and September (13 days) (Fig.2.1.1.2.). The country as a whole received 961.4 mm rainfall during the southwest monsoon season, 9 per cent excess than the long period average (LPA) of 881 mm.

During the year 2021, the monthly average maximum temperature was above normal during January, March, August, October and December months while the below normal maximum temperature was recorded in other months (Fig.2.1.1.3.). The highest positive deviation in monthly average maximum temperature from normal was observed in January (1.4˚C) followed by August (1.0˚C). At the same time, the average monthly maximum temperature was 2.2 and 1.5˚C lesser than normal in May and June, respectively. The monthly average minimum temperature was above normal by 2.9˚C in November followed by January (1.8˚C) and December (1.1˚C). The monthly minimum temperature was below normal in six months and the highest deviation was noticed in February (-1.6˚C), March (-1.5˚C) and May (-1.1˚C) (Fig.2.1.1.4.). Weekly weather parameters recorded at HRF is furnished in Table 2.1.1.1.

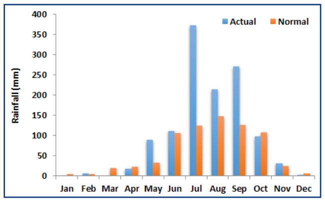


Fig. 2.1.1.1. Rainfall in mm in Hayathnagar Research Farm, CRIDA

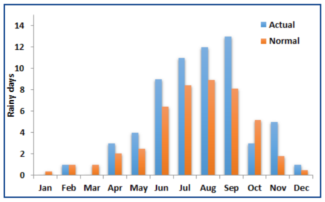


Fig. 2.1.1.2. Month-wise actual and average rainy days at Hayathnagar Research Farm, CRIDA

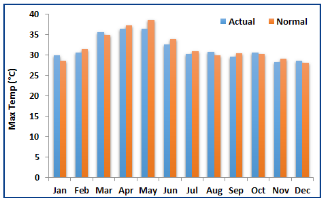


Fig. 2.1.1.3 Month wise maximum temperature at Hayathnagar Research Farm, CRIDA

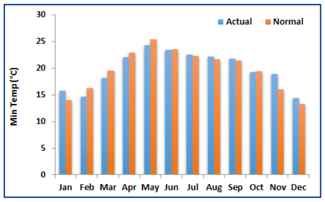


Fig. 2.1.1.4. Month wise minimum temperature at Hayathnagar Research Farm, CRIDA

Table 2.1.1.1. Weekly meteorological parameters recorded at HRF during 2021

Week	MaxT(°C)	MinT(°C)	RH1 (%)	RH2 (%)	WS (kmph)	RF (mm)	EVP (mm)
1	28.0	15.4	92.0	60.0	0.7	0.8	23.4
2	29.7	16.6	93.0	47.0	5.2	0.0	24.8
3	30.2	15.0	93.0	42.0	7.3	0.0	29.1
4	31.6	16.1	92.0	40.0	3.9	0.0	28.9
5	29.5	14.8	87.0	45.0	7.6	0.0	31.0
6	29.7	12.5	90.0	39.0	0.3	0.0	37.4
7	31.3	14.6	84.0	45.0	1.0	0.0	34.0
8	29.9	16.3	87.0	42.0	0.3	6.8	32.0
9	35.1	16.9	80.0	30.0	0.8	0.0	40.6
10	35.4	17.0	80.0	31.0	0.9	0.0	42.0
11	34.7	17.3	82.0	34.0	1.3	0.0	41.9
12	34.8	18.9	72.0	40.0	1.5	0.0	47.9
13	36.8	20.5	60.0	30.0	1.6	0.0	55.6
14	37.5	21.9	60.0	37.0	1.4	0.0	51.2
15	35.3	20.8	84.0	46.0	0.8	9.8	45.1
16	36.8	21.9	70.0	40.0	0.8	4.4	45.6
17	37.2	23.2	63.0	39.0	0.5	3.4	53.3
18	36.2	23.5	75.0	46.0	0.4	1.2	53.4
19	37.2	24.6	75.0	46.0	0.9	19.8	54.9
20	35.0	23.3	80.0	56.0	1.6	69.2	45.1
21	37.0	24.9	72.0	38.0	2.0	0.0	55.4
22	35.7	24.7	77.0	51.0	2.4	0.0	59.4
23	33.0	23.7	79.0	62.0	1.8	64.6	39.7
24	31.7	22.7	86.0	65.0	2.5	24.6	36.9
25	32.3	24.0	77.0	58.0	2.1	0.0	42.6
26	32.9	23.2	81.0	57.0	1.5	22.6	33.5
27	32.6	22.8	83.0	61.0	1.6	50.0	35.9
28	28.5	22.3	86.0	77.0	1.6	234.0	22.0
29	28.7	21.9	86.0	73.0	1.2	72.4	22.4
30	30.9	22.4	81.0	64.0	2.3	16.4	29.2
31	30.7	22.7	74.0	60.0	2.8	0.0	39.8
32	33.1	23.4	77.0	59.0	0.7	0.0	36.4
33	29.5	21.7	85.0	70.0	1.6	28.8	26.8
34	31.6	21.7	89.0	65.0	0.6	56.6	28.8
35	28.9	21.5	92.0	82.0	0.6	130.2	25.2
36	28.3	20.8	91.0	73.0	1.1	143.4	16.9
37	30.5	22.4	85.0	61.0	2.2	4.6	26.1
38	30.5	21.9	87.0	68.0	0.4	25.0	25.3
39	29.3	21.7	88.0	71.0	1.1	96.4	22.0
40	31.3	22.3	88.0	64.0	0.7	2.8	25.5
41	31.3	20.8	89.0	58.0	1.1	95.8	33.6
42	30.2	17.1	85.0	53.0	0.5	0.0	27.4
43	30.1	17.0	82.0	57.0	0.8	0.0	25.2
44	28.9	19.3	86.0	66.0	0.8	0.0	24.4
45	28.6	16.5	86.0	48.0	0.5	0.0	21.5
46	28.5	21.1	92.0	72.0	0.5	5.6	19.5
47	28.5	20.0	96.0	71.0	0.7	26.2	15.0
48	28.2	17.4	88.0	55.0	0.7	0.0	20.6
49	29.9	15.7	89.0	48.0	0.7	0.0	22.8
50	27.6	16.6	91.0	54.0	0.7	2.5	19.5
51	27.6	10.0	89.0	34.0	0.6	0.0	20.2
52	28.9	14.3	93.0	53.0	0.7	0.0	22.6

MaxT, MinT, RH1, RH2 and WS are weekly average values; Rainfall (RF) and Evaporation (EVP) are weekly total values.

2.1.2. Weather conditions at Gungal Research Farm (GRF)

The total annual rainfall during 2021 was 932.5 mm which was 25 per cent higher than the normal (748 mm) at Gungal Research Farm. Rainfall distribution was good during 2021 as the total annual rainfall was received in 58 rainy days while the annual average number of rainy days is 43 only. Among the seasons, the winter season (Jan-Feb) was the driest followed by the summer season (Mar-May) as only 1 mm and 98 mm was received during 2021 against the average rainfall of 13 and 85 mm, respectively. During the southwest monsoon season (June-Sept), 697.5 mm rainfall was received and it was 39 per cent more than the normal rainfall of 502 mm. During this season, July and September months experienced excess rainfall than normal (July 141 per cent and September 42 per cent) while lesser than average rainfall was received in June (-31 per cent) and August (-8 per cent) (Fig. 2.1.2.1.). An amount of 136 mm rainfall was received during the post-monsoon season (Oct-Dec) which was 10 per cent more than the normal rainfall of 149 mm. Regarding the distribution of rainfall, southwest monsoon rainfall was distributed in 42 rainy days while the average number of rainy days was 30. In the case of summer and post-monsoon seasons, rainfall was received in 6 and 7 rainy days, respectively. The highest number of rainy days was observed in July (13) followed by June and September (10) (Fig.2.1.2.1). Occurrence of a dry spell (rainfall ≤ 2.5 mm/day continuously for 7 days or more) during the southwest monsoon season was witnessed three times. The longest dry spell duration was noticed for 19 days (July 24-Aug 11) while a dry spell of 8 days duration was experienced during June 19-26 and Aug 19-26. Weekly rainfall received at GRF is depicted in Fig.2.1.2.2.

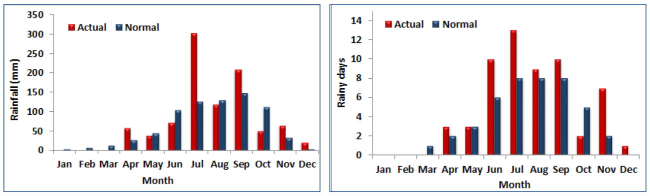


Fig. 2.1.2.1. Monthly rainfall distribution and number of rainy days during 2021 at GRF

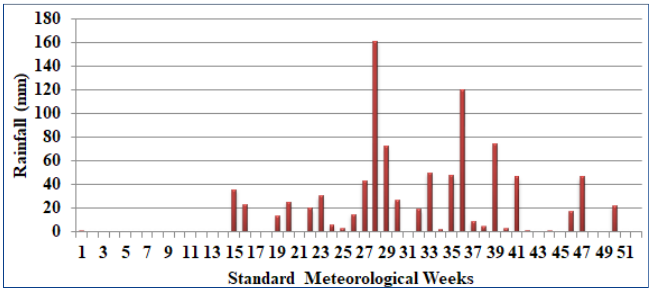


Fig. 2.1.2.2. Weekly rainfall during 2021 at GRF

2.1.3. Unreaped Yield Potentials of Major Rainfed Crops (D&A/AS/02)

District-level yield efficiency maps were developed for 7 important rainfed crops. A map depicting cotton yield efficiency at the district level is furnished as Fig. 2.1.3.1. There are 85 districts in India cultivating cotton with more than 10,000 ha area. The 85 districts were divided into 22 clusters based on climate, soil and irrigated area parameters. The yield of districts within a cluster is compared with the highest yield in the cluster and efficiency is computed as a per cent of it. The yield efficiency of 14 of the 85 districts is found less than 50 per cent indicating scope for doubling of cotton yield in these districts. Maharashtra (4) and Madhya Pradesh (4) states were found to have the highest number of such districts.

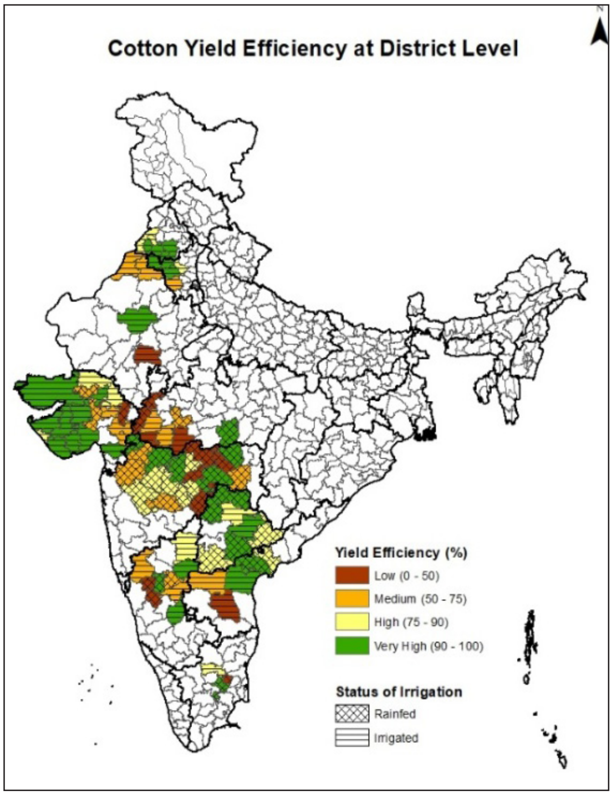


Fig. 2.1.3.1. Groundnut yield efficiency at district level

Improved version of the Yield Gap DSS (Decision Support System) is available at http://www.icar-crida.res.in:8129/

2.1.4. District Agricultural Contingency Plans (DACP)

Based on the suggestions of The Parliamentary Consultative Committee on Agriculture, Food, Civil Supplies and Consumer Affairs, Government of India (GoI), ICAR through the Natural Resource Management (NRM) division and CRIDA, along with agricultural universities and KVKs developed contingency plans at district level for 650 districts spread across all the 126 agro-climatic zones of the country to deal with weather-related aberrations.

Availability of plans

The district-based contingency plans were prepared for 648 districts in the country and hosted on ICAR/DAC websites (**http://agricoop.nic.in/acp.html, http://crida.in/)** and circulated to all state agriculture departments during interface meetings.

Updation of DACPs

Updation of contingency plans is also taken up with financial support from the Dept of Agriculture and Cooperation, MoA and FW for all districts. During the year 2021-22, about 67 plans have been updated with support from SAUs thus totalling the updated DACPs to 502.

Implementation of DACPs

- The contingency plans operationalisation requires extensive planning both at the district and state level. Sensitization of district authorities to respond to various weather aberrations impacting the agriculture sector is an important activity. As part of the systematic sensitization exercise, the ICAR and DAC organized interface meetings with concerned line departments of the State Government before the commencement of the *kharif* season.
- During the year 2021, following the forecast of the India Meteorological Department (IMD) (during April and May) and South Asian Seasonal Climate Outlook Forum (SASCOF) (during April) (Fig. 2.1.4.1.) from above-normal rainfall conditions to normal conditions, interface meetings were organized across seven states (Maharashtra, Karnataka, Telangana, Odisha, Gujarat, Madhya Pradesh and Rajasthan) during the season.

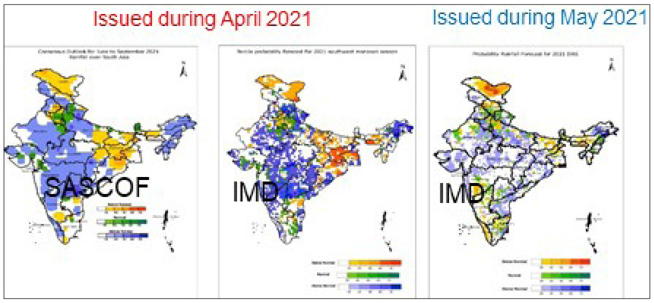


Fig. 2.1.4.1. Southwest season rainfall forecast issued by IMD and SASCOF

Though there were dry spells during the season and delays in monsoon in a few states, the monsoon picked up soon after normal monsoon was witnessed. Since the commencement of the organization of interface meetings for operationalization of contingency plans from 2014, a total of 55 meetings were held across different states.

2.1.5. Groundwater recharge prospects

The rainfall distribution coupled with total rainfall greatly influences the groundwater recharge during the monsoon period. Since the exact estimation of groundwater recharge would require considerable time and large quantities of data, a qualitative estimation of groundwater recharge prospects due to rainfall was devised by interpreting the rainfall received on a week-to-week basis at the district level. For example, if scanty rainfall is received in more than 65 per cent of weeks or deficit rainfall is received are more than 80 per cent of weeks on a cumulative basis, the recharge possibility is considered to be extremely low. Criteria followed for groundwater recharge prospects are given in Table 2.1.5.1.

Table 2.1.5.1. Criteria followed for groundwater recharge prospects

S. No	Per cent of deficit rainfall weeks	Per cent scanty rainfall weeks	Groundwater recharge prospects
1	80	65	Extremely low
2	70	50	Very Low
3	50	30	Low
4	30	10	Medium
5	10	0	Normal

Rainfall data available from IMD (www.imd.gov.in) during the current monsoon was utilized for the analysis purpose. Based on the above criteria analyzed for about 672 districts in major states of the country, groundwater recharge due to monsoon rainfall was normal in about 424 (63 per cent districts). Extremely low to very low groundwater recharge prospects was estimated in about 123 districts. State-wise distribution of groundwater recharge prospects is given in the following table 2.1.5.2.

Table 2.1.5.2. Groundwater recharge prospects in different states across India during *kharif* season-2021

State	No. of districts					Total
	Extremely Low	Very Low	Low	Medium	Normal	
Andhra Pradesh	-	-	-	-	13	13
Arunachal Pradesh	11	-	1	-	4	16
Assam	9	2	2	2	12	27
Bihar	1	-	1	-	36	38
Chhattisgarh	2	2	-	3	20	27
Goa	-	-	-	-	2	2
Gujarat	9	2	9	11	2	33
Haryana	1	-	1	1	19	22
Himachal Pradesh	1	1	-	1	9	12
Jammu & Kashmir	5	1	5	5	4	20
Jharkhand	1	-	3	2	18	24
Karnataka	-	-	1	-	29	30
Kerala	5	5	2	-	3	15
Madhya Pradesh	2	6	3	2	38	51
Maharashtra	-	1	-	2	33	36
Manipur	5	1	2	-	1	9
Meghalaya	2	1	1	-	3	7
Mizoram	4	-	1	-	3	8
Nagaland	7	-	1	-	3	11
Odisha	6	3	6	6	9	30
Punjab	3	2	3	5	9	22
Rajasthan	-	1	4	12	16	33
Sikkim	1	-	-	-	3	4
Tamil Nadu	-	-	1	-	37	38
Telangana	-	-	-	-	33	33
Tripura	1	1	-	-	2	4
Uttar Pradesh	3	12	10	11	39	75
Uttarakhand	-	1	1	2	9	13
West Bengal	2	-	1	1	15	19
Total	**81**	**42**	**59**	**66**	**424**	**672**

2.2. Rainwater Management

2.2.1. Drought monitoring, planning and management: Improving food security and resilience of the drought affected states in India

Validation of South Asia Drought Monitoring System Index (SADSI) for rainfed and irrigated agriculture for selected drought-prone sub-districts on a developmental scale is being carried out in collaboration with International Water Management Institute (IWMI), Sri Lanka. As part of the validation of the Integrated Drought Monitor Index (IDSI) (developed by IWMI) under Indian conditions, experimental sites are identified at Hyderabad (ICAR-CRIDA research farms), selected farmers' fields of NICRA-TDC operating centres in Kurnool, Anantapur, Aurangabad, Jalna and Khammam districts. Data on crop growth of dominant crops in the selected fields are being monitored along with rainfall information which would be verified with IDSI. Monsoon season was monitored for rainfall departures, dry spells and maximum dry spells during the season. District-based normal, actual and departure from normal rainfall was estimated for each district and the whole of India (Fig. 2.2.1.1). Categorization of districts (as per IMD criteria) was done based on normal rainfall and the actual status during *kharif* season 2021 (Table 2.2.1.1.).

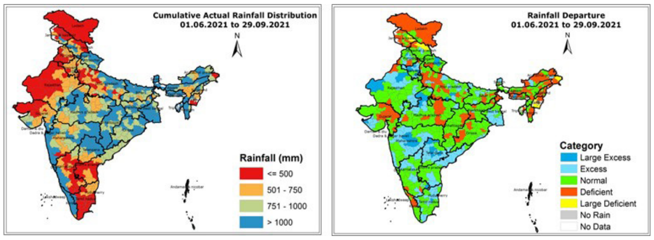


Fig. 2.2.1.1. District-based normal, actual and departure from normal rainfall for different districts of India.

Table 2.2.1.1. Categorization of districts (as per IMD criteria) based on normal rainfall and actual status during *kharif* season 2021

Normal Rainfall (mm)	Large Deficit	Deficit	Normal	Excess	Large Excess	No. of districts
<500	3	13	57	39	10	122
500-750	-	25	60	40	14	139
750-1000	-	34	92	38	12	176
1000-1500	1	54	98	15		168
>1500	4	28	49	8	1	90
No. of districts	8	154	356	140	37	695

One hundred and sixty-two districts out of 695 districts for which data is available received less than 75% of their normal rainfall. About 30% of districts in high rainfall zone of >1000mm received deficient rainfall during the season. Similarly, the maximum dry spell at different thresholds of 2.5 mm and 10mm based on IMD grid data for the *kharif* season of 2021 is estimated (Fig. 2.2.1.2.). The maximum dry spell observed during the *kharif* season in selected states based on daily block/mandal level rainfall is depicted in Fig. 2.2.1.3. The occurrence of dry spells at different locations can be monitored through dry spell maps generated at weekly intervals for interventions by line departments (Fig. 2.2.1.4.).

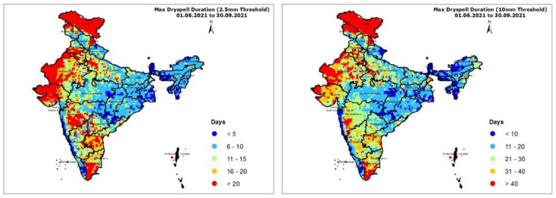


Fig. 2.2.1.2. Maximum dry spell at different thresholds of 2.5 mm and 10 mm based on IMD grid data for the kharif season of 2021

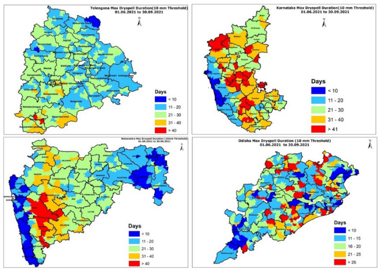


Fig. 2.2.1.3. Maximum dry spell observed during the kharif season in selected states based on daily block/mandal level rainfall

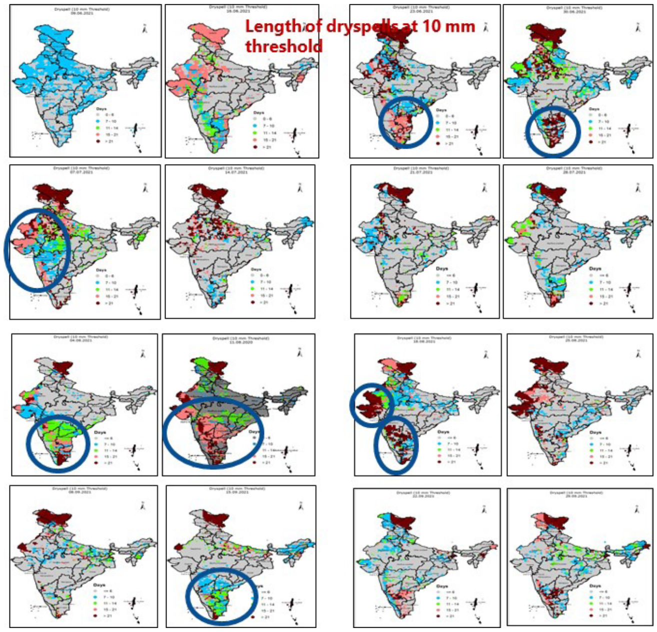


Fig. 2.2.1.4. Occurrence of dryspells at different locations generated at weekly interval

2.2.2. Study on performance and economics of farm ponds for sustainable rainfed ecosystems

Performance of farm ponds constructed under different schemes like Krishibagya (Karnataka), NGO's (RDT), MNREGA, NICRA and Individuals (A.P.) and in Rajasthan, NHM, RKVY, PR department, Agriculture department and NICRA were evaluated for economic gains under rainfed ecosystem. Farm pond with cement + soil lining (6:1) was found effective in scarce rainfall zone (Rayalaseema) in Andhra Pradesh, High-Density Poly Ethylene (HDPE) (250 microns) sheet lined farm ponds were found useful in eastern dry zone with semi-arid Alfisols of Karnataka, HDPE (500 microns) sheet lined farm ponds were found effective in the southern zone with semi-arid Vertisols in Rajasthan. The major constraints observed in this study were the exposure of lining material to high temperature, poor maintenance of lining material, possible physical damage by animals and availability of runoff during the off-season.

2.2.3. Water resources development and livelihood improvements of farmers in rainfed areas: an on-farm research

The cadastral boundaries of three villages namely Nagampet, Mallampet and Edagutta which lie in Kondampet watershed was delineated with a drainage area of 5886 ha (Fig. 2.2.3.1.). Inventory of samples and data collection on water utilisation patterns and crops grown are under progress.

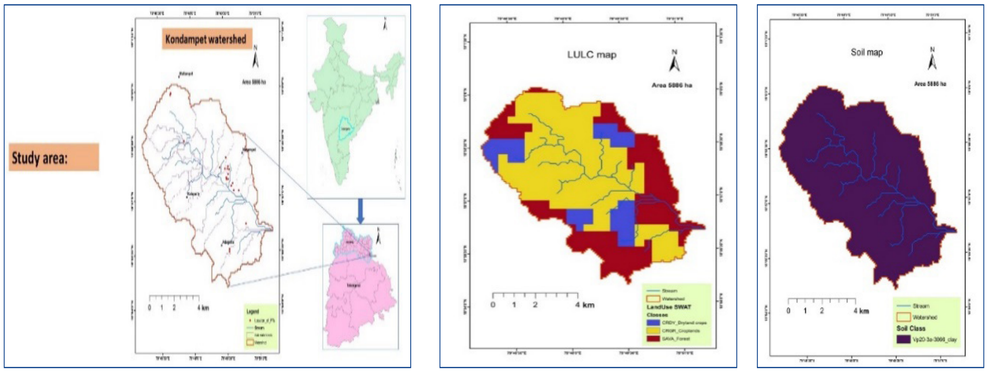


Fig 2.2.3.1. Location of the study area and land-use land cover and soil maps

2.2.4. Design and development of sub-surface water harvesting and recycling system for augmentation of farm ponds in dryland agriculture

An experiment was initiated in 2019 at Gungal Research Farm, ICAR-CRIDA to design and develop the sub-surface water harvesting system and recycling system for enhancing water harvesting and storage to augment the efficacy of farm pond technology. The experimental setup includes the installation of a subsurface drainage system. The device for measuring subsurface runoff was installed at the field which includes a multi-slot division connected with a water storage tank (Fig. 2.2.4.1.). Additionally, a surface and subsurface drip irrigation system was also installed using the same trench in which the subsurface drainage system was installed. Thus, in this system farm pond was augmented with additional subsurface water harvesting and an efficient water management system (Fig. 2.2.4.2.). The sub-surface drip irrigation system was developed in such a way that farm machinery application could be allowed (Fig. 2.2.4.3.).

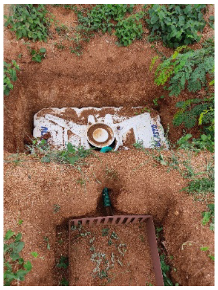


Fig. 2.2.4.1. Fixing of multi-slot divisor with water storage tank for runoff measurement

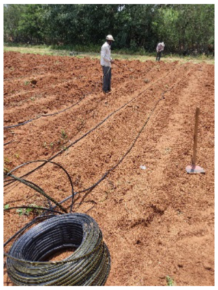


Fig. 2.2.4.2. Installing subsurface drip irrigation system

Fig. 2.2.4.3. Agricultural operations in the field with subsurface drip irrigation system

2.2.5. Identification and site selection for water resource development and management in tribal regions of Adilabad district

Forty farm pond sites spread over 3 mandals and 7 villages in the Adilabad district of Telangana were identified under TSP. The geo-tagging of these locations of proposed farm ponds in TSP villages was completed for 45 farmers.

2.2.6. Soil water dynamics in raised bed with modified furrow system and supplemental irrigation in Alfisols

The study was initiated in 2021 to evaluate the efficacy of raised beds with modified furrow systems and supplemental irrigation on the productivity of selected crops and to model the soil water dynamics in the root zone of the crops. Raised bed with modified furrow system with coir pith compost/FYM application conserved more moisture, resulting in increased crop growth, biomass and grain yield in maize crop. Compared to control with 8.5 per cent (db) soil moisture, raised with furrows conserved moisture up to 9.8 per cent (db) and by addition of coir pith compost and FYM in raised bed furrows, it retained moisture up to 12.5 per cent (db) by 25 DAS (August). Compared to control, raised with furrows increased the grain yield of maize by 11 per cent. Raised bed furrows with moisture-holding materials like coir pith compost/ FYM, increased yield up to 16 per cent & with 2 supplemental irrigations, yield increased >30 per cent compared to control.

Raised bed with modified furrow system in maize

2.3. Crops and cropping systems

2.3.1. Development of mapping population and genetic enhancement for drought tolerance in maize

In India, maize is mainly cultivated under rainfed conditions (~80 per cent) during *kharif* season. Drought stress at anthesis-silking initiation and grain filling stages cause significant yield losses in maize. Developing drought-tolerant crops with better water use efficiency is very important to feed the ever-increasing population. Identification of morpho-physiological traits associated with drought stress and using them in the evaluation of genetic resources will be critical in the crop improvement program. Quantitative Trait Loci (QTLs) identification by phenotyping and genotyping of mapping population associated with drought tolerance related traits will further help to accelerate the genetic enhancement of drought tolerance in maize through marker-assisted selection (MAS) breeding.

Seventeen hybrids and four checks were evaluated under rainfed conditions. The flowering and yield-related traits such as days to anthesis (DA), days to silking (DS), anthesis silking interval, cob weight (CW), hundred seed weight (HSW), total biomass (TB) and grain yield per plant (GY) were recorded. The RIL mapping population (HKI161/SNJ201126) was evaluated under well-watered and water-stressed conditions. Various parameters such as relative water content (RWC), normalized difference vegetation index (NDVI), canopy temperature depression (CTD), quantum yield (QY), net CO$_2$ assimilation rate (AN), stomatal conductance to water vapor (gs), transpiration rate (TR), leaf temperature (LT), anthesis silking interval (ASI), plant height (PH), cob height (CH), cob length (CL), number of kernel rows (NKR), number of kernels per row (NKPR), cob weight (CW), total biomass (TB) and grain yield/ plant (GY). For SNP genotyping, a subset of 79 RILs was used representing the entire genetic diversity of the mapping population, along with parents SNJ201126 and HKI161 in triplicates. High throughput SNP genotyping was carried out at Bionivid Technology Pvt. Ltd. Bangalore, India. Linkage map construction, QTL analysis and multi-environment (MET) analysis were carried out using QTL IciMapping software, version 4.2.

The ANOVA for the hybrid trial revealed significant variances among hybrids for all traits. The days to anthesis ranged from 40 to 57.67 days while days to silking ranged from 42 to 60 days. The grain yield ranged from 51.97 to 11.03 g/plant. Among hybrids evaluated SNJ201126/RJR385, SNJ201126/Z10115, HKI7660/SNJ201126, Z10115/HKI161, HKI161/SNJ201126, Z10115/HKI7660 performed at par in terms of yield (79.35 – 101.14 g/plant) when compared to commercial hybrids.

The RIL population showed wide variation for morpho-physiological and yield-related traits under well-water and water stress conditions. Frequency distribution histograms for most of the morpho-physiological and yield-related traits showed normal distribution. This indicates that selected RILs captured the genetic variability of the whole mapping population to be utilized for QTL identification. The maximum number of markers was detected on chromosome (chr) 2 and the minimum number of markers on chr 10. A total of 40 QTLs associated with 17 traits under well-watered (26) and water deficit stress (14) conditions were identified, of these 14 were major QTLs identified for the traits viz., RWC, NDVI, CTD, AN, gs, TR, PH, CH, CL, NKPR and CW. The LOD score values for these QTLs ranged between 2.54 and 6.07 capturing phenotypic variation ranging between 15.05 to 22.34 per cent. While 26 minor effect QTLs were identified for the traits viz., NDVI, CTD, QY, AN, gs, TR, LT, CH, NKR, NKPR, TB, CW, GY with LOD score values ranging from 2.52 to 3.37 and PVE percentage ranging between 6.75 and 14.91 per cent. The function of the candidate genes associated with QTLs corroborated with the trait of interest.

Co – localization of QTLs for TR and ASI on chr 1 (qTR-1-1, qASI-1-1), g$_s$ and GY on chr 6, (qg$_s$-6-2, qGY-6-1), g$_s$ and TR on chr 7, (qg$_s$-7-1, qTR-7-1) were

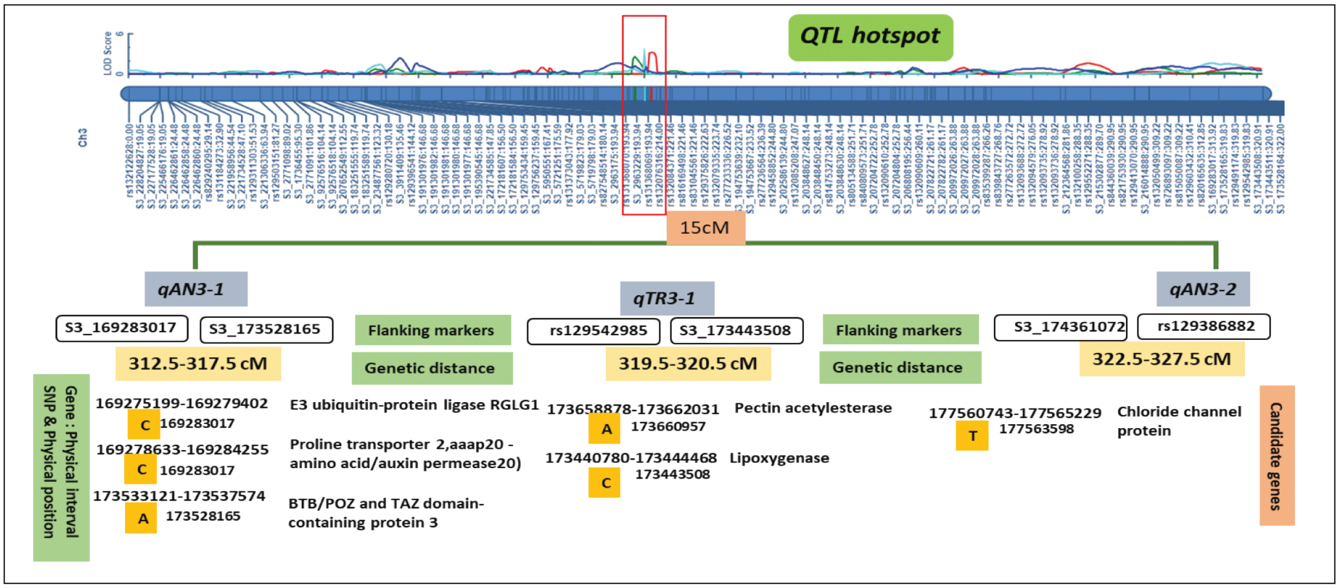


Fig. 2.3.1.1.QTL hotspot identified for traits net CO2 assimilation rate and transpiration rate using combined phenotyping data under well-watered and water deficit stress conditions

detected. QTLs which expressed both under well water and stress treatments by MET analysis were detected for AN, g_s, NDVI, NKPR QY, and TR. Three QTL hotspots were identified. The region between the marker interval, S3_169283017- rs129386882 on chromosome 3 (15cM) encompassed three QTLs for the traits net CO_2 assimilation rate and transpiration rate qAN3-1, qTR3-1 and qAN3-2. with LOD scores ranging from 2.51 to 3.24 and the phenotype variance ranging from 10.10 to 17.24 per cent. The region between the marker interval, rs130916094 - rs849450935 on chromosome 8 (27cM) encompassed two QTLs for cob height and plant height qCH-8-1 and qPH-8-1 with LOD scores 2.78, 3.19 and the PVE percentage 14.9, 17.98 per cent, respectively. The region between the marker interval, S2_213060766 - S2_14679066 on chromosome 2 (33cM) encompassed three QTLs for the traits cob weight, total biomass and grain yield qCW-2-1, qTB2-1, qTB-2-2 and qGY2-1 with LOD scores ranging from 2.53 to 4.23 and the phenotype variance ranging from 10.54 to 22.33 per cent. The QTL hotspot region for AN and TR on chr 3, encoded for genes involved in signal transduction pathway under water-deficit stress tolerance and maintenance of plant membrane and cell wall integrity. While QTL hotspot for PH and CH encoded genes involved carbon utilization in plant growth and development, directed movement of proteins in the cell and transmembrane transporter activity.

2.3.2. Genetic enhancement for nutritionally rich high yielding horse gram varieties suitable for rainfed conditions

Horse gram [*Macrotyloma uniflorum* (L.) Verdc] is an important drought hardy, climate-resilient dual-purpose rainfed crop adaptable to grow in poor soils with minimum or nil input and aftercare. It is the cheapest source of protein, vitamins, minerals and dietary fibre for the rural and tribal population. It is known as a poor man's pulse because it is consumed only by the less privileged population of the society.

This year, twenty-two genotypes of horse gram genotypes including six checks were evaluated in RBD under rainfed conditions at HRF. CRHG-19 was earliest in flowering and maturity followed by CRHG-9 and AK-42. The highest yield was recorded by CRHG-22 followed by CRIDA-18R, CRHG-16 and CRHG-4. The lowest canopy temperature was recorded by CRHG-4 whereas the highest SPAD value was recorded by CRHG-6 followed by CRHG-4. The seeds will be analyzed for nutritional and antinutritional factors.

Development of mutant population

Three released varieties of horse gram CRIDA 18R, CRHG-19 and CRHG-22 were treated with two doses of EMS (Ethyl Methane Sulfonate) viz., 0.2 and 0.3 per cent. Four hundred seeds of each variety were pre-soaked overnight in distilled water. Two hundred seeds each were soaked in 0.2 per cent and 0.3 per cent EMS solution for six hours with occasional stirring. After six hours the seeds were washed and rinsed thoroughly in distilled water and soaked in distilled water for three hours. After three hours 50 seeds were kept in Petri plate for germination studies and 150 seeds were sown in five rows of 3 m length along with control. The germination was recorded and in the seedling stage chlorophyll mutations were noted in later stages few recovered and few mutations were lethal. The germination percentage was calculated and found that CRIDA18R treated with 0.3 per cent EMS recorded the highest germination percentage of 58.66 followed by CRHG-19 treated with 0.2 per cent EMS (52.66 per cent). The lowest germination percentage was noticed in CRHG 22 treated with 0.3 per cent of EMS (21.33 per cent and 0.2 per cent EMS (30.66 per cent).

Evaluation of F_1 and F_2 population of horse gram

Generation advancement of 9 F_1 crosses and 12 F_2 crosses of horse gram were carried out and single plants were selected and harvested.

Multilocation trial of horse gram

Eleven entries including three released varieties of CRIDA as check were evaluated in RBD in three replications at HRF. The entries HG-13, HG-14 and HG-10 were earlier in flowering and maturity. HG-7 was the highest yielding entry followed by HG-6 and HG-5.

Breeder seed production of released varieties

Breeder seed production of CRIDA released varieties *viz.*, CRHG-19, CRHG-22 and CRIDA 18R were carried out and about 2 quintal breeder seeds is produced during this year.

2.3.3. Assessing the potential of mechanized strip row intercropping systems for crop intensification as a climate adaptive strategy in rainfed agriculture

An experiment on evolving mechanized flexible cropping systems suitable for rainfed lands which have already established the sowing of strip row intercropping system, along with the soil and water conservation measure of broad bed furrow (BBF) in addition to which could accommodate an extra post-monsoon crop (either as a relay crop or as a sequence crop in place of harvested medium duration cereal/millet crop/short duration legume), horse gram, in this case, and it's mechanized management operations was carried out in Hayathnagar Research Farm. The test crops are sorghum/bajra and pigeon pea. This system was compared with the strip row intercropping without BBF. CRIDA 9 row planter was used for the successful sowing of the system and BBF planter was also used successfully.

Both the sorghum and pigeon pea yielded on an average to the tune of 300 – 400 kg each per hectare in addition to some fodder from horse gram and not much difference in grain yield was observed between the strip intercropping system with BBF and the strip intercropping without BBF treatments for the rainfall distribution during 2021 (Fig.2.3.3.1.). However, high-intensity rainfall events have an impact on the retention of BBF in rainfed Alfisols.

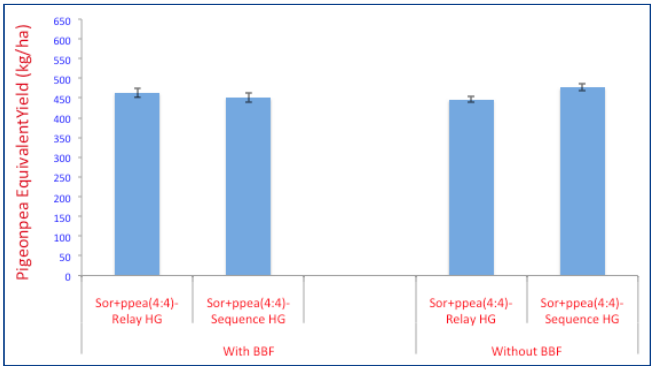


Fig 2.3.3.1 Pigeon pea seed equivalents (kg/ha) of 4:4 sorghum and pigeon pea strip row intercropping systems with and without BBF during 2021

2.3.4. Development of fodder based cropping system to improve livelihood security in rainfed areas

A field experiment was carried out with seven crops/crop-fodder combinations: Sorghum/annual fodders (fodder cluster bean – fodder cowpea – fodder horse gram), sorghum + pigeon pea/hedge lucerne, sorghum + pigeon pea/guinea grass, castor/hedge lucerne, castor /guinea grass, sole sorghum, and sole pigeon pea to identify sustainable fodder based cropping systems with higher system productivity and resource use efficiency to meet the fodder needs of rainfed farmers.

Since the outputs from each system are different, they were compared based on sorghum equivalent yield (SEY) and system productivity. Highest SEY was recorded in sorghum + pigeon pea/guinea grass (Fig. 2.3.4.1.) The highest system productivity of 69445kg/ha were obtained with sorghum + pigeon pea/hedge lucerne, followed by castor + hedge lucerne (62762kg/ha) (Fig. 2.3.4.2.). In both these systems, the perennial fodder (hedge Lucerne) component contributed significantly to system productivity. Due to good rains, five perennial cuts were harvested. The system productivity of sole pigeon pea is the lowest due to the poor yield in this year and no fodder component. These four systems are also better in providing green fodder for at least 8-9 months without any supplementary irrigation. In addition, these systems resulted in less water loss (40-48 per cent less), sediment loss (50-58 per cent less) and less pest and disease incidence due to diverse crops and higher number of natural predators. The value of fodders is expected to be further magnified when they are efficiently utilized to enhance livestock productivity.

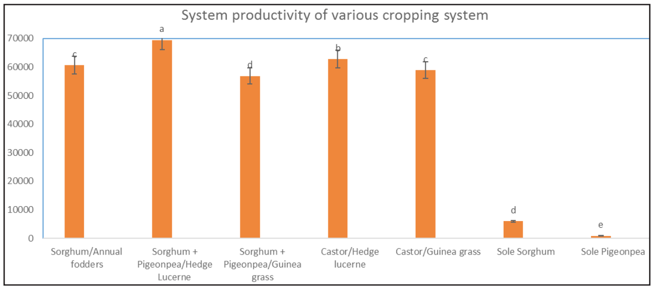


Fig 2.3.4.1 System productivity of various cropping system

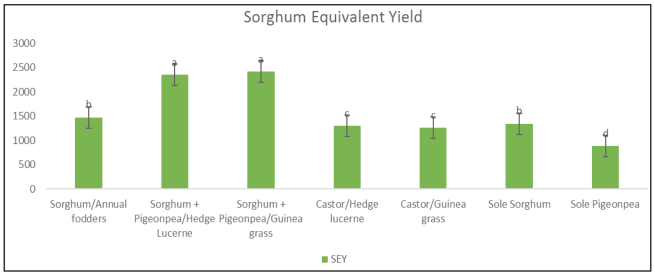


Fig 2.3.4.2 Sorghum Equivalent yield of various cropping system

2.3.5. Dry fortified Total Mixed Ration (TMR) for indigenous sheep

Agricultural crops generate considerable amounts of leftover residues which is a great pool of nutrients for livestock if utilized properly. The current investigation has been carried out to fetch the benefit of crop residue into Total Mixed Ration (TMR) as well as fortify them with suitable additives to enable indigenous sheep to overcome heat stress. The overall objective of the project is to prepare combinations of crop residues as fortified TMR ration for fattening sheep.

Table 2.3.5.1. Composition of TMR in study

Ingredients	Non-fortified TMR (NFTMR)	Fortified TMR (FTMR)
Chuni	35.0	35.0
Stover	15.0	15.0
Dry fodder	30.0	-
Tamarind shell	-	30.0
Brans	10.0	10.0
Jaggery	8.0	8.0
M.M.	2.0	2.0
Salt	1.0	1.0
Price (Rs/ kg)	**10.67**	**10.36**

Tamarind shell was added to the TMR @ 30 per cent of total weight as a replacer to dry fodder (Table 2.3.5.1) to act as heat stress ameliorative fortification agent. TMR using tamarind fruit shell was evaluated as an additive in dry TMR during summer. Both the ration had Crude protein – 11.5 per cent, Crude fat - 4 to 5 per cent, and Crude fibre - 18 to 19 per cent and had good palatability. An improved growth rate was observed in terms of ADG as 65g per day in FTMR group as compared to 53g per day in NFTMR group (Fig. 2.3.5.1.).

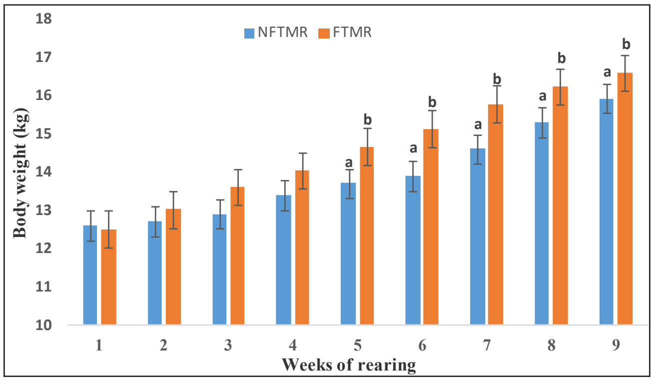


Fig. 2.3.5.1 Body weight (kg) of Nellore sheep during 9 weeks of rearing under different TMR feeding regimen

2.3.6. Biofortification for improved nutritional traits on selected dryland crops (CS/FN/01)

A field experiment was carried out at HRF, CRIDA with ten treatments to biofortify nutritional trait in selected dryland crops. The treatments were, T_1: NPK, T_2: NPK + PSB, T_3: N, T-4 NPK + $FeSO_4$ T_5: NPK + $ZnSO_4$ T_6: NPK + $FeSO_4$ + $ZnSO_4$ (soil application with PSB), T_7: NPK + $FeSO_4$ (FS) T_8: NPK + $ZnSO_4$ (FS) T_9: NPK + $FeSO_4$ + $ZnSO_4$ (foliar application with PSB), T_{10}: NPK + $FeSO_4$ and $ZnSO_4$ (SA) + $FeSO_4$ + $ZnSO_4$ (one foliar spray) with PSB. Sorghum variety CSV – 23 seed was biofortified/treated with PSB-3 at the time of sowing. Nutritional quality parameters estimated in sorghum grain were total carbohydrates and total ash.

Among the treatments, higher total carbohydrate content (Fig.2.3.6.1.) was found in treatment T_9 (71

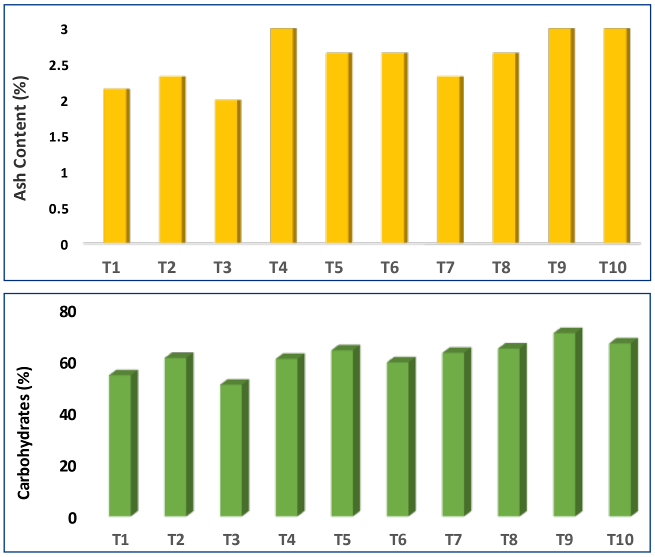


Fig. 2.3.6.1. Effect of treatments on carbohydrate and ash content of Sorghum grain

g) followed by T_{10}, whereas lower content was seen in treatment T_3 (51 g) alone. The treatments, T_3, T_9 and T_{10} (3.00 g) were on par for the ash content (Fig.2.3.6.1.). This shows that in the treatment were both soil application and one foliar spray of $FeSO_4$ and $ZnSO_4$ increased the total mineral content in grain.

2.3.7. Physiological characterization of tillering genotypes of maize for rainfed conditions

A natural mutant with ineffective tillers was identified at CRIDA. To improve the number of effective tillers it was crossed with Teosinte. The progeny of mutant and Teosinte was crossed with African tall to improve tiller height. The above crossing with Teosinte and African tall, using them as male parent was done in alternate seasons. After 4 years of crossing these were again crossed with maize composite Harsha to attain the effective cob size as well as normal maize seed. This was followed by recurrent selection, backcrossing, selfing, half-sib, full-sib followed by pedigree breeding method and selection in each season to identify plants with desirable characteristics of higher number of tillers, tillers with effective cobs and normal maize type seed.

During the *kharif* season, the tillering maize plants with three tillers that are equally tall and productive as of the main stem were identified. It was observed that pollen from productive tillers (tiller with cob) had exhibited better tillering ability in the off springs as compared to the off spring obtained from pollen from main stem within the tillering plants. It was observed that 60 per cent of the progeny had tillers in the next generation. Further advance of identified lines with better tillering ability is in progress.

2.3.8. TmapGen+: Online Interactive Thematic map Generator (CS/ CA/41)

TmapGen+ is an automated thematic map-generating web tool based on user input. Non-GIS users can visualize their biophysical and socio-economic data as thematic maps on the fly. A web interface was developed using Streamlit to create thematic map in three steps. Step 1: User has to select base map for which the thematic map has to be generated. Step2: Download data template for the selected base map and fill the user data for each parameter. This interface can read up to 5 user parameters. Step 3: Upload filled data template for generating the thematic map. This interface allows to change the colours and overlay the parameters.

2.3.9. Crop pest surveillance and advisory project (CROPSAP) in Maharashtra

Daily weather data (Tmax, Tmin, Morning RH and rainfall) was collected from IMD Mumbai (www.imdmumbai.gov.in), Nagpur (www.imdnagpur.gov.in), Pune (www. aws.imd.gov.in:8091) websites and Rainfall: Mahawedh project. Missing daily weather data was also compiled from IMD Automatic Weather Stations (IMD-AWS), for all districts during 2021-22.

Corresponding pest data was collected from https://cropsap.maharashtra.gov.in/dept/ website and downloading pest data as per SMW for district and Tehsil level. Isoline maps were prepared using ARCGIS for maximum and minimum temperatures and interpolation maps of RH, rainfall and moisture adequacy index (MAI) superimposed with pest data received from field scouts for different crops *viz.*, soybean, cotton, rice, pigeon pea, chickpea, maize, sorghum and sugarcane. These maps were provided regularly to different partner institutes of CROPSAP project and the Commissioner, Department of Agriculture, Govt. of Maharashtra for facilitating pest control advisory. All the maps generated during the year were uploaded on weekly basis in the Crop-Pest DSS website of CRIDA highlighting the risk-prone districts for different pests and diseases.

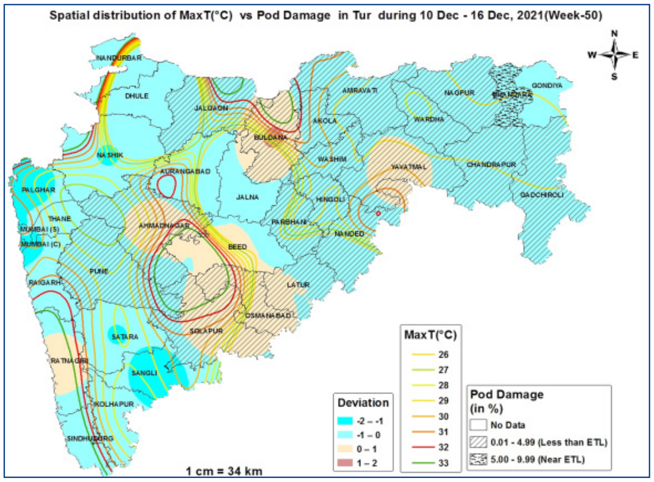


Fig. 2.3.9.1. Spatial distribution of Max (°C) Vs Pod damage in pigeon pea during 10 Dec–16 Dec, 2021 (Week 50)

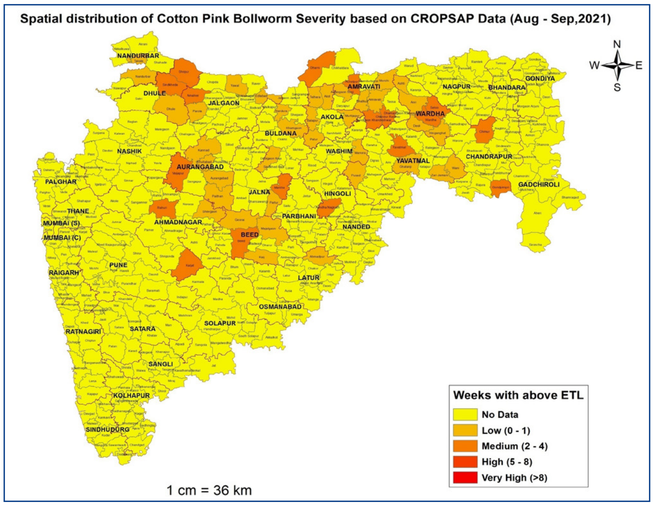


Fig. 2.3.9.2. Spatial distribution of cotton pink bollworm severity based on CROPSAP data (Aug-Sep, 2021)

2.3.10. Evaluation of low-cost approaches for the management of fall army worm (FAW), Spodoptera frugiperda in maize

The fall armyworm (FAW), *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae), is a new invasive insect pest, polyphagous and highly destructive insect pest of economically important crops such as maize, rice, sorghum, cotton and vegetables. It is well known that the control of this insect pest is achieved by applying several rounds of insecticides which in turn become very costly and may lead to the development of insecticide resistance also. With this background evaluation of low-cost approaches for the management of FAW was initiated. Creation of crop diversity by adopting an intercropping system like maize + pigeon pea and maize+ cowpea in 1:2 ratio and were compared over maize sole crop. These three cropping systems are main plots and sequential application of various pest control options/components was adopted to have low-cost evaluation. Various pest control options/treatments are as follows, i. application of K Nutrition (higher dose of K@ 20 kg/ha), ii. Prophylactic (application of dry fine sand after sieving in leaf whorl of maize crop at regular intervals, Application of 5 per cent sugar solution), iii. Biorational (application of NSKE 5 per cent and *Vitex negundo* leaf extract solution 1/10 w/w), iv. Chemical (insecticide application of Emamectin benzoate, chlorantraniliprole, Thiodicarb, v. Integrated measures (integration of all measures excepting chemical treatment), and vi. untreated check (without any application for pest control). These served as subplots and the design of the experiment was split-plot and all were replicated thrice.

Data on pest incidence- absolute, leaf damage, dead hearts formation and natural enemy population at regular intervals was recorded and the impact of various pest control approaches on absolute larval population across three cropping systems was depicted in Fig 2.3.10.1.

Significant variation of larval population was noted among three cropping systems and treatments. The reduction of pest population was higher in chemical and integrated treatments and was at par with each other. The rest of the treatments also caused a reduction of larval population than the untreated check. The mean incidence larval population was lower in chemical and integrated treatments ($F_{5,34}$ = 199.6, $p < 0.05$) and was higher in in maize +cowpea intercropping system ($F_{2,34}$ = 16.20, $p < 0.05$) than sole crop of maize crop. The interaction between cropping systems and treatments was also significant ($F_{10,34}$ =3.88, $p<0.05$)

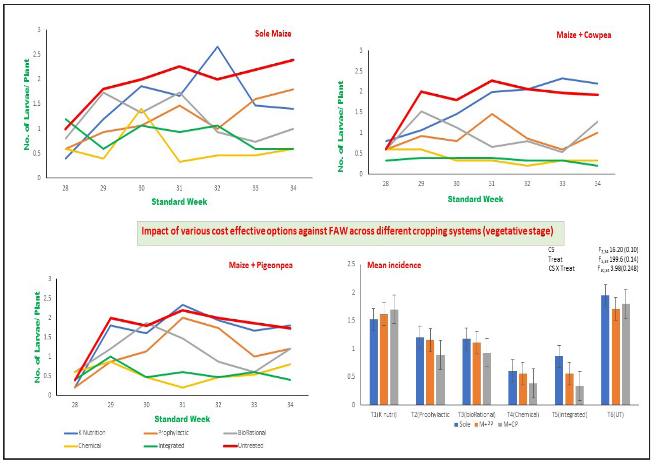


Fig.2.3.10.1. Impact of various cost-effective pest control options against S. frugiperda across different cropping systems

2.3.11 ARIMAX- Artificial Neural Network hybrid model for predicting *semilooper incidence* on soybean

Field datasets of eight seasons of Maharashtra were used to study the influence of weather factors on soybean semi looper (*Chrysodeixis acuta*) incidence. Kendall's correlations revealed a significant and positive influence of maximum temperature (MaxT), MaxT deviation, minimum temperature (MinT), MinT deviation and rainfall (RF). Relative humidity (RH) negatively influences the pest. The multiple linear regression indicated the significance of MaxT, MaxT deviation, MinT deviation and RF accounting for only four per cent of variations in semi looper. Nonlinear models individually and in the hybrid mode indicated the best performance of hybrid of autoregressive integrated moving average with exogenous variable (ARIMAX) with artificial neural network (ANN). The non-linear models were evaluated based on statistical measures of mean square error (MSE) and root mean square error (RMSE). The proposed artificial intelligence-based non-linear ARIMAX-ANN model has the potential for forecasting the current week's semi looper incidence on soybean one week in advance based on weather factors of the previous week across Maharashtra. ARIMA-ANN hybrid methodology is given in Fig. 2.3.11.1.

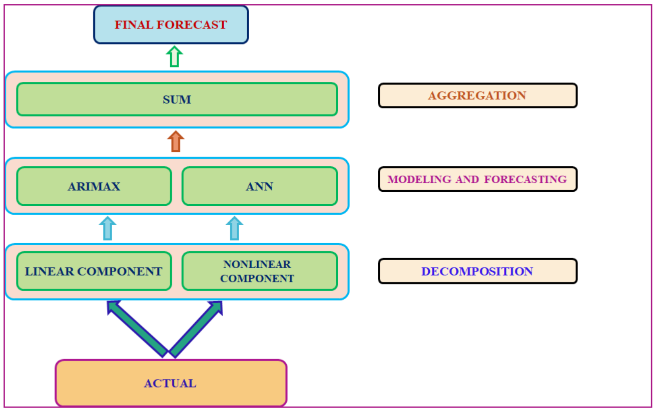


Fig.2.3.11.1 Schematic representation of ARIMA-ANN hybrid methodology

2.3.12. Rhizo-microbiome of rainfed crops under semi-arid region of India

A pot experiment in groundnut (cv. K-9) was conducted under rainout shelter to assess the effect of different levels of moisture stress on soil microbial population, plant growth and physiological parameters.

Population of different functional groups of soil microorganisms

Enumeration of culturable soil microbial populations such as bacteria, fungi, actinomycetes, phosphorus solubilizing bacteria (PSB), free-living nitrogen-fixing bacteria (NFB) and *Pseudomonas* spp. was done using suitable growth media. The population of PSB, NFB and *Pseudomonas* spp. decreased as the level of soil moisture content decreased from 20.6 to 4.9 per cent. The population of PSB was lowest at 4.9 per cent soil moisture content (Fig. 2.3.12.1.).

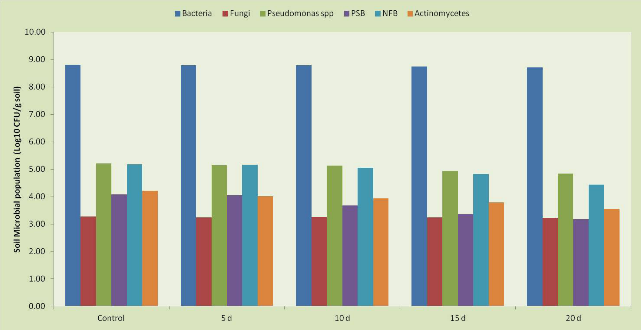


Fig 2.3.12.1. Effect of soil moisture stress on culturable soil microbial population

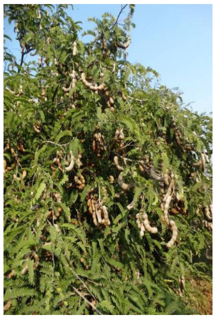
***PSB-Phosphorus solubilizing bacteria, NFB- free-living nitrogen-fixing bacteria**

Initial soil physico-chemical parameters such as available NPK and organic carbon contents were 182.37, 15.13, 215.10 kg ha^{-1} and 0.62 per cent, respectively. The soil was sandy clay loam in texture with a pH of 6.46. The soil moisture content at field capacity and permanent wilting point was 20.5 and 4.40 per cent, respectively.

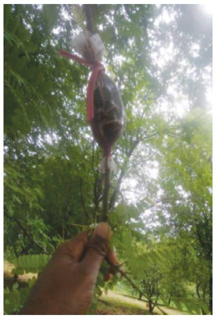
The soil moisture stress was imposed at 35 DAS (flowering) and 79 DAS (pod development). The plant parameters such as plant biomass, shoot length, the number of pods and pod weight were recorded. The plant biomass ranged from 40.25 to 310.75 (g/plant) and decreased substantially when soil moisture content decreased.

2.3.13. Collection and evaluation of tamarind germplasm from rainfed areas of Deccan and Bastar plateau

Systematic evaluation of 22-year-old 40 accessions of tamarind in the field at HRF was carried out for flowering, yield, and fruit characteristics. For the year 2021-22 flowering started from the first week of May-2021 and continued up to the end of September 2021. Out of 40 accessions evaluated at the HRF, 35 accessions, had flowering and fruit yield. The best promising accessions for the year 2021-2022 are BDM-3, Red, Vellore-29, KRMR, SMG-3 and Hasnur-5. There was staggered flowering in accessions like Hasnur- 3, PKM-1and NTI-85. In accessions like NTI-86, NTI -14, NTI- 42, NTI-60 and SMG-3 flowering was high but fruit set was very low. Observations recorded on pod characteristics revealed that average pod weight was higher in NZB (19.24 g) followed by Salem 132 (19.08 g), Hasanur #5 (18.59 g) and PKM (Red) (16.34 g) and the lower was noticed in CMK-6 (8.82 g) followed by KRMR (9.05 g Urigam CT 164 (9.37 g) and Red (9.42 g). The highest pulp weight per fruit was recorded in NZB (S) accessions (9.27 g) followed by Hasanur # 5 (9.24 g), Vantoor (8.93 g) and Salem-132 (8.72). Fibre weight per fruit ranged from 0.81 to 0.22 g and the higher was recorded in NTI-42 (0.81) followed by Vantoor (0.73), Prathistan (0.72) and BDM-3 (0.71) the lower was noticed in NZB (S) (0.22 g). followed by Salem 132 (0.24 g), Vellore#2 (0.25 g) and NTI-84 (0.32 g) which is a desirable trait from a commercial point of view. The total higher yield was recorded in NZB (15.72 kg/plant). As part of collection of germplasm from rainfed areas of Deccan and Bastar plateau. 20 trees from different places in Telangana were selected and among them four which were found to be promising based on the desirable traits were added to the germplasm block. By employing standard vegetation propagation by air layering about 180 plants of good performing accessions have been produced and these accessions are ready for plantation in farmers/ main field.



Best performance of BDM-3



Air layering

Nursery

2.3.14. Evaluation of multipurpose tree species based agroforestry systems

Under alternate land use and ecologically sustainable agriculture, a study was initiated on twelve multipurpose tree species (MPTS) based agroforestry system with finger millet (KMR 301) as an understory crop and stylos on the intra-spaces and bunds of the trenches between MPTs (Fig 2.2.14.1.). The trees (*Ailanthus excelsa*, *Bauhinia purpurea*, *Hardwickia binata*, *Butea monosperma*. *Dalbergia latifolia*, *Chloroxylon swetienia*, *Grewellia robusta*, *Pterocarpus santalinus*, *Syzygium cuminii*, *Azadirachta indica*, *Madhuca longifolia* var *latifolia* and *Tamarindus indica*) were selected on the basis for their ability to provide fodder, fuel and furniture and other forest products. The system is being evaluated under two modules viz., Silvi-Agriculture and Silvi-Pasture system. The main objectives of the study are to assess the performance of MPTS based agroforestry systems in terms of tree-crop/pasture interaction, fuelwood, fodder, timber and medicinal values and also to evaluate the livelihood support potential of different MPTS based agroforestry systems and their impact on natural resource base at farm level.

During 2021, results of grain yield finger millet (KMR 301) grown on the tree interspaces indicated that the finger millet grown under *Dalbergia latifolia* with staggered trenches produced maximum grain (KMR 301) yield of 2973 kg/ha and whereas, finger millet grown under *Madhuca longifolia* without staggered trenches produced the maximum grain yield of 3721 kg/ha compared to other tree species. Stylos grown under *Dalbergia latifolia* intra- spaces without trenches and on the bunds of the trenches produced maximum green fodder yield of 5148 and 3721 kg/ha, respectively compared to other MPTS (Fig 2.2.14.2.). The maximum quantum yield of PSII (Fv/Fm) and net rate of PS II Reaction Centre (RC) closure (Mo) was recorded in the understorey crop under all the tree species. In addition, photosynthetic photon flux density (PPFD) was also recorded under the trees and in sole crop stands. The maximum quantum yield of PSII (Fv/Fm) of ragi crop was seen under *Madhuca longifolia* (0.64) and was less than what was observed in sole crop stands (0.71) indicating that tree shade reduced the quantum yield of PSII. The net rate of closure of PS II Reaction Centre (RC) (MO) was more in the ragi plants under the tree shade in general with the plants in the sole crop stand. Photosynthetic Photon Flux Density (PPFD) was also reduced by tree shade and exhibited the highest reduction under *Azadirachta indica* and *Madhuca longifolia*. The least reduction in PPFD was seen under *Chloroxylon sweitiena* and *Pterocarpus santalinus*.

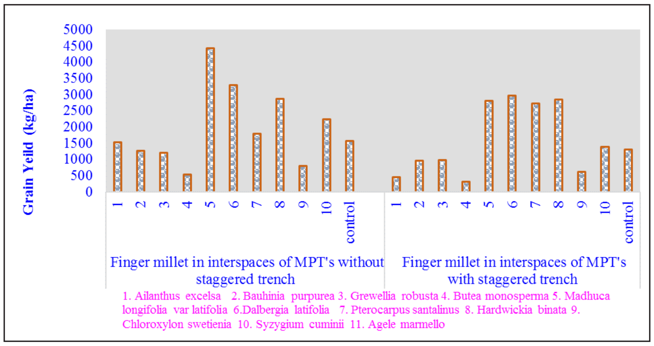


Fig 2.2.14.1 Finger millet (KMR 301) grain yield under different multipurpose tree species (MPT's) in dryland Alfisol

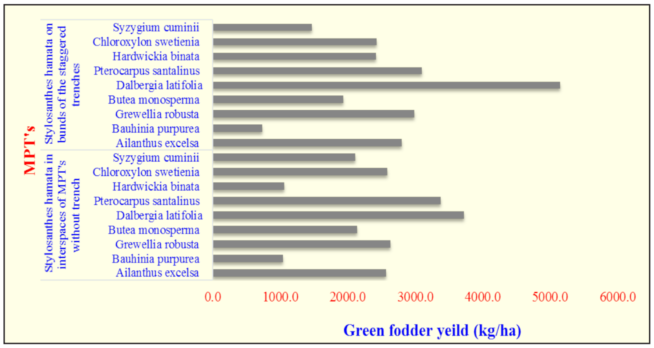


Fig 2.2.14.2. Stylosanthes green fodder yield from bunds and tree intra-spaces under different MPT's based agroforestry system grown with and without staggered trenches in dryland Alfisol

2.3.15. Evaluation of bamboo species suitable for Southern Telangana region

Bamboo in India is an exceptionally diverse plant group consisting of nearly 76 genera and 136 species. It encompasses about 8.96 million hectares of forest area, which is equivalent to 12.8 per cent of the total forest cover of the country. Bamboo is the fastest-growing, multipurpose plant and has several advantages over tree species in terms of sustainability; increase in green cover; provides various ecosystem services viz., carbon sequestration, preventing soil erosion and cultural rituals in rural areas. Bamboos have the potential to be incorporated into agroforestry systems in the semi-arid tropics in place of conventional tree species. The major user of bamboo in India is the paper industry. In addition, bamboo supports several traditional cottage industries, including the production of handicrafts, incense sticks, and related articles. So far systematic research on bamboo has been carried out in high rainfall/irrigated areas. Very limited work on bamboo has been done in dryland/rainfed areas for evaluating the performance of bamboo species. For extending bamboo cultivation, species suitability needs to be tested and evaluated for dryland areas of Southern Telangana for large scale promotion and adoption. Therefore, a research project entitled "Evaluation of bamboos species suitable for Southern Telangana region" was initiated to evaluate the growth performance of the bamboo species for its suitability under dryland Alfisols of Southern Telangana conditions. A study was initiated at Hayatnagar Research Farm in 2021 with three bamboo species (germplasm resources of TFRI, Jabalpur) viz., *Bambusa balcooa*, *Bambusa tulda* and *Bambusa nutans* under dryland Alfisol. The experiment was set up in randomized block design with four replications. For each species, 12 clumps (3 x 4; Rows x clumps) per replication was established at 8 x 8 m spacing. The recommended dose of fertilizer (RDF) was applied as recommended by National Bamboo Mission. The survival was 100 per cent after 06 months of planting. Initial observations on culm height, collar diameter and number of culms per species were recorded after planting. Initially, *Bambusa nutans* (99.21 cm) recorded higher average culm height followed by *Bambusa balcooa* (70.9 cm) and *Bambusa tulda* (61.4 cm); whereas *Bambusa balcooa* (0.80 cm) recorded a higher average collar diameter (0.80 cm) and total no of culms (82) followed by *Bambusa nutans* (0.59 cm and 68, respectively) *and Bambusa tulda* (0.52 cm and 52, respectively).

Fig 2.3.15.1. Evaluation of three different bamboo species (Bambusa balcooa, Bambusa tulda and Bambusa nutans)

2.3.16. Quantification and Valuation of Ecosystem Services from agroforestry systems in different rainfed agro ecologies

Studies have shown that agroforestry has the potential to maintain agricultural productivity, conserve biodiversity in agricultural landscapes as well as helps to mitigate climate change impacts. It has the potential to enhance soil fertility, reduce erosion, improve water quality, enhance biodiversity, increase aesthetics, and sequester carbon. However, a comprehensive analytical framework for quantifying and valuing ES is missing or is at infancy. The present study aims to develop total economic value (TEV) framework that takes into account both the use and non-use values. Therefore, a research project entitled 'Quantification and Valuation of Ecosystem Services from agroforestry systems in different rainfed agro ecologies' was initiated. This study is an attempt to answer the most pertinent question, what is the monetary value of the societal benefits of agroforestry systems. Eight ecosystem services were selected for valuation from three different types of agroforestry systems across different agro-climatic zones: regulating services such as soil quality, carbon sequestration and infiltration rate, etc and provisioning services such as timber, fruit, fodder, fuelwood, and grain. The major outcomes of the study were, the biometric observations of trees from agroforestry systems which were established at AICRPDA centres *viz.*, *Melia dubia* based system, Raichur, Tamarind and Sapota + Guava based systems, Vijaypura and Custard apple and Aonla based agroforestry systems, Bangalore, were recorded as per the standard procedure. The estimated amount of biomass kg/tree/year was (2.74), amount of carbon was (1.28) kg/year/tree and carbon dioxide absorption was (4.73) kg/year/tree in *Melia dubia* based agroforestry systems. The litter decomposition study was carried out at AICRPDA Bengaluru centre under Custard apple based agroforestry system and Aonla based agroforestry system.

Melia dubia based agroforestry system at Raichur

Tamarind based agroforestry system at Bijapur

Custard apple based agroforestry system at Bengaluru

Fig 2.3.16.1. Different Agroforestry systems present at the study area

2.4. Soil and nutrient management

2.4.1. Estimating the carbon sequestration potential of semi-arid soils using carbon saturation concept

A soil's ability to sequester carbon is finite and determined by the content of fine particles. Measurement of the carbon saturation capacity and the current extent of saturation of this capacity allows an estimation of the carbon saturation deficit, which represents the soil's potential for further C sequestration. A project was initiated in 2018 to determine the C sequestration potential of soils under different land use and management systems in semiarid climate. The carbon sequestration potential of the soils was estimated using existing relationships reported in world literature. One of the assumptions in the existing relationships is that organic carbon (OC) associated with <20 µm soil particles constitutes 85 per cent of the total organic carbon in the soil. This assumption was tested by separating the <20 µm soil particles from the bulk soil and determining the organic carbon in the <20 µm soil fraction. The actual proportion of OC in < 20 µm soil fraction to total OC in the soil ranged from 52.4 per cent to 87.4 per cent and was, in general, higher for cultivated soils compared to undisturbed soils with permanent vegetation. The carbon sequestration potential of the soils up to 40 cm depth, calculated using measured values of OC in < 20 µm soil fraction ranged from 5.73 kg/m^2 in native forest land-use system to 7.72 kg/m^2 in the cropping with large C input land-use system. Carbon sequestration potentials of the soils calculated using measured values of OC in < 20 µm soil fraction were, in general, higher than the potentials calculated using the 85 per cent factor which underestimated the C sequestration potential, especially for undisturbed soils under permanent vegetation. Carbon sequestration potentials (C saturation deficit) based on measured OC in < 20 µm soil fraction were generally higher for arable systems over cultivated systems, and for soil of 20-40 cm depth over soil of 0-20 cm depth (Fig. 2.4.1.1.).

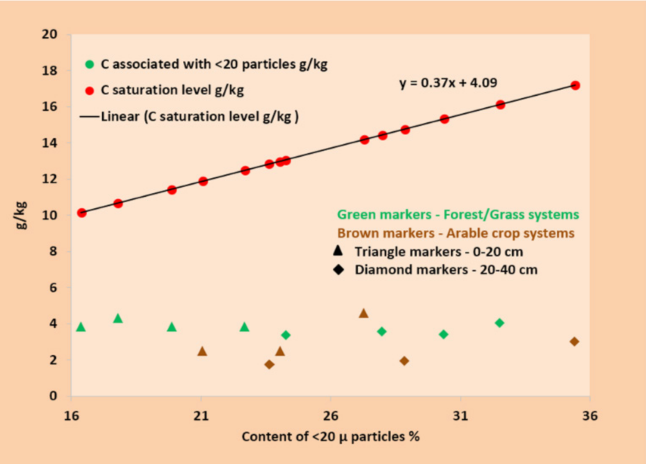


Fig. 2.4.1.1. Status of current saturation against potential saturation of 0–20 and 20–40 cm soil depths under different land uses.

2.4.2. Impact of conservation agriculture practices on soil physical properties in maize-pigeon pea crop rotation under rainfed Alfisols

A project was initiated in 2012 to develop sustainable tillage and nitrogen management strategies to improve the soil health of dryland farming system (maize-pigeon pea crop rotation) and farm productivity and profitability with three tillage practices (No-tillage, reduced tillage and conventional tillage) and four nitrogen levels (no-nitrogen, 75, 100 and 125 per cent RDN). This year pigeon pea crop was sown. Both tillage practices and nitrogen management did not influence the seed germination of pigeon pea. About 24.1 and 12.8 per cent significantly higher pigeon pea seed yield recorded in NT and RT as compared to the CT, respectively and about 10.1 per cent higher seed yield recorded in the NT as compared to the RT. The added level of nitrogen enhanced the seed yield significantly. The per cent increase over N-0 was 163.0, 204.8 and 231.6 per cent in N-75, N-100 and N-125 respectively (Fig. 2.4.2.1.).

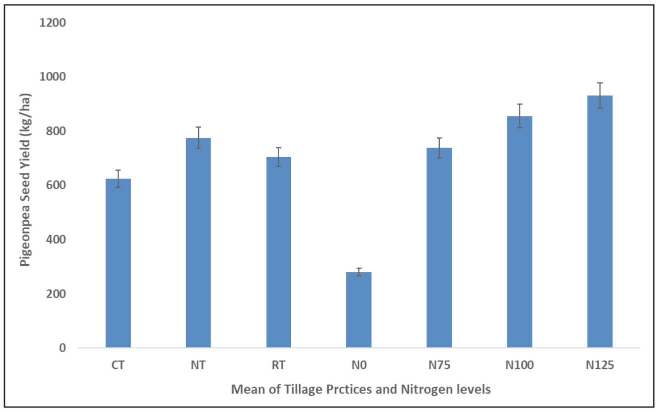


Fig. 2.4.2.1. Mean effect of tillage practices and nitrogen levels on pigeon pea seed yield (kg/ha).

The results on the analysis of the aggregate associated soil total carbon after seven years of the experiment revealed that it increased with decreasing the aggregate size fractions except 0.25-0.106 mm. The least total soil carbon is associated with the silt + clay fraction. Both tillage practices and nitrogen levels significantly influenced the aggregate associated total carbon. In different aggregate size fractions, 12.2-22.9 per cent and 5.6-10.6 per cent increase were observed in NT and RT, respectively as compared to the CT. The added levels of nitrogen significantly increased the aggregate associated total carbon. The increase was 16.4-29.1, 10.3-19.7 and 7.4-13.2 per cent in N-125 per cent as compared to respective N-0 in NT, RT and CT, respectively. The interactive effect of tillage practices and nitrogen levels was found non-significant in 4.75-2, 0.25-0.106 mm size classes, and silt + clay fractions. In other size classes, higher aggregate associated total carbon was observed under NT-N-125 per cent as compared to the other N-levels (Fig. 2.4.2.2.). In the below soil layers ie, 7.5-15, 15-30 and 30-45, the effect of the tillage and nitrogen management decreased.

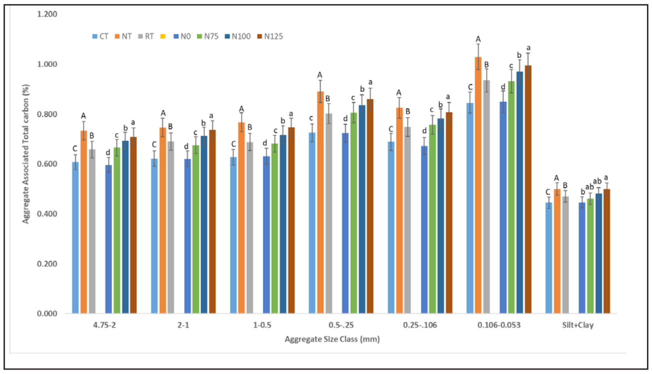


Fig. 2.4.2.2. Effect of tillage practices and nitrogen levels on aggregate associated carbon in 0-7.5 cm soil.

2.4.3. Assessment of soil quality and development of indices for predominant rainfed areas of Karnataka falling in AESR-6.2 under different crops and cropping systems

The soil samples were collected at the grid point of 20X20 km from the five districts of Karnataka ie, Raichur, Bijapur, Yadgir, Kalaburagi (Gulbarga) and Bidar. The collected samples were analysed for various soil physical, chemical and biological parameters. In the study area of Bidar district, soil type ranges from deep black, mixed black, mixed to red soil and texture of the ranges from clay to sandy clay. In the study area of Bidar district the sampling points fall in the Bidar, Aurad, Balki, Basavkalyan and Humanabad taluka/tehsil. The dominant cropping system in the study area of Bidar district was pigeonpea-sugarcane, sugarcane-sugarcane, pigeonpea-soybean and pigeonpea-sorghum. The SQI (Soil Quality Index) and RSQI (Relative Soil quality Index) were calculated for different taluka/tehsil of Bidar district soil under different soil types and cropping systems. Across the soil type and cropping system, the order of SQI and RSQI in different taluks/tehsil of the Bidar district follows the order as Aurad (1.92 and 0.95)>Balki (1.58 and 0.78)>Basavkalyan (1.54 and 0.76)>Humanabad (1.28 and 0.63)>Bidar (1.24 and 0.61). In the Bidar district, the soil parameters viz. CEC, MBC, Ca + Mg, Mn, BD, Zn Ca, Cu S, K and B significantly contributed towards the SQI and RSQI. The per cent contributions were 19.1, 18.6, 18.2, 9.8, 7.2, 6.8, 6.3, 6.2, 3.7, 3.7, 2.2 and 2 per cent, respectively (Fig. 2.4.3.1.).

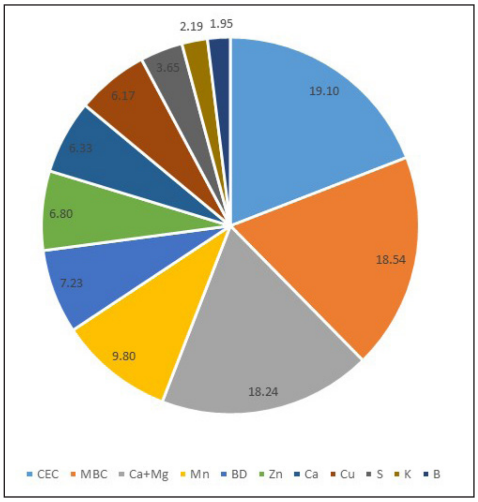


Fig. 2.4.3.1. Per cent contribution of the soil parameters towards the SQI

2.4.4. Effect of Ca-bentonite on soil moisture dynamics and availability of nutrients in semi-arid rainfed Alfisols

The application of the Ca-bentonite in semi-arid rainfed Alfisols can enhance the soil moisture dynamics, nutrient availability and crop yield. Therefore, a project on "Effect of Ca-bentonite on soil moisture dynamics and availability of nutrients in semi-arid rainfed Alfisols" was initiated this year. The different types of Ca-bentonite ie., reddish colour Ca-bentonite, yellowish colour Ca-bentonite, roasted Ca-bentonite, Ca-bentonite granules etc. collected from the various Ca-bentonite industries situated in the Vikarabad district of the Telangana State.

Different types of the Ca-bentonite

The basic soil physico-chemical properties of different Ca-bentonite were analyzed in the Soil Physics Laboratory. The pH in the different grades ranged between 6.5 to 7.7, the ECs ranged between 0.23-1.34 dS/m, OC ranged from 0.22-1.2 per cent, available nitrogen ranged 0.04-0.22 per cent, phosphorus 0.02-0.45 ppm, potassium 194-300 ppm, Zn 0.10 to 0.31 ppm, Mn 1.86-7.5 ppm, Cu 0.049-2.98 ppm Fe 2-8.3

ppm. The Ca content ranged 11-43 meq/L. The Mg content ranged 13.9- 39.8 meq/L. The total Ca+Mg ranged 32.5-75.1 meq/L. The clay content ranged 2.46-81.0 per cent, The sand content ranged 9.3-97.5, the silt content ranged 0.02-31 per cent.

2.4.5. Characterizing preferential flow in soils of semi-arid Telangana

Based on preferential flow fraction parameters were compared under different elevations and land use. The preferential flow advantage of forest land is more evident than that of fallow land. Middle and lower reach had heterogeneous matrix flow and fingering as major flow types in the surface while macro-pores with mixed interaction in the subsurface of the soil profile. It was also evident that the micro-watershed mainly comprises of heterogeneous matrix flow and fingering at the surface while at subsurface macro-pore flow with low and mixed interaction prevails. This suggests that subsurface soils are mainly responsible for spatial redistribution of flows and generating lateral flow than vertical flow.

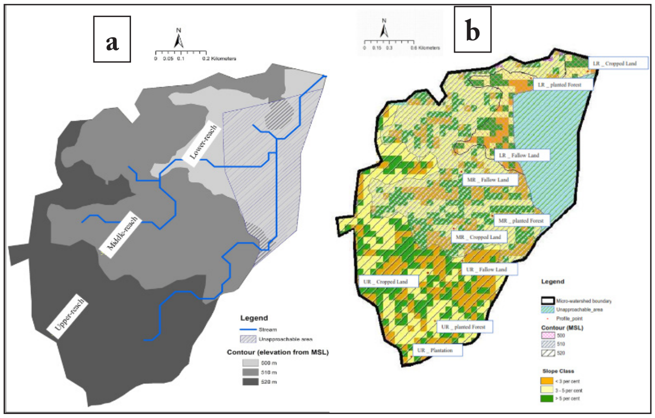


Fig 2.4.5.1 Hayathnagar micro- watershed a) elevation map, b) profile point selection map based on elevation and land use.

2.4.6. Zeolite characterization and its application effect on enhancing water and nutrient use efficiency in rainfed crops

An experiment was carried out to determine the N, P and K concentration and their uptake using N levels of 0, 40, 80 and 120 kg/ha and zeolite levels of 0, 2, 4 and 8 t/ha in maize crop. Zeolite application has increased the plant nutrient content and nutrient uptake as compared to control (Fig 2.4.6.1.). Among the N application rates, application of N @ 120 kg/ha has shown the highest uptake as compared to N application of 80 and 40 kg/ha. However, the N uptake was improved due to zeolite application as compared to without zeolite application. The application of N @ 120 kg/ha along zeolite application @ 4 and 8 t/ha improved the N uptake by 46.2 and 57.9 per cent over sole application N @ 120 kg/ha.

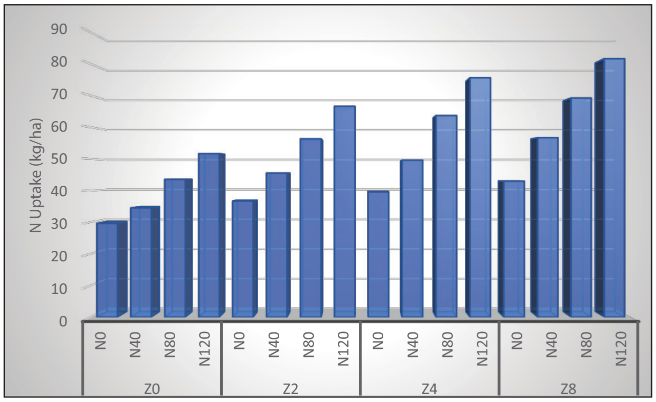


Fig.2.4.6.1. Mean N uptake in maize grown in Alfisols for 2 years (2019-2020).

2.4.7. Effect of polyhalite application on maize yield, nutrient use efficiency and GHGs emission under rainfed condition (External funded project)

A field experiment was initiated in *kharif* season of 2021 in Gungal Research Farm (GRF), ICAR-CRIDA, Hyderabad in Alfisol under the rainfed condition to study the effect of polyhalite (Poly4) ($K_2Ca_2(MgSO_4)_4.2H_2O$) application on maize crop yield, use efficiency of nutrients, soil properties, GHGs emission and economic viability. Significantly higher leaf area index, dry matter production at 30, 60 and 90 DAS, crop growth rate was observed in the recommended dose of NPK (75 per cent through Poly4+25 per cent through MOP) which was at par with 75 per cent N +100 per cent P +K (100 per cent K through Poly4) and recommended dose of NPK (100 per cent K through MOP).

Collection of GHGs from maize field

2.4.8. Potential role of in situ moisture conservation and nutrient management strategies for sustainable production and resource use efficiency in rainfed areas

An experiment was initiated to study the efficacy of different *in situ* moisture conservation treatments and fertilizer on crop productivity and resource use efficiency in cotton. The lint yield of cotton was influenced by *in situ* moisture conservation and fertilizer treatments CF at sowing recorded 31 and 30 per cent higher yield as compared to flat sowing and live mulch respectively. CF at 30 DAS recorded a higher yield as compared to flat sowing+live mulch. The crop yield was higher 125 per cent RDF as compared to 100 per cent and 75 per cent RDF. (Fig.2.4.8.1.).

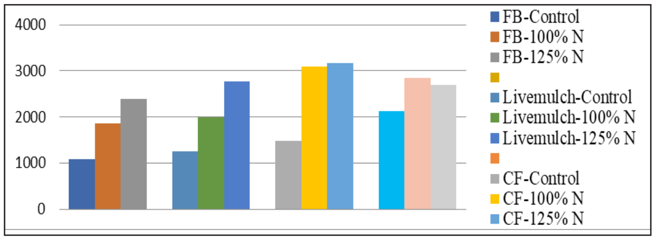


Fig. 2.4.8.1. Influence of different treatments on cotton yield (kg/ha)

2.4.9. Development and validation of CA practices for rainfed systems. (CRP- CA)

Field experiments were conducted at different locations, with different cropping systems, soil types, and rainfall. The experiments were conducted at ICAR-CRIDA, two AICRPDA centres (Bengaluru and Akola) and on-farm (two KVK and farmers' fields). The experiments were conducted on location-specific crops to develop CA technologies for different soil types and cropping systems. Some of the important findings are as follows:

1. At ICAR-CRIDA, a long-term experiment was initiated during 2013 on conservation tillage farming strategies and crop residue management for soil health improvement and higher crop productivity in the sorghum-black gram system in rainfed Alfisol. Treatments include two tillages practices viz. conventional (CT) and minimum (MT) and three residue retention treatments viz; no residue application (S_0), retaining the residue by cutting the crop at 35 cm height (S_1), retaining the residue by cutting the crop at 60 cm height (S_2) in case of sorghum. For black gram crop, the residue retention treatments were no residue (S_θ), 50 per cent residue retention (S_1) (clearing of residue from alternate rows), 100 per cent residue retention (S_2). Sorghum variety CSV 20 was grown in the year 2021. In the 9th year of the study, the grain yield of sorghum in the sorghum-black gram rotation was significantly higher with residue retention. The treatment with higher residue retention recorded 27.5 per cent higher sorghum grain yield (Fig.2.4.9.1.) and 24 per cent higher straw yield over no residue treatment. Grain yield with minimum tillage was not significantly different from conventional tillage. Sorghum was harvested at the base (S0), at a height of 35 cm (S1) and 60 cm (S2). The sorghum residue retained in the field was 1176 kg/ha in S1 and 1381 kg/ha in S2.

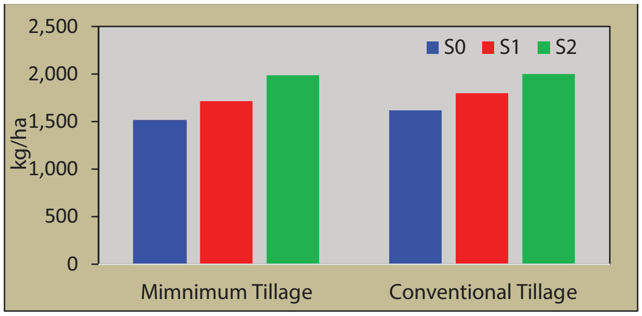


Fig. 2.4.9.1. Sorghum grain yield with tillage and residue management practices

2. At ICAR-CRIDA, experiment on "Evaluation of system productivity and profitability in major rainfed cropping systems under conservation agriculture practices (EF053) (CRP-CA) revealed that in pear millet-pigeon pea (and horse gram on residual fertility) based system recorded significantly higher pearl millet grain yield in

MT (2361 kg/ha) as compared to ZT and CT. Similarly, a higher yield was observed in 125 per cent RDF (2348 kg/ha). Pooled data of 5 years (2016-2020) revealed that significantly higher pearl millet equivalent yields were obtained in minimum tillage (MT) with 125 per cent RDF compared to zero tillage (ZT) and conventional tillage (CT) (Fig. 2.4.9.2.). The yield increase in MT was 14.6 per cent over ZT and 13 per cent over CT. There was a slight buildup of available N, P and K (kg/ha) with a progressive increase from the initial year 2016 current year. With regard to tillage practices, 13 kg/ha buildup of available N was observed in ZT as compared to 5 kg/ha in MT and 10 kg/ha in CT. In the case of available P, 0.7 kg/ha depletion of available P was observed in MT, whereas, in CT and ZT, a slight buildup was observed. Among the tillage and RDF levels, 2, 12, 13 kg/ha buildup of available K was observed in CT, MT and ZT respectively. Significantly higher N_2O emission was observed in CT followed by MT and ZT. Higher N_2O emission was observed in 125 per cent RDF followed by 100 per cent RDF and 75 per cent RDF. ZT required 12.6 per cent lower energy input over CT and MT. ZT recorded 23.27 per cent and 11.75 per cent higher energy output compared to CT and MT.

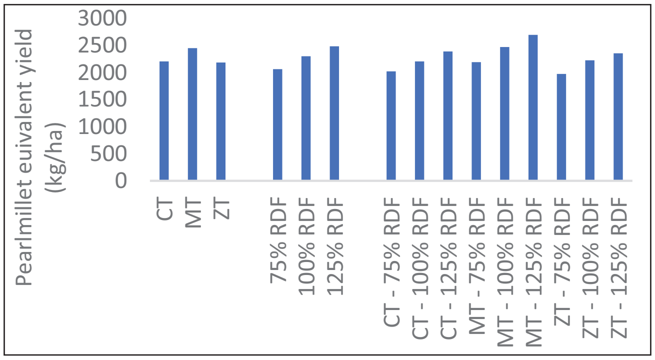


Fig. 2.4.9.2. Effect of tillage and different fertilizer doses on pearl millet yield.

3. In another set of the experiment based on the cotton-pigeon pea system, pooled data of 5 years (2016-2020) revealed that significantly higher cotton equivalent yield (CEY) was obtained with minimum tillage with 125 per cent RDF as compared to zero tillage (12 per cent increase) but at par with conventional tillage (Fig.2.4.9.3.). In a cotton-based system, significantly higher very labile and less labile C was observed in CT, but higher labile C was observed in ZT.

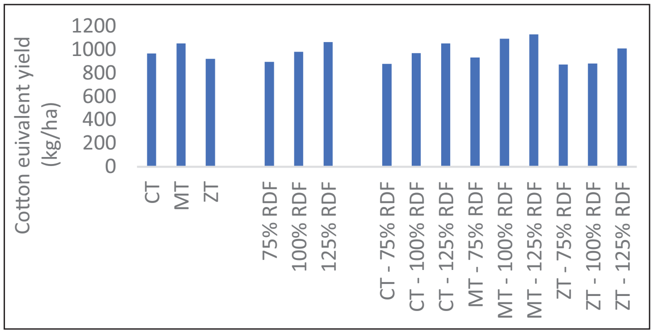


Fig. 2.4.9.3. Effect of tillage and different fertilizer doses on cotton equivalent yield

4. At ICAR-CRIDA, pigeon pea +setaria intercropping system was sown after castor on different levels of castor residues with different tillage practices like conventional tillage, reduced tillage and zero tillage, and different residue levels by harvesting castor crop at different heights (0 cm, 10 cm and 30 cm anchored residues height). In subplots, the intercrop foxtail millet was grown in 10 and 30 cm. The foxtail millet was also harvested at different levels. Results revealed that zero tillage recorded 20 and 18 per cent higher pigeon pea equivalent yields as compared to conventional and reduced tillage respectively. The pigeon pea equivalent yields in 10 and 30 cm anchored residue recorded significantly higher yield as compared to no residues. 10 and 30 cm height anchored residues recorded 55 and 54 per cent higher yield as compared to no residue. (Fig. 2.4.9.4.).

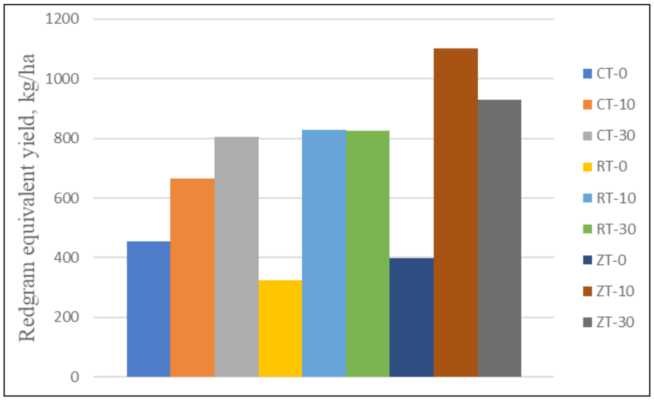


Fig 2.4.9.4 Influence of tillage and residue levels on red gram equivalent yield

5. At ICAR-CRIDA, the results of the experiment on the integration of *in situ* moisture conservation practice as complementary practice with CA revealed that conventional tillage without residues recorded the lowest yields. Integration of *in situ* moisture conservation practices either through conservation furrow or bed and furrow method in both CA and conventional tillage has recorded higher yield as compared to no moisture conservation treatments in both the crops. Among the conservation treatments, permanent conservation furrow recorded higher yields (Fig. 2.4.9.5.).

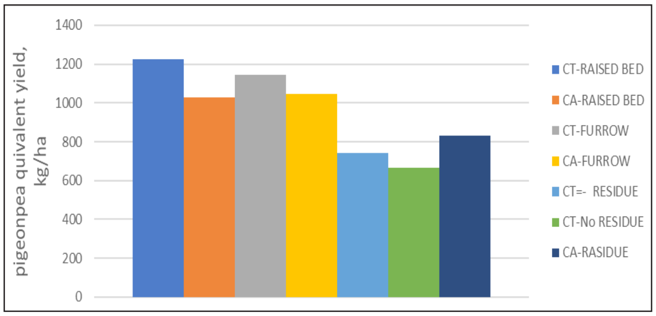


Fig. 2.4.9.5. Influence of tillage and residue levels on red gram equivalent yield.

6. At ICAR-CRIDA, results of the experiment on the integration of *in situ* moisture conservation and weed management practices as complementary practices along with CA revealed that integration of *in situ* moisture conservation practices through permanent bed and furrow, permanent conservation furrow recorded 19 and 10 per cent higher maize yields as compared to conventional tillage without moisture conservation treatment. Among the weed control treatments, pre-emergence + post-emergence herbicide application recorded higher yields as compared to other weed management practices. Reduction in crop yield in un-weeded treatment in ZT was higher than in CT (Fig. 2.4.9.6.).

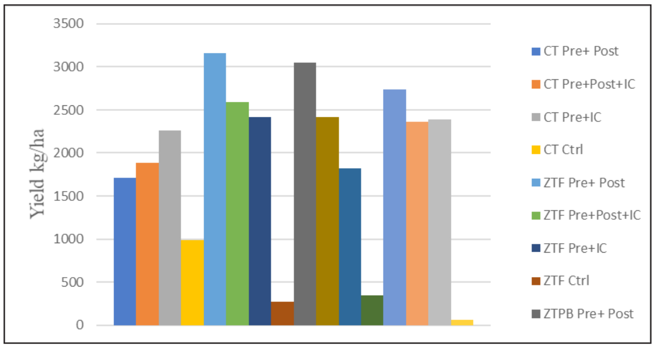


Fig. 2.4.9.6 Influence of different treatments on maize yield

7. In on-farm trials at KVK Yagantpalle in Kurnool district, the foxtailmillet + pigeonpea was sown. After harvest of foxtail millet, Bengal gram was sown in between the pigeon pea rows. The total system productivity was 30 per cent higher as compared to sole crops. In another experiment, Bengal gram sown on raised bed recorded 35 per cent higher yields as compared to conventional tillage without conservation furrow.

Pigeon pea + Bengal gram intercropping

2.4.10. Effect of foliar application of different nanofertilizers on nutrient use efficiency, drought stress tolerance, productivity and economics of rainfed crops

The use of nano particles (NP) in agriculture as nanofertilizers is gaining wide interest in recent times due to various advantages. These NPs are reported to improve crop productivity by influencing fertilizer nutrient availability in soil and uptake by plants. They are also reported to reduce the overall requirement of fertilizers thus reducing input cost and also increasing efficiency and thus contributing to climate change mitigation by reducing the environment impact. However, there is scarcity of information especially on effect of nanofertilizers on growth and yield of rainfed crops, nutrient use efficiency and on soil properties. A field experiment was conducted during *kharif*, 2021 at Gungal Research Farm (GRF) of the institute to study the effect of nano-urea, nano-Zn and Nano-Cu alone and in combinations with different doses of recommended NPK on rainfed maize. The recommended dose of NPKZn was 90:45:45:25 kg N,

P_2O_5, K_2O and $ZnSO_4$/ha. Nanofertilizers were sprayed @ 2 ml/liter water at 25 and 45 days after sowing as per the treatment. Application of recommended NPK + foliar spray of nano-urea + nano-Zn + nano-Cu being on par with recommended NPK + foliar spray of nano-urea + nano-Zn recorded significantly higher grain yield (3308 kg/ha) compared to other treatments.

A pot experiment was also conducted during *kharif*, 2021 to study the effect of nano-urea, nano-Zn and nano-Cu in various combinations with NPK fertilizers on the photosystem II dynamics and yield of maize. Photosystem II photochemistry which is given by Fv/Fm is a robust indicator of the efficiency of the photosynthetic system in the plants. The parameter was affected by the treatments in different ways. It was observed that the maximum quantum yield of Photosystem II photochemistry was observed with N sufficient and nanofertilizer spray treatments. The treatments N_{75}PKZn + nano-urea and N_{75}PK + nano-urea + nano-Zn showed the highest quantum yield of Photosystem II photochemistry among all the treatments, and it was translated into yield as seen in yield increase in these treatments. Nano-urea and nano-Zn were effective in maintaining optimum photosynthetic capacity in the absence of chemical supplemented N and Zn, respectively.

Performance of maize with application of N75PK + foliar spray of nano-urea and nano-Zn

Another field experiment was conducted during *kharif*, 2021 at GRF of the institute to study the effect of Nano-DP and Nano-Zn alone and in combinations with different doses of NPK on rainfed maize. The experiment was laid out in a randomized block design (RBD) with three replications. The recommended dose of NPKZn was 90:45:45:25 kg N, P_2O_5, K_2O and $ZnSO_4$/ha. Seed treatment with nano-DAP was also done for treatments involving nano-DAP application. Nanofertilizers were sprayed @ 2 ml/liter water at 30 days after sowing as per the treatment. The seed yield of maize differed significantly among the treatments. Soil application of Zn @ 25 kg/ha along with 100% recommended NPK had no significant effect on yield (2290 kg/ha) compared to application of recommended NPK alone (2269 kg/ha). Application of Nano-DAP with $N_{75}P_{75}$KZn (2363 kg/ha) and $N_{100}P_{100}$KZn (2409 kg/ha) resulted in significantly higher grain yield compared to recommended dose of fertilizer without Nano-DAP ($N_{100}P_{100}$KZn) (2290 kg/ha). $N_{75}P_{75}$KZn with Nano-DAP recorded about 26.2% higher grain yield compared to that under $N_{75}P_{75}$KZn. In addition, the grain yield of maize further increased when Nano-DAP was applied along with Nano-Zn. The treatment $N_{75}P_{75}$K + Nano-DAP +Nano-Zn produced grain yield of 2450 kg/ha whereas application of $N_{100}P_{100}$K + Nano-DAP +Nano-Zn produced grain yield of 2443 kg/ha.

2.4.11. Effect of POLY4 on yield and quality of rainfed groundnut and on soil properties in Telangana and Andhra Pradesh

Like other crops, groundnut also requires all the essential macronutrient (N, P, K, Ca, S and Mg) and micro-nutrients (Fe, Mn, Zn, Cu, B and Mo) for proper growth and development. Besides conventional fertilizers, other multi-nutrient compositions like Ploy4 (polyhalite) ($K_2SO_4.MgSO_4.2CaSO_4.2H_2O$) could be potential sources for nutrient management in groundnut and for maintaining/restoring soil fertility. Polyhalite is a natural combination of four (K, S, Mg and Ca) of the total six essential macronutrients required for growth and development of plants. It has 14% K2O, 19% S, 6% MgO and 17% CaO. Information on optimum rate of POLY4 in groundnut crop of Andhra Pradesh and Telangana would help in reducing the need for chemical fertilizer use, improve the groundnut productivity and soil properties. A field experiment was conducted during *kharif*, 2021 at GRF to study the effect of POLY4 in combination with different doses of recommended NPK and gypsum on rainfed groundnut. The recommended dose of fertilizer was 20:40:50 kg N, P_2O_5 and K_2O/ha. All the nutrients except gypsum were applied as basal at the time of sowing. Gypsum was applied at flowering stage of the crop as per the treatments. Application of recommended NP + 100% recommended K through POLY4 being on par with recommended NP + 100% recommended K through POLY4 + gypsum 310 kg/ha (2367 kg/ha) and recommended NP + 50% recommended K through POLY4 (2283 kg/ha) recorded significantly higher pod yield (2406 kg/ha) compared to other treatments (Fig 2.4.11.1.). Similarly, Application of recommended NP + 100% recommended K through POLY4 recorded higher plant height (43 cm), 100-seed weight (39.7 g), harvest index (0.54) and shelling % (69.6). However, haulm yield (2239 kg/ha) was higher with application of application of recommended NP only compared to other treatments.

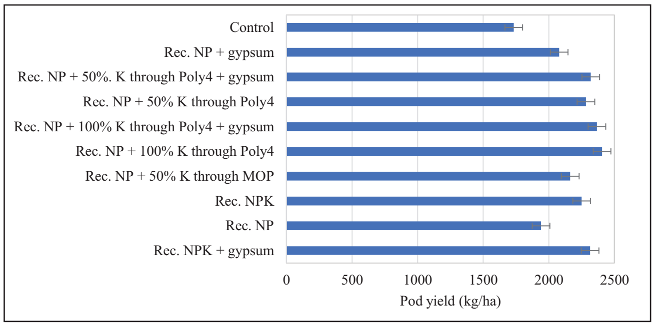


Fig. 2.4.11.1 Effect of treatments on pod yield of groundnut

Performance of groundnut with application of rec. NP + 50% K through POLY4 + gypsum @ 310 kg/ha

2.5. Energy Management

2.5.1. Development of resource-efficient and crop-specific farm machinery for rainfed farms

Development of an autonomous platform for weed removal in the raised bed planting system

As the autonomous platform is designed to operate in raised bed planting system and it requires structure versatility to attend to all the terrain situations in the field. For this application, a platform was designed with four wheels which will run in between two side by side furrows and the bed will come underneath the frame, so that crop damage can be avoided. The mechanical structure can be separated into three parts *viz.*, 1. Main rigid frame 2. Drive wheels 3. Steering wheels. The drive wheels comprise an agricultural lug tire with dimensions of 3" x 12" powered by 350 W DC motor as a propulsion system. Front wheels are steering wheels oriented along the vertical axis whereas the rear wheels are meant for driving the machine which is fixed on a horizontal shaft. The steering system is powered by a high torque motor which acts as an actuator based on the signals received from the ultrasonic sensors. It consists chain sprocket mechanism connected to the wheel axis shaft, which drives a sprocket and rotates the wheel vertically. The steering system allows the wheel an orientation from 0° to 360° in clockwise and anticlockwise direction but it is programmed as per field requirement. This range is enough to turn the platform 180 degrees at the end of the bed and get the straight-line position in the next furrow.

Development of tractor mounted harvester for maize and sorghum crops

A Power Take-Off (PTO) drive consisting of a rotating blade assembly, vertical drum conveyor and vertical flat conveyor operate the modified harvester. The rotating blade assembly of the harvester consisted of four blades covering 1300 mm width of operation whereas the vertical conveyor assembly consist of four vertical cylinders fitted with fins on its periphery. Moreover, five crop guiders were also fixed for guiding the plants inside. The rotational speed of the blade and drum can be varied using PTO speed and gear arrangements. The conveyor assembly can carry the stems to a side without the forward dropping.

Working principle of developed harvester

The newly developed harvester is divided into three parts i.e. counter-rotating blade assembly, vertical drum conveyor and vertical flat conveyor. The crop guide (rotary drum) present in front of the machine guide the crop towards the rotary cutter. The rotating blade assembly consisted of three/four rotary blades on one circular disc. After cutting, a vertical roller equipped with fins conveys the crop towards the windrower. Vertical drum conveyor assembly consists of four vertical cylinders fitted with a star wheel on its periphery.

The developed harvester was mounted at three-point linkages for testing purposes. The foremost operation to be performed by the sorghum harvester is to cut the sorghum stems without letting the stems fall in the forward direction. The second operation is windrowing of cut stems. The performance of the harvester was evaluated on maize crop during *kharif* season at Industry farm near Pune. The average height of the crop was about 1.6 m and row to row spacing is about 45 cm. The developed prototype was operated at different forward speeds 1.0-2.2 km/h. It was observed that cutting efficiency increased with an increase in blade rpm from 650 to 850 rpm. This may be due to the increasing impact of the blade of the stem. Further, a decreasing trend in cutting efficiency was observed with an increase in forward speed. This may be due to the lodging of the stem in front of the cutting blade. The best cutting efficiency of 80 per cent was recorded when the harvester was operating at 1 kmph and the rotational speed of the cutting blade was 850 rpm. Further, more crop lodging/bending was observed in front of the machine as speed increased. However, it is unable to stop the lodging of stems during its forward motion. Hence it is decided to further refine the prototype.

2.5.2 Development and performance evaluation of self-propelled reaper for harvesting of short and bushy crops

Reaper for harvesting of short and bushy crops was developed at Farm Machinery Research Workshop (FMRW) of ICAR - CRIDA, Hyderabad. Initial testing of cutting mechanism conducted on green gram crop. The average plant density of green gram varied between 35-42 plants per m and height varied from 20-30 cm at the time of harvesting. It was observed that the developed mechanism can cut the crop stems very smoothly with better cutting efficiency. Moreover, it cuts the stem from the ground level. Further, minimum grain loss was observed as compared to the conventional cutting mechanism. The manoeuvrability of the machine is good and one man can operate it easily. This prototype will be tested on other bushy crops like chickpea, soybean, horse gram etc.

2.5.3 Development of solar-powered mechanization package for small farm holders in rainfed system

Solar-cum-battery operated rotary weeder/tiller was developed at Farm Machinery Research Workshop (FMRW) of ICAR - CRIDA, Hyderabad and tested in the field. This was a modified version of rotary tiller over rotary tiller of 1 hp electric prime mover developed during 2020-21. The newly developed model consists of 1 kW DC motor, motor controller, accelerator (throttle), lead-acid batteries, and rotary unit. Each battery was of 12 V and 26 AMPs. A set of 4 batteries were connected in series to obtain 48 V supply to the DC motor. The motor controller regulates the speed of the rotor in the range of 40 to 120 rpm through an accelerator for a given power transmission mechanism without load. Motor controller also facilitates reverse and forward motion of rotary tiller while in-field operation.

Solar-cum-battery operated weeder was tested in the field. The performance of the machine was varied with (i) soil moisture (ii) soil type (iii) weed density and (iii) operating speed. With full charged batteries, the operational speed obtained was 0.3 m/s. Performance in favorable operating conditions gives 84-92 per cent weeding efficiency as against 51-64 per cent in non-favourable conditions. Machine with fully charged batteries with good soil moisture (≤ 12 per cent) gives better weeding efficiency due to better tilling depth and soil inversion. In favourable conditions, tilling depth obtained was up to 5 inches. The operational speed decreased as the charge of batteries decreased. It was observed that the newly developed battery-operated weeder worked for 20 min and an area of 0.012 ha was covered. After that speed was drastically low and it needed charging. To overcome these limitations, continuous charging on solar power is thought to be an alternative option. Identification and design of suitable charge controller to 1 kW DC motor helps to operate the machine with constant power supply either directly from solar power or through batteries and its testing for field operation is in progress.

Solar-cum-battery operated weeder in operation

2.5.4 Development and performance evaluation of intra row weeder cum basin lister for tree-based dryland horticultural crops

The machine tool frame was developed in the previous year with hydraulic system main components and hydraulic tool kit circuitry was synchronized with the weed inflorescence biomass shredding tool. This tool has three main components, a 75 cm length and 32 mm diameter rotating shaft, a hydraulic motor with a bell coupler fitted at one end of the shaft and a concave covering the rear side of the rotary shaft with L angle support frame. Different types of working elements like flexible nylon rope, rubber stripe and swinging knife blades about 35cm in length one at a time could be fitted to the shaft to shred the inflorescence depending on the type of weed species. The shaft rotates upto a maximum 1500 rpm in clockwise as well as anti-clock directions. The hydraulic supported tool has an advantage over the mechanical tool, avoiding winding and entangling of slender stems of gross species, twigs of shrubs making the working elements more effective and faster in operation. The developed tool has been tested in the shredding of *Celosia argentea* Silverweed species and performance was found satisfactory.

Machine in field operation

2.6. Socio-economic studies

2.6.1. Farmer centric natural resource development for socio-economic empowerment in rainfed areas of southern Telangana region (Farmer FIRST)

The Farmer FIRST approach focuses on participatory innovations and resources combined with science and technology for higher productivity, profitability and increasing income of farmers. Module-wise major activities carried out is listed below.

Crops and Cropping Systems

Field demonstrations on soil test based balanced fertilizer application in chickpea

About 550 soil samples were collected from farmers' first villages during the last 4 years (2017 to 2020) and analyzed for different soil properties and available nutrients. These results were presented in Soil Health Cards and distributed to farmers of different villages every year along with soil test-based fertilizer dosages to major crops. The results of soil testing showed that about 32-51 per cent of soils were deficient in available Zn in Pudugurthy, Rakamcherla, and Thirumalapur villages. Almost all soils of these villages were low in available N and low to medium in available P. Almost all soils were medium to high in available K. Despite, widespread deficiency of Zn in the villages, farmers are applying only N and P. Therefore, field demonstrations (FLDs) on soil test based balanced fertilizer application in chickpea on eight farmers' fields were conducted in Pudugurthy village. The balanced fertigation (26-60-0-5: kg N-P_2O_5-K_2O-Zn/ha) produced 43per cent higher chickpea seed yield over the farmers' practice (22.5-57-0-0: kg N-P_2O_5-K_2O-Zn/ha) (Table 2.6.1.1).

Table 2.6.1.1. Response of rainfed chickpea (var NBeG 47) to balanced fertigation on farmers' fields

S.No	Farmers	Chickpea Seed yield (kg/ha) (2020-2021)		Increase in BF over FP
		Farmer's Practice (FP)	Balanced Fertigation (BF)	
1	S Chandraiah	750	1250	500
2	S Kistaiah	1000	1550	550
3	Ch Narsimlu	1000	1630	630
4	Vadde Ramesh	750	1250	500
5	N Mallesh	1000	1250	250
6	P Ramakrishna	1000	1380	380
7	Telugu Ravindar	1000	1000	000
8	Telugu Balayya	1050	1500	450
Mean		**943.8**	**1351.2**	**407.4**

Field demonstrations on chickpea at Pudugurthy village

Soil fertility status of Pudugurthy and Gangupally villages

Soil samples were collected from 30 farmers' fields in Pudugurthy village and 36 farmers' fields from Gangupally village in May 2021, were processed and analyzed for soil fertility status. Using the soil test data, Soil Health Cards were prepared and distributed to farmers at Gangupally village on World Soil Day (5th December 2021). The soil test data indicated that almost all soils were deficient in available N in both villages. As expected, soils of both the villages were high in available K. Importantly 70-80 per cent of soils in these villages were low in available S. Therefore, field demonstrations are being conducted on farmers' fields in the *rabi* season of 2021-22 on chickpea to demonstrate the beneficial effect of S application along with N and P. Boron deficiency was also widespread in soils of both the villages which may attribute to the growth of vegetable crops in the area. Most of the soils were high in available phosphorus. So, a need was felt to conduct field demonstrations on utilization of accumulated P (residual P) in the soil through reduced fertilizer P dose and/or INM with PSB without affecting crop productivity which would help in reducing the cost of cultivation and enhancing the net income of farmers.

World Soil Day Celebrations in farmer FIRST village

Small farm mechanization

After thorough interaction with the farmers of the cluster, seven types of need-based implements/machinery have been identified such as dryland weeders, self-propelled weeders, bullock drawn weeders, brush cutters, crop stalk shredder, disc harrow, and nine/six-row planter which were procured and demonstrated to farmers during the crop season.

A nine-row planter was widely used to sow maize and pigeon pea intercropping systems. There was good crop stand when maize-pigeon pea crop sown with nine-row planter. Small hand weeders were operated in farmers' fields that help in the reduction of drudgery and improve field capacity. Farmer's feedback was positive. Demonstration with a manually operated hand weeder in maize crop provided important feedback about its use in black soils.

Using 9-row planter at farmer's field

Livestock management and production

Promotion of backyard poultry varieties (Srinidhi and Vanraja)

A total of 40 SC women farmers of Gangupally village, Pudur mandal were covered under this intervention.

Five adult birds of both varieties were given to them which resulted in an improved profit of Rs. 5,124 per household and an increased protein intake of 12.7 per cent per household.

Area-specific mineral mixture supplementation in small ruminants and dairy animals

A total of 55 farmers were covered under this intervention in Gangupally and Pudugurthy village. An overall increase of 11.5 per cent in ADG (equivalent to a net profit of Rs 345 per animal) was observed in goats and an overall increase of 8.7 per cent in milk yield (equivalent to a net profit of Rs 1740 per animal) was observed in dairy cows.

Promotion of mineral licks in small ruminants

A total of 12 goat rearing farmers in Gangupally village were covered under this intervention which resulted in negligible kid mortality (2 per cent) and improved growth rate (4.87 per cent in ADG) equivalent to a net profit of Rs. 118 per animal. One block was sufficient for a herd of 5 goats for 2 months.

Improved fodder production and management (Co-4 and Super Napier)

Twelve farmers from Pudugurthy village were covered under this intervention which resulted in a yield of 175 t/ ha which has a potential to support almost 200 sheeps.

Training and distribution of backyard poultry to women farmers

Distribution and offering mineral mixture to animals

Distribution of mineral lick to goat rearer

Monitoring growth of Super Napier in the Pudugurthy village

Compost evaluation using poultry litter

An integration of inter-institutional project on compost evaluation using poultry litter was carried out at farmer's field where poultry litter was added with dry leaves/wood chips/rice hulls with or without vermicomposting (total 11 products with C/N ratio 25 to 35) in Devenoniguda village, Pudur Mandal, Vikarabad from 3rd July 2021 to 5th September 2021 (65 days duration WGG-45 variety of green gram). The results were also compared with RDF and Farmer's practice. All fortifications were found to be at par in terms of the performance of crops in the field. The best combination was found using rice hulls and vermicomposting with C/N ratio 25-30.

Plotting of experiment

Lush green gram crop at farmers field

Social Network Analysis for information flow in FFP adopted villages

A study was carried out to map the flow of information and social network structures along with its properties in farmer first adopted villages, Social networks in villages are generally untapped, needed to be used mainly to understand the extent of dissemination of technological information and key informant identification. The findings reported from social network analysis:

Table 2.6.1.2. Whole network properties for information network

Whole network properties	Gangupally	Rakamcharla	Pudurgurthy	Devononiguda
Deg centralization	0.212	0.157	0.102	0.229
In degree centrality	0.220	0.153	0.070	0.197
Out degree centrality	0.077	0.049	0.050	0.079
Avg distance	3.147	3.397	2.790	2.970
Avg degree	1.773	2.150	1.519	2.306
Density	0.041	0.036	0.030	0.066

The results of the study indicated that fellow farmers (friends) and progressive farmers were the most important sources of information regarding agricultural technologies (Table 2.6.1.2). The villages which are easily accessible to Hyderabad city (Gangupally, Devanoniguda and Rakamcharla) have a less dense network and heterophilous in comparison to interior villages that showed dense homophilous (Pudugurthy). The outcome helped to design interventions at village level.

Impacts of COVID on Agriculture and farming community

The effect of COVID during the first and second wave followed by lockdown was studied in FFP villages. For the study, thirty farmers were selected following simple random sampling from 4 FFP villages namely Gangupally, Rakamcharla, Pudurgurthy and Devoninguda. The data were collected using a structured questionnaire. About 38 per cent of the farmers responded that marketing and transportation of the produced were severely affected during the pandemic followed by intercultural operations (25 per cent and application of plant protection measures (Figure 2.6.1.1.). Horticulture (46 per cent) was the most affected sector during COVID 19. The study also showed that there was about 38 per cent increase in the wage rate of men and a 40 per cent increase in the women's wage rate before COVID and after one year of pandemic. The findings on the perception of farmers towards various agricultural activities

(Figure 2.6.1.2.) showed that about 42 per cent of the farmers expressed that the agricultural activities were much reduced (10-50 per cent) during the pandemic and subsequent lockdown while 81 per cent felt that employment opportunities reduced in the same ratio. After the first wave about 55 per cent of the farmers perceived the prospects for the next agricultural season as poor. The majority of farmers (56 per cent) had their income reduced by 50 per cent during the first wave and had to take loans for covering their expenses.

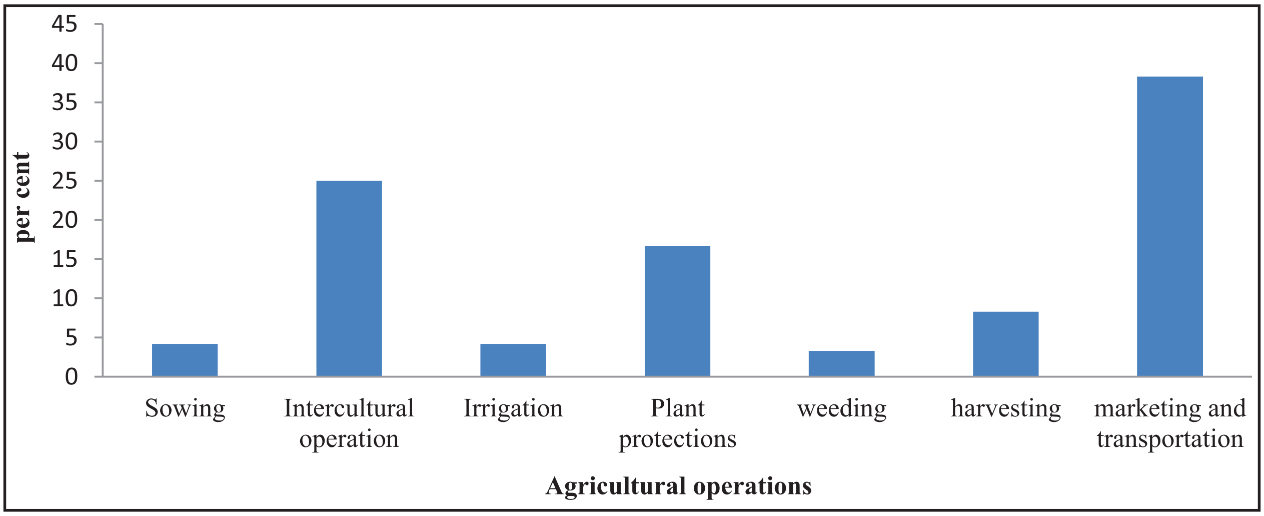


Fig.2.6.1.1. Agricultural operations being affected during COVID 19 and lockdown

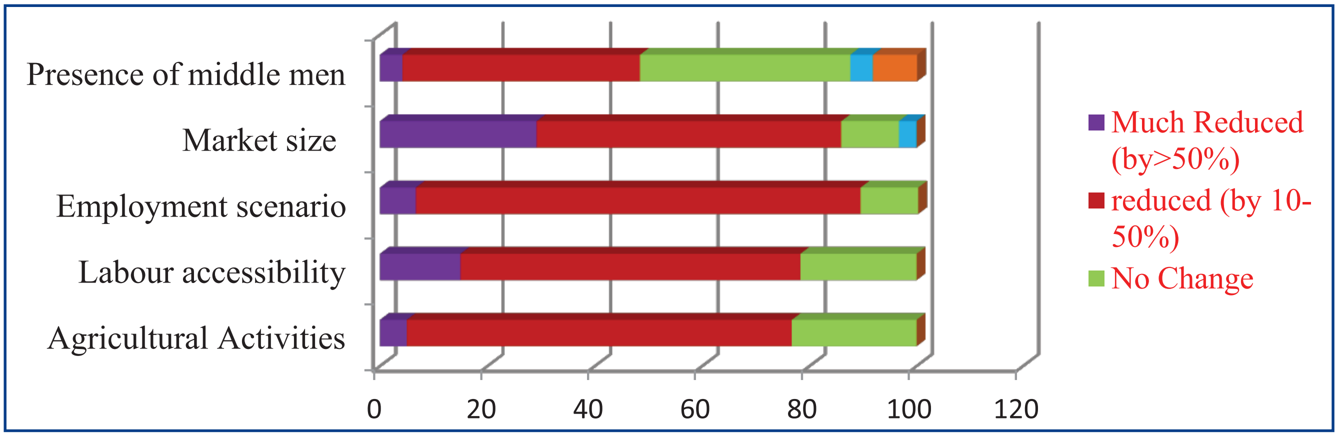


Fig.2.6.1.2. Perception of farmers towards agriculture-related activities during the pandemic

Extension Activities

Celebration of International Woman's day in farmer FIRST village Gangupally

On 8th March 2021 celebrated International women's day in Gangupally village. Mrs Sai Geeta, entrepreneur on Jute Bags and Mrs Ramadevi, President, Farmer Society motivated women to develop entrepreneurship activities and shills for economic empowerment. Seventy women participated in the program.

Exposure visit of Farmers First Project (FFP) farmers to organic farm

An exposure visit was organized for Gangupally (FFP) village farmers (20) to Organic field (fruits and vegetables) of Sri. P. Manoharachary, Padmaram village, Ranga Reddy district on December 23, 2021 commemorating 75 years of Independence to India (Azadi ka Amrut Mahotsav). The Theme of the Day was "*Jai Kisan-Jai Vigyan; Uttam Kheti-Unnat Kisan*." Sri. Manoharachary holding 4 acres, is cultivating Papaya on 2 acres, Onion and Garlic in one acre each, organically in black soils. He is preparing *Panchagavya,* a mixture of cow milk, curd, ghee, urine, dung in a shed near his field. Also, he is adding jaggery, banana fruit, liquid tobacco, yeast mixture to make it *Jeevamritam.* This *Jeevamritam* is applied to fruits and vegetable crops in his field. It costs him Rs. 75/- to prepare one litre of *Jeevamritam*. He is also selling this liquid mixture to farmers in Telangana, A.P. and Bangalore regions. Net profit from the sale of this mixture is Rs. 20/- per litre. The cost of Papaya cultivation is Rs. 70,000/acre in this way. The net profit he gets from the sale of Papaya is Rs. 4 lakhs/acre**.** Papaya grown organically fetches nearly double price in the market when compared with normal papaya. Farmer imparts training to other district farmers namely Khammam, Adilabad and Karimnagar districts in Telangana; and Vijayawada and Visakhapatnam in Andhra Pradesh.

Awareness campaign organized on Organic cultivation of crops, fruits and vegetables to the farmers

A group of 30 Farmers from the villages of FFP Pudur mandal had taken up Organic cultivation fields in August 2021. Farmers were exposed to organic cultivation of different crops, different methods to control pests and diseases, soil health and nutrition by organic means. Organic production essentially excludes the use of many inputs notably synthetic pesticides and fertilizers. To the maximum extent possible, organic farming relies upon crop rotations, crop residues, animal manures, legumes, green manures, off-farm organic wastes, mechanical cultivation and biological pest control. These components maintain soil productivity and tilth, supply plant nutrients and help to control insects, weeds and other pests.

Farmer named Manohara Chary from village Padmaram, near Parigi mandal of Vikarabad district, shared all his experiences in organic cultivation of guava, papaya, banana, sugarcane and vegetable crops to the fellow farmers. He also explained how to prepare different organic products like Ghana Jeevamrutham by mixing fresh desi cow dung, desi cow urine, water, jaggery, besan flour, and fertile soil in a certain proportion and letting it ferment for 48 hours. Panchagavya is prepared with nine ingredients viz. cow dung, cow urine, milk, curd, jaggery, ghee, banana, Tender coconut and water.

Mahila Kisan Diwas in Farmer FIRST village

Aa part of Azadi Amrut Mahotsav Mahila Kisan Diwas was organised on 14th October 2021 in farmer FIRST Village Pudur Mandal. The theme of the year was 'Equity and empowerment' Speaking on the occasion Chief guest Dr Sarah Kamala, ACRP Home Science Chief Scientist highlighted the importance of women in agriculture and their role in farming. 100 farm women participated in the event.

Dr Sarah Kamala, Scientist addressing participants

2.6.2. Behavioral surveillance of farmers in the wake of COVID 19: A psychosocial study

The present study was conducted in Rangareddy and Vikarabad districts which are surrounding Hyderabad. These districts supply vegetables, fruits, flowers (Horticultural products) and dairy products to Hyderabad in large quantities. Two Mandals from each district were selected randomly. Subsequently, two villages from each Mandals were selected using random sampling. Thirty farmers from each village were selected randomly hence constituting a sample size of 240 farmers. The objectives of the project were to assess the knowledge, attitude and perception (KAP) of farmers toward COVID 19, to study the psychological distress among the farmers due to COVID 19 and to examine the Communication behaviour and adoption of the preventive measures during and after the outbreak of COVID 19. The findings of the study showed that the first source of information about the pandemic showed that 68 per cent of the farmers received the information through the news on the television followed by 12 per cent from the family members through telephone. Knowledge of farmers towards COVID 19 showed that about 93 per cent of the farmers knew the main symptoms of COVID 19. Around 90 per cent of the farmers responded that wearing a face mask can help in the prevention of infection of COVID 19. Nearly 85 per cent of respondents knew that there was no effective cure for COVID 19 but early symptomatic and supportive treatment can cure can help them recover. But knowledge about the asymptomatic carriers was less. Attitude towards COVID 19 showed that the majority of the respondents had a positive attitude towards disease control and had faith in the government for control and management of the pandemic. Farmers were also in agreement that People with COVID 19 should not be given a negative stigma in society. Psychological distress among the farming population was assessed using Kesseler K 10 scale and about 76 per cent of the farmers experienced high to a very high level of psychological distress during the second wave of COVID 19.

2.6.3. Livelihood diversification strategies in rainfed areas of Telangana state

A study was undertaken to understand the livelihood diversification pattern adopted by farming communities cultivating rainfed crops in different rainfed regions of Telangana State. The study focused on objectives to identify the various options for household livelihood diversification, available with rainfed farmers with an estimation of diversification index and to determine the factors that influence livelihood diversification strategies. Respondents were selected from major rainfed crop cultivation areas. In the year of the report, pigeon pea growing farmers were selected from the high pigeon pea cultivating area of Telangana State (Table 2.6.3.1.). The high net sown area of pigeon pea reported in three mandals in divisions of Vikarabad district namely Tandur (97 per cent), Peddamul and Dharur have been selected in 2021. Ninety farmers constituted a sample of study comprising small, medium and large majorly cultivating pigeon pea crop and other crops on aspects of sources of family income received from crops, livestock, horticulture, remittances received from government schemes and other household activities.

The majority of farmers were small (70 per cent), followed by medium (20 per cent) and large (10 per cent) and cultivated a short duration pigeon pea variety of 150 days in *rabi* season on leased land. Sources of income for farm households ranged from crops, livestock and horticulture and less than 10 per cent of farmers are getting income from business and other non-farm activities.

Table 2.6.3.1. Pigeon pea cultivated area in 3 sample mandals of Vikarabad District

Mandal	Normal area (acres)	Actual pigeon-pea sown area 2021(acres)	Percent sown area
Tandur	18,979	18,659	97
Dharur	4927	8190	160
Peddamul	8486	11238	132
Vikarabad District Total area	1,46,589	1,69,656	115

Source: Agriculture Commissionerate, Telangana State

2.6.4. Dynamics of innovation-decision process for climate-resilient agriculture (CRA) technologies and practices in rainfed areas (TOT/RM/47)

The project was carried out with the objectives to assess the stages of the innovation decision process for the adoption of climate-resilient agricultural technologies and practices and to examine the relationship between the socio-economic, personality, and communication variables with stages of IDP. The research was carried out in two districts namely, Kurnool and Ananthpur selected purposively due to the implementation of agromet advisory services to the farmers. In Kurnool, three villages viz Yagantipalle, Mirapur and Chirolokuttur were purposively selected as AAS were provided to them by KVK, Yagantipalle. A total of 180 farmers were selected from Kurnool district. While two villages were purposively selected in Ananthpur namely Venododdi and Bachupally. A sample of 100 farmers was randomly selected for the study. The total sample size was 240. A conceptual framework known as Integrated Theory of Diffusion and Adoption (ITDA) has been proposed to study the dynamics of the innovation-decision process (IDP) in agromet advisory services (AAS) for the project. This framework integrates the recent theories of adoption in the Rogers Innovation of Decision Process.

In the knowledge stage, statistical significance was found between the way farmers got awareness about the agromet advisories between Kurnool and Ananthapur. In Kurnool, a majority (38 per cent) of the total farmers were informed by the fellow farmers about the AAS while in Ananthpur about 52 per cent (majority) got knowledge about AAS through the officials. The principle knowledge was low for both the districts but the extent of knowledge about the principle was quite low in Anantapur. This leads to either improper adoption of the message for discontinuation later. The dynamics at the persuasion stage indicated the presence of more than one opinion leader in social network analysis. Degree and betweenness centrality showed the predominance of opinion leaders in these districts. In the attributes of the innovations, the findings showed that result demonstrability and ease of use were the perceived characteristic of innovation found to be a significant factor in the adoption of AAS.

2.6.5. Evaluation of Communication Networks for the adoption of rainfed technologies – An experimental study

Adoption of agricultural technologies is an essential means for boosting agricultural productivity. Intensive leveraging of farmers' communication networks will be a time-efficient and cost-effective strategy to disseminate the technologies. These networks are particularly important to small-scale, resource-poor farmers, who tend to rely more on informal than formal sources of information. In this context, a project was initiated to evaluate the communication network for the adoption of rainfed technologies. The basic detail of the study area was collected from secondary sources. For facilitating primary data collection, an interview schedule has been prepared and pre-tested. A survey was undertaken to understand the different agricultural information needs of rainfed farmers in the Mahabubnagar district of Telangana state. A five-point Likert-type scale ('Not Important' to 'Very Important') was used to collect information needs of farmers on various aspects related to farming.

The study revealed that personal contact with line departments like the department of agriculture (83 per cent), followed by input dealers (78 per cent), friends and neighbours (76 per cent) and other progressive farmers (64 per cent) were the major sources of information contacted by most of the farmers. Modern ICTs (Mobile/Internet, Television) were also accessed by a large proportion of the farmers for information. Further analysis of the frequency of access to different information sources by the farmers revealed that ICTs (Mobile/Internet, Radio and Television) dominate the spectrum, followed by friends and relatives, departments, progressive farmers and input dealers. The frequency of access to KM/exhibitions field day, GD and meetings, field trips etc. were found to be very low. The result figures out the fact that sources that are in the proximity, of the farmers were accessed more than the sources which are away. Information sources that are in the possession of farmers like, mobile/internet, radio, television was more frequently accessed.

A knowledge test was developed for identifying the knowledge level of farmers on water management and farm implements and machinery and it was found that the knowledge level of the selected farmers was improved during the project through the interaction with the scientists and department personnel. Analysis of Social Network indicated that the network among the farmers in the Vennached village appears to be well connected as compared to other villages. This could be due to the fact that the village is far located and hence, people here are more connected to each other.

2.6.6. Development of strategic framework for upscaling of proven technologies in rainfed areas

This work was initiated to study the components and process of technology upscaling, factors determining it, to develop the framework / workable models for upscaling of rainfed technologies and to delineate the opportunities and constraints for scaling out technologies. A compilation of proven technologies with upscaling potential for 121 KVKs demonstrated under TDC of NICRA was prepared and data aggregation was done from 121 KVKS on processes and factors influencing technology upscaling.

2.6.7. Assessment of effectiveness of extension approaches in adoption of rainfed technologies (TOT/AE/57)

This project was initiated to identify the existing extension approaches of different agencies vis-a-vis their performance in drylands. A sample of 40 farmers randomly and extension personnel purposively (maximum available) from Telangana and A.P. states was selected for data collection. The sample agencies selected for the study were Coromandel Fertilizers Limited (CFL), Watershed Support Services and Activities Network (WASSAN) and the State Department of Agriculture (SDA). The data was collected using a pre-tested interview schedule and focus group discussion guides from the farmers' and extension personnel of each agency. Frequency, per cent analysis, means, standard deviation, t-test and extension effectiveness index will be employed for data analysis.

In Anantapuramu, Bukkarayasamudram (CFL), Nallacheruvu (WASSAN), and Atmakur (SDA) mandals were selected for the study. The main crops in the surveyed villages are groundnut, banana, paddy along with citrus and pomegranate. From the selected farmers' from each of the three agencies, 60 % of them are above the age of 44 ; 57.5 per cent had no education; a majority of farmers had >20 years farming experience and 65 per cent had 2-5 ha landholdings. The major source of irrigation is bore well for WASSAN and SDA and drip and borewell for CFL. The annual income was > Rs. 60,000 for 90 per cent for CFL farmers, 45 per cent for WASSAN farmers and 52.5 per cent for SDA farmers. Cows and buffaloes were the predominant livestock in CFL and SDA villages; while poultry was predominant in WASSAN villages. Demonstrations and group meetings were the main extension approaches employed both by CFL and SDA. Farmer to Farmer extension (in the form of a trained community resource person who trains a group of farmers) was found to be the predominant extension approach of WASSAN. Different government schemes implemented by SDA are Rythu Bharosa, Crop Insurance, Community Custom Hiring Centres, Polambadi, (National Food Security Mission) NFSM etc. The frequency of extension officials from CFL visit to farmers was once in a week; twice in a week from WASSAN and once in a fortnight from SDA respectively. Rating of extension services by farmers from CFL was good (70 per cent) followed by average (30 per cent); excellent (100 per cent) from WASSAN farmers and good (100 per cent) from SDA farmers. Information, credit, market, training support is required for technology adoption by farmers from SDA; whereas, credit was not required for WASSAN farmers due to savings formed by groups and information support already exists for CFL farmers for technology adoption. Extension activity of state dept. of agriculture was observed to be less when compared with CFL and WASSAN. It was observed that AEO and VAA were fully preoccupied with govt. schemes leaving little scope for extension and advisories. Majority of the farmers from all the agencies interviewed were requesting reinitiation of subsidy on drip irrigation by the state government.

2.6.8. Assessment of adoption potential and constraints for popularizing/upscaling raised bed planter (RBP) and broad bed and furrow planter (BBF) in unreached areas

This project was initiated to demonstrate the RBP and BBF Planter in selected cropping systems and farmers' fields of Telangana and to identify the field constraints in the adoption of RBP and BBF Planter by different stakeholders. Field demonstrations of RBP and BBF planters were attempted in farmer fields of KVK/FFP villages during July, August this year with red gram as trial crop. Both trial farmers along with other participating farmers were educated about the furrows and its importance in conserving and retaining of water, thereby avoiding runoff. They were convinced of the benefits of this technology. There were no rains after sowing (long dry spells) and hence crop germination could not be properly established due to insufficient soil moisture.

2.6.9. Potential options for doubling farmer's income in rainfed regions of Karnataka and Telangana

The impact of drought on farm incomes from villages in Nalgonda, the district was studied. The differ-

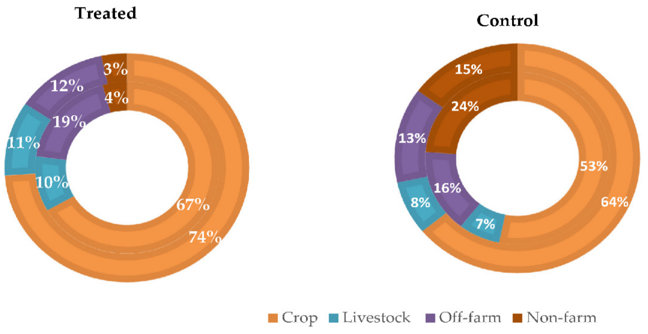


Fig.2.6.9.1. Income composition of farmers during drought and normal years

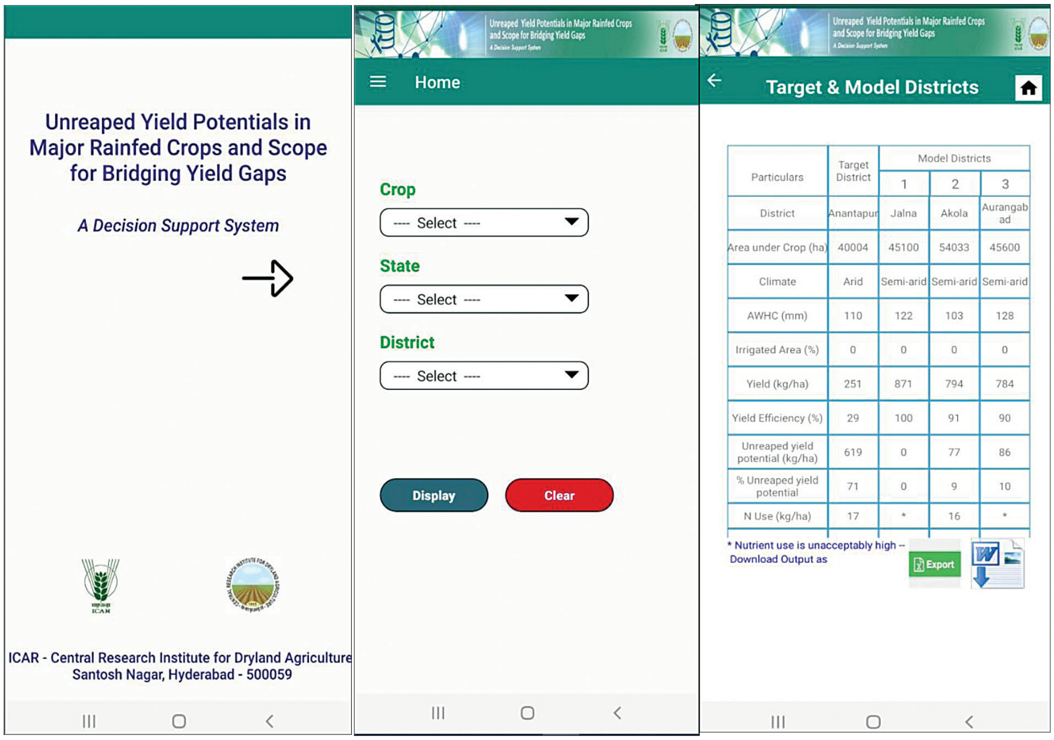
ence-in-difference model (DID) and stepwise multiple linear regression (MLR) were employed to quantify the impact of adopting climate-resilient technologies (CRTs) and factors influencing the farm household income during a drought. Farmers reported that droughts decreased the income from crops by 54 per cent and income from livestock rearing by 40 per cent (Fig.2.6.9.1.), the crop yield reduced by 28-58 per cent and the employment days were reduced during drought compared to a normal year.

The farmers reported that employment from crop and livestock activities during droughts reduced by 29 and 23 per cent. A farm household, when adopting climate-resilient technologies, has saved an average income of Rs. 31,877/farm household/year. The results of the stepwise multiple regression revealed that farm size, livestock possession, adoption of CRTs and investment in agriculture were found to significantly determine the income of farmers. Rearing livestock will receive an income benefit of Rs. 55,083 compared to those who depend on crops for their income and results showed that adoption of climate-resilient technologies significantly and positively influences the income of farmers.

2.6.10. Enabling decision makers in technology transfer in rainfed agriculture through Mobile based applications

Attempts were made to develop a mobile app based on the developed DSS-unreaped yield potentials of major rainfed crops. The DSS is available at http://www.icar-crida.res.in:8129/ which is an android based app. The database of the app has been designed using SQlite. User Interfaces were designed to integrate all the menus and databases. This App has been tested with different datasets and evaluated for its user-friendly environment. The App accommodated 17 rainfed crops viz., rice, sorghum, pearl millet, maize, finger millet, chickpea, pigeon pea, black gram, green gram, lentil, groundnut, soybean, sunflower, sesame, rapeseed, mustard, castor and cotton. The user has to select a crop and a district cultivating the crop.

The APP lists the model districts for a given crop and target District and indicates possible crop management for bridging the yield gap. The App identifies 3 model districts having climate, soil, share of irrigated area under the crop and share of a particular season in area under the crop similar to the district (target) selected.



Particulars	Target District	Model Districts		
		1	2	3
District	Anantapur	Jalna	Akola	Aurangabad
Area under Crop (ha)	40004	45100	54033	45600
Climate	Arid	Semi-arid	Semi-arid	Semi-arid
AWHC (mm)	110	122	103	128
Irrigated Area (%)	0	0	0	0
Yield (kg/ha)	251	871	794	784
Yield Efficiency (%)	29	100	91	90
Unreaped yield potential (kg/ha)	619	0	77	86
% Unreaped yield potential	71	0	9	10
N Use (kg/ha)	17	*	16	*

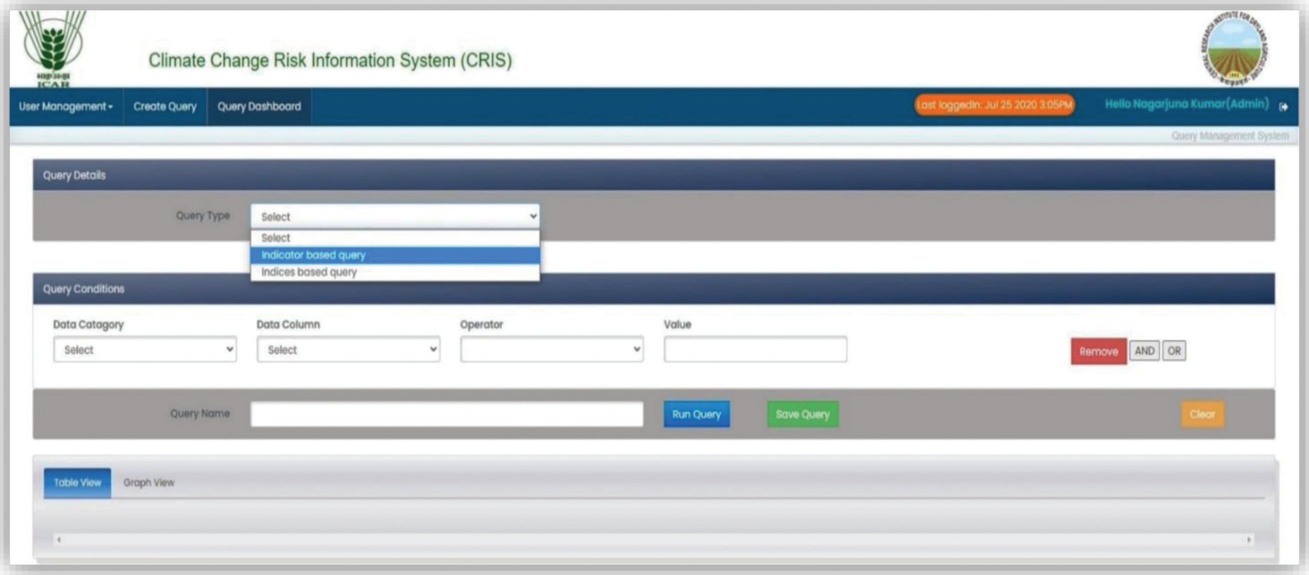
* Nutrient use is unacceptably high --
Download Output as

Mobile app for unreaped yield potentials of major rainfed crops-DSS

The App provides climate and available water holding capacity (AWHC) of the soil of the district, area under the crop and share of irrigated area and share of a particular season (in case of rice, sorghum, maize, black gram and green gram) in the area under the crop and yield of the district in the crop. It further provides yield achieved by model districts. If the target district itself is the highest yielding district in the cluster, a remark to this effect is generated. If there are only 1 or 2 districts with a yield more than that of the target district in a cluster, only those districts will be listed as model districts. The highest yield among the model districts may be regarded as potential yield. The output can be downloaded as word file or in Excel sheet format for further use.

Climate Change Risk Information System (CRIS) – An application for data retrieval from risk and vulnerability database

District-level data on various attributes of exposure, hazard and vulnerability were congregated, compiled and built as a database in the study of risk in vulnerability assessment. Besides the final output of risk, district-level data on various indicators are useful to various development agencies/stakeholders involved in adaptation research (TDC-NICRA) and planning & development (DACFW, state and central government agencies) in designing appropriate interventions to alleviate risk in hotspot districts. It calls for the development of a user-friendly front end for retrieval of relevant information by the stakeholders from the back-end database. A provision of user-defined queries is made in the application of retrieval of data without much technical knowledge of database and the retrieved data can be saved in excel for further use. The software was developed using SQL Server as backend and CSS and HTML used for front end Angular software is used for middleware. The application is hosted on an intranet system. The output screens for the CRIS is as follows.



Climate Change Risk Information System (CRIS) – an application for data retrieval from risk and vulnerability database

2.6.11. Harnessing statistical tools for informed decision making towards sustainable rainfed agriculture

In order to assess the sustainability of different technological interventions, a new measure for assessing sustainability of treatments/practices evaluated in long term experiments was developed from the following two-way linear model:

$y_{ij} = \mu + d_i + e_j + V_{ij}$ where

y_{ij} is observed yield of ith treatment in jth year

μ is grand mean and its estimate $\hat{\mu} = \bar{y}_{..}$

d_i is ith treatment mean deviation and its estimate $\hat{d}_i = \bar{y}_{i.} - \bar{y}_{..}$

e_j is jth year mean deviation and its estimate $\hat{e}_j = \bar{y}_{.j} - \bar{y}_{..}$

V_{ij} is interaction between ith treatment and jth year and its estimate $\hat{V}_{ij} = y_{ij} - \hat{\mu} - \hat{d}_i - \hat{e}_j$

2.6.12. Development of IOT applications for Resource Management.

This IOT application was developed to collect the soil moisture and weather data from the remote location using IOT Network. As Node MCU has built in Wi-Fi and also low power requirements we have selected Node MCU for the IOT prototype development. We have used DHT 11 sensor for weather data and LM 100 sensor for the soil moisture data collection. Arduino Integrated development environment is used for the programming requirements. Using Arduino environment, we are able to collect the soil moisture, humidity and temperature data into MySql Database.

2.6.13. KRISHI - Knowledge based Resources Information Systems Hub for Innovations in agriculture.

KRISHI-Knowledge based Resources Information Systems Hub for Innovations in agriculture, is an initiative of Indian Council of Agricultural Research (ICAR) to bring its knowledge resources to all stakeholders at one place. The portal is being developed as a centralized data repository system of ICAR consisting of Technology, Data generated through Experiments/ Surveys/ Observational studies, Geo-spatial data, Publications, Learning Resources etc. In the six repositories, Observational repository is designed developed by CRIDA. In observational Repository 10 AWS stations weather data is harvested for data dissemination to the stakeholders. web applications were developed and hosted under observational database to upload the metrological data into observational database from other ICAR units. We have uploaded around 4500 publications, 110 technologies, 40 video films of CRIDA into the KRISHI portal.

2.6.14 Building longitudinal panel data on development pathways in dryland villages

Building a micro-level farm, household and village level data base (comparable across space and time) for tracking technological and climate changes and its impact on incomes of dryland farmers is crucial to understand the dynamics of the changes taking place in the dryland villages. The study quantified the benefits from all social and welfare schemes working in a village in Warangal by conducting census of all households in the village. In general, middle-income households are getting more benefits, only self-targeted schemes like MGNREGA are benefiting poor more than rich. Utilization of in-kind subsidies are mostly utilized for intended purpose, but cash transfers are used for general purposes and some are spending for consumption purposes although cash transfer is for purchasing agricultural inputs.

2.7 Scheduled Castes Sub Programme (SCSP)

The Institute is implementing the SC Sub Plan in two States of India in the identified districts by NITI Aayog, GoI, New Delhi namely Mancherial (erstwhile Adilabad) in Telangana and Kalaburagi in Karnataka.

The highlights of the activities undertaken during 2021:

- **Distribution of tarpaulins, nutri-millet kits and vegetable seed kits**

An awareness programme was organized at Mallampet village of Kotapally Mandal, Mancherial district, Telangana on 28.01.2021 among the farmers about safety of farm produce and use of biofertilizers. The Chief Guest of the programme, Sri Balka Suman, Chief Whip and MLA, Chennur constituency distributed tarpaulins along with packets of PSB, *Azospirillum* and *Azotobacter* biofertilizers. A total 2000 tarpaulins were distributed in nineteen villages of Kotapally mandal among SC farmers. Nutri-millet kits were procured from ICAR-IIMR, Hyderabad and a meeting was organized with farmers at Rythu Vedika, Mallampet and highlighted the importance about the nutrition among women & child. Distributed nutri-millet kits about 1000 Nos. along with vegetable seed kits (1000 Nos.) for kitchen gardening.

Distribution of tarpaulins by Shri. Balka Suman, Chief Whip and MLA, Chennur

Distribution of nutri millet kits & vegetable seed kits

- **Improved variety of red gram (PRG-176)**

  Red gram was introduced in the cluster of six villages and distributed 2000 kg seeds of improved variety (PRG-176) during June 2021and the seeds were procured from ICAR-CRIDA, KVK seed hub. The seeds sown in the backyard for self-consumption and as an intercrop was found to be in good condition and received well by all the farmers.

Distribution of red gram seed (PRG-176)

Red gram crop in farmers' field

- **Distribution of Battery-operated sprayers & *Kheti Rakshak*:**

  In commemoration of 75 years of India's Independence, organized the programme of SC-Youth for Plant Protection (SC-YPP) under ARYA in Kotapally mandal of Mancherial district, Telangana State under SC Sub Plan as part of Azadi Ka Amrit Mahotsav on 1st September, 2021. In this context, distributed 450 numbers of battery-operated sprayers in selected twenty-one villages of the mandal according to the population of SC household. The battery-operated sprayers were given on the mode of custom hiring in these villages. Two youth from each village were selected for maintenance and repair of sprayers. Receipt books were provided to youth for collecting the rent from the farmers and to deposit half of the amount in the account of post office for repair and maintenance. This model was found to be helpful for creating employment potential among rural youth. Also, installed four devices of *Kethi Rakshak* for the management of wild boar in both Mallampet and Kondampet villages.

Distribution of battery-operated sprayers and installation of kheti rakshak in the village

- **Organized Field Day in Mallampet village of Kotapally mandal:**

  The programme was organized in Mallampet village of Kotapally mandal on 17th December, 2021. Dr. V. K. Singh, Director, ICAR-CRIDA was the chief guest of the programme. He addressed the gathering on this occasion and emphasized to work with state department officials and farmers hand in hand to achieve the objectives of SC Sub Plan program. Sharing of knowledge among the farmers by scientists is more important rather supplying only inputs. Later, distributed the foot sprayers for plant protection in mango orchards and yellow sticky traps to chilli farmers for the management of sucking insect pests. About 150 SC farmers from Kotapally mandal participated in the program along with State officials.

Organized Field day in Mallampet village and visit to farmer field

Director, ICAR-CRIDA visited different interventions in the village

- **Field Day organized at Bhogalingadahalli village, Chincholi Taluka :**

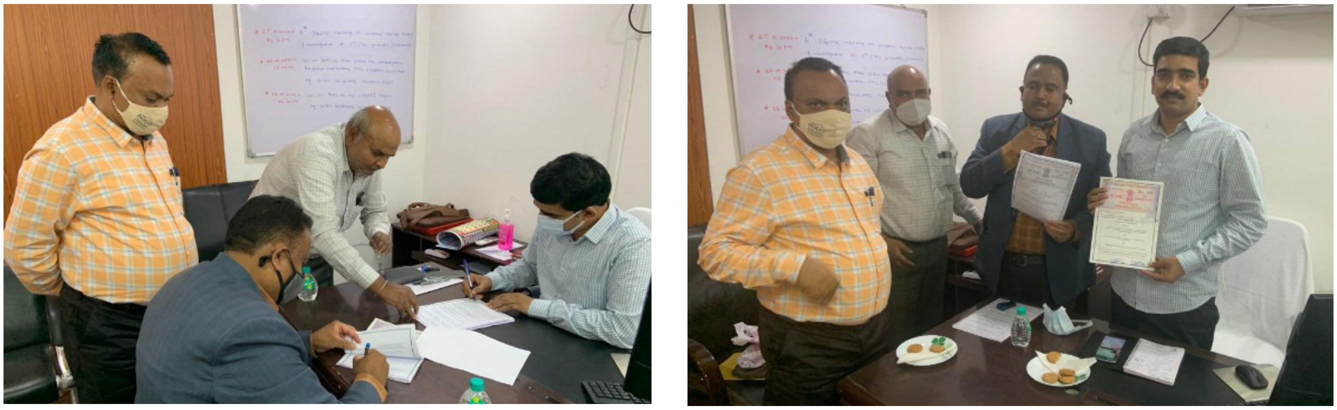
  As part of Azadi ka Amrit Mahastov of 75 years of India's Independence organized a field day at Bhogalingadahalli village, Chincholi Taluaka, Kalaburagi district, Karnataka on 18th October 2021 under SC Sub Plan. The field day was attended by the Director, ICAR-CRIDA, Dr Anil Kumar Rathod, Assistant Director of Agriculture other Agricultural Officers of State Department of Agriculture and Village leaders. About 150 farmers of Bhogalingadahalli and Kalabhavi villages participated. Dr V. K. Singh, Director, ICAR-CRIDA in his address requested the farmers to enhance their income by following eco-friendly, cost effective and resource conservation technologies. He also requested to the farmers that the improved varieties of seed that are being promoted under the SCSP to be shared with other farmers of the village. He also advocated to practice cost effective integrated pest management practices for managing the pests and diseases. The farmers were educated and trained to use pheromone traps for monitoring and control of pests of pigeon pea and weed management using wheel hoe. About 10 quintals of certified bengal gram (JG-11) seeds and 100 tarpaulin sheets for protecting the farm produce were also distributed to the eligible SC farmers in this event.

Dr. V.K. Singh, Director, ICAR-CRIDA addressing the farmers on field day celebration and distributed bengal gram seed and tarpaulins to SC farmers

Demonstration of weed hoe and pheromone traps in farmers' fields

- **Signing of MoU between ICAR-CRIDA and PR&RD, Government of Telangana**

  On 25th January 2022, an MoU was signed by Dr V.K. Singh, Director, ICAR-CRIDA and Shri V.S.N.V. Prasad, Special Commissioner, PR & RD & CEO, SLNA, Government of Telangana State to take up Natural Resources Management based developmental activities in Kotapally mandal of Mancherial and tribal mandals of Adilabad districts in Telangana State under SCSP/TSP. The renovation of old and new on-farm reservoirs are planned in Mancherial and construction of farm ponds in Adilabad which aim at doubling of cropping intensity to enhance farmers' income.



Signing of MoU between ICAR-CRIDA and PR&RD, Government of Telangana

Organized Training programme

- Three training programmes were organized on "Sustainable Rice Production Technology" during 23-25th February, 2021, 08-10th March, 2021 & 16-18th March, 2021 in three batches which benefitted 60 farmers from Mallampet and Edagatta village at ICAR-IIRR, Rajendranagar, Hyderabad. The participants were exposed to latest advances and hands on training for sustainable rice production. ICAR-CRIDA celebrated "International Women's Day" on 8th March, 2021 for women farmers under SCSP. The theme for this year by ICAR was "Women leadership in agriculture: entrepreneurship, equity and empowerment". Dr. V. K Singh, Director, CRIDA in his address highlighted the increasing level of participation of women farmers in agriculture and allied sectors. He praised the women farmers for their hard work in every sphere of life. He encouraged and motivated the women farmers to take up entrepreneurial activities in agriculture also.

NICRA-CRIDA Achievements 3

Climate change has become an important area of concern for India to ensure food and nutritional security for the growing population. Indian agriculture is highly vulnerable to climate change and variability. One or other part of the country is experiencing frequent extreme weather events such as heavy rainfall, droughts, floods, frost, heat wave, cold wave, hailstorms etc. causing sizeable loss to yield and income to the farmers at microscale and to the Nation's economy at the macroeconomic level. Agriculture is likely to be one of the most affected sectors directly in terms of crop yields, water availability and indirectly through changes in pest and pathogen incidence. As per the latest IPCC AR-6 Report increase in rainfall, high inter annual variability, intense and frequent heatwaves, likely temperature increase by 1.5 to 4.0 ^{o}C and rise in sea level by 300 mm could be the major challenge for sustainable agriculture in the coming years. This necessitates accelerated research on developing resilient technologies against climate change as well as their mainstreaming through the adaptation mechanism for upscaling. The Indian Council of Agricultural Research (ICAR), Ministry of Agriculture and Farmers' Welfare, Government of India launched a flagship network project 'National Innovations in Climate Resilient Agriculture' (NICRA) in 2011. NICRA project is being implemented by Natural Resource Management Division of ICAR and coordinated by ICAR-Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad.

The project aims to develop and promote climate-resilient technologies in agriculture which can address vulnerable areas of the country and the outputs of the project will help in coping with the districts and regions prone to extreme weather conditions. The project is implemented through components viz. strategic research, technology demonstration (151 clusters of villages in each one of the identified climatically vulnerable districts) and capacity building. The objectives of the project are

- To undertake strategic and applied research on climate change adaptation and mitigation
- To validate, demonstrate and assess the impact of climate resilient technologies on farmers' fields
- To strengthen the capacity of scientists, farmers and other stakeholders on climate resilient agriculture

During the year 2021, the NICRA project has been in operation in 25 ICAR Institutes, different State Agriculture Universities (SAUs), Indian Institute of Technology (IIT) (Chennai), 151 KVKs, 25 AICRPAM and 22 AICRPDA centres. This year, the activities under NICRA project at ICAR-CRIDA were divided into five major themes and the projects are presented theme wise.

3.1. Theme I. Impact of elevated carbon dioxide and temperature on crops, pests, diseases, weeds, soil, microbes and livestock in rainfed ecosystem.

3.1.1. Productivity of rainfed crops under enhanced carbon dioxide and its interaction with water deficit and elevated temperature

A field experiment under Free Air Temperature Elevation (FATE) facility was conducted to assess the impact of elevated temperature (eT) and its interaction with elevated CO_2 (eT+eCO_2) on phenology, physiology, biomass and grain yield of four maize (*Zea mays* L.) hybrids- DHM-117, DHM-121, NK-6240 and 900M GOLD. The eT was maintained as 3.0 ± 0.5°C above ambient canopy temperature (aT) and eCO_2 was maintained at 550 ± 50 ppm.

The elevated crop canopy temperature (eT), influenced the phenology of days to 50 per cent tasselling, anthesis and silking of maize genotypes and significant variation among the genotypes was also observed. Anthesis and Silking Interval (ASI) increased by 1.7 days with

DHM-117, 0.4 days with NK-6240 and 0.3 days with DHM-121 at eT condition as compared with ambient control and while it was decreased by 0.3 days with 900M GOLD. The presence of eCO_2 along with eT reverted the ASI as ambient control. (Fig.3.1.1.1.). The eT reduced Anet, gs, Tr of all the four maize genotypes. With eT, the reduction in Anet ranged from 14.2 per cent (900M GOLD) to 32.2 per cent (DHM-117), while $eT+eCO_2$ condition improved it to that of aT level in 900M GOLD and DHM-121, better than aT in DHM-117 and NK-6240. The gs and Tr reduced under both eT and $eT+eCO_2$ conditions, however the magnitude of the response differed with genotype. DHM-121 registered higher WUE at $eT+eCO_2$ condition due to improved response of Anet and higher reduction in Tr (Fig. 3.1.1.1.).

Elevated temperature (eT) significantly impacted biomass and yield components and the magnitude of response of individual genotype varied. The reduction of total biomass at eT ranged from 9.3 per cent (DHM-121) to 18.0 per cent (NK-6240) and vegetative biomass from 5.4 per cent (DHM-117) to 19.8 per cent (NK-6240). The reduction in cob weight due to eT ranged from 10.7 per cent (900M GOLD) to 16.7 per cent (NK-6240). Similarly, the reduction in grain yield ranged from 6.8 per cent (900M GOLD) to 22.2 per cent (DHM-117) and for grain number it was from 3.5 per cent (NK-6240) to 6.7 per cent (DHM-117). In DHM-117, the decrease in grain yield (22.2 per cent) with high temperature (eT) was mainly due to reduction in grain number (6.7 per cent) and 100 seed weight (16.7 per cent) revealing that high temperature impacted both seeds set and filling (Fig. 3.1.1.2.). Among the selected four maize genotypes, 900M GOLD was less impacted for yield components at eT. The genotype DHM-117 responded positively to eCO_2 for yield components as it ameliorated the ill effects of eT. Though eCO_2 improved overall biomass of the genotypes, its ameliorative capacity was more for yield and yield components of DHM-117.

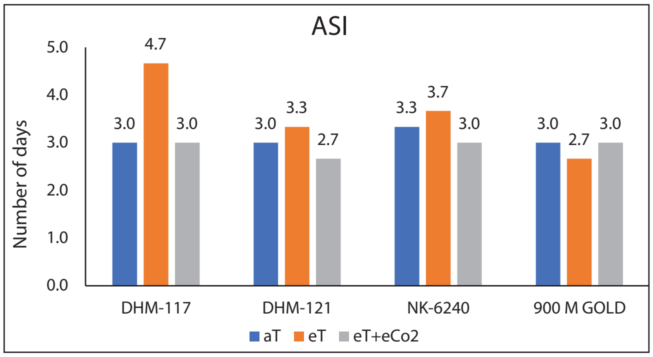


Fig. 3.1.1.1. Anthesis silking interval (ASI) of four maize hybrids at aT, eT and $eT+eCO_2$ conditions

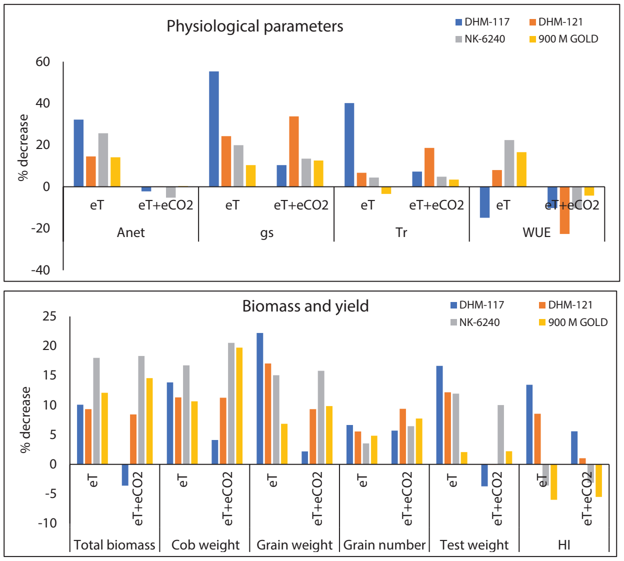


Fig.3.1.1.2. Impact of eT and $eT+eCO_2$ conditions on physiological, biomass and yield parameters of four maize hybrids

3.1.2. Impact of e CO_2 and e Temp on growth, phenology, physiology and yield of potato (*Solanum tuberosum* L.) under CTGC

Global climate change accompanied by continuous increases in atmospheric carbon dioxide (CO_2) concentration and temperature affects the growth and yield of important crops. The study investigated the effect of elevated temperature and CO_2 concentrations on the growth, yield, and photosynthesis of potato (*Solanum tuberosum* L. cv.) crop using Carbon dioxide and Temperature Gradient Chambers (CTGC chambers) that allows the regulation of temperature and CO_2 concentration under chambers.

The experiment was laid out on 11-11-2021with potato variety Kufri Pukhraj variety suitable for this location in CTGC chambers at HRF with four treatments. T_1- Control (reference), T_2-Temperature gradient of 5 ± 0.5°C over reference - 'eTemp'. (three Gradients), T_3- Elevated CO_2 concentration of 550 ± 50 ppm- 'eCO_2' and T_4- interaction of eCO_2 and eTemp. Temperature gradient 5 ± 0.5°C over reference with elevated CO_2 concentration of 550 ± 50 ppm – 'eTemp + 'eCO_2.

The initial germination and the growth parameters viz., plant height, number of branches, and biomass were measured for six plants from each chamber at 30 days after emergence (DAE) and found there is a difference among treatments in four different chambers (Fig.3.1.2.1.). Observations were recorded on plant height, number of branches, leaf area, number of tubers and stem thickness during 40 days after emergence. The results revealed that average plant height in Chamber-IV (e CO_2) Gradient -1 recorded the highest value of 62.32 cm followed by Chamber - I (Ref) gradient -1 (53.46), Chamber - II (e Temp) gradient -1 (51.35) and Chamber - III (e CO_2 and e Temp) gradient -1 (46.4). Average number of branches per plant in Chamber - I (Ref) Gradient -1 recorded the highest value of 5.36 followed by Chamber - II (e Temp) gradient -2 (3.68), Chamber-IV (e CO_2) gradient -2 (3.57) and Chamber - III (e CO_2 and e Temp) gradient -2 (3.34). Average leaf area in Chamber-IV (e CO_2) Gradient -3 recorded the highest value of 2807.9 followed by Chamber - I (e Temp) gradient -1 (1631.88), Chamber - III (e CO_2 and e Temp) gradient -1 (1493.26) and Chamber - II (e Temp) gradient -3 (1280.78). Average number of tubers per plant in Chamber - III (e CO_2 and e Temp) Gradient -1 recorded the highest value of 11.20 followed by Chamber - II (e Temp) gradient -2 (10.85), Chamber-IV (e CO_2) gradient -3 (10.79) and Chamber - I (Ref) gradient -3 (7.28). Average stem thickness in Chamber-IV (e CO_2) Gradient -1 recorded the highest value of 1.05 followed by Chamber - II (e Temp) gradient -3 (1.03), Chamber - III (e CO_2 and e Temp) gradient -1 (0.85) and Chamber - I (Ref) gradient -3 (0.63).


Ref *e -Temp* *e CO_2 and e Temp* *e -CO_2*

Fig.3.1.2.1. Growth after 30 Days after planting in 4 Chambers

3.1.3. Individual and interactive effects of moisture deficit and elevated temperature on physiological efficiency of C3 and C4 rainfed crops

Elevated CO_2 and elevated temperature responses at early developmental stages impact plants differently from responses during late generative developmental stages. Given the specific dynamics of elevated CO_2 and elevated temperature responses, an ideal trait dissection platform should facilitate detailed and efficient tracking of the studied trait across the entire crop lifecycle. A study was conducted in pearl millet (*Pennisetum glaucum*) under controlled environmental conditions in the carbon dioxide and temperature gradient chambers (CTGC) with different levels of

CO_2 (ambient and elevated 550 ppm) and different gradients of temperature in the chambers designed as temperature gradient tunnels (TGT). We hypothesized that during exposure to heat stress and elevated CO_2, specific strategies are employed by the plants, such as structural and functional changes in the photosynthetic systems by which they acquire new homeostasis which may be protective adaptations. Photosystem II (PSII) photochemistry, light energy absorption, excitation energy trapping, and conversion of excitation energy into electron flow and phenomenological fluxes parameters were studied.

High-resolution photosystem II electron transport and chlorophyll fluorescence induction kinetics data was collected at various growth stages – three different stages at each of the major growth phase viz., vegetative, panicle development and grain filling stage at three different times of the day. Three single point pre-dawn observations were also recorded. Results indicate distinct differences in quantum yield, OJIP, electron transport and phenomenological fluxes. Temporal heterogeneities in terms of variations at different times of the day also was observed in the photosystem II dynamics as affected by temperature and elevated CO_2. Some of the responses were differential and some were similar indicating the complex nature of the interaction between temperature and elevated CO_2 in combination.

3.1.4 Impact of elevated temperature and its interaction with elevated CO_2 on plant N uptake and Nitrogen Harvest Index (NHI) in maize

Climate change will impact plant growth and N metabolism, but these impacts have mostly been studied to date by examining the effects of individual climate-change factors (especially eCO_2, higher temperatures, and drought). However, since these main climate-change factors will change concomitantly, discerning the interactive effects of these factors will be necessary to understand how climate change will impact plant N relations. The impact of elevated temperature and its interaction with elevated CO_2 on plant N uptake in maize genotypes was studied in four maize genotypes, DHM-117, DHM-121, NK-6240 and 900M Gold. The eT condition decreased the total N uptake in all the genotypes, however, the impact of eCO_2 differed with genotype as it improved in DHM-117 and DHM-121 and decreased in NK-6240 and 900M Gold. Nitrogen concentration (N per cent) in different plant parts of maize and were in the order of seed > leaf > root > husk > stem under aT, eT and eT +eCO_2 in all genotypes (Fig.3.1.4.1. and Fig. 3.1.4.2.). Seed N concentration (per cent) increased at eT and eCO_2 in DHM-117 and NK-6240 while it was not significantly changed in DHM-121 and 900M Gold. Seed N yield showed a similar trend as that of total N uptake. Grain NUE (grain yield/total N uptake) was highest under ambient conditions (aT) in DHM-117, DHM-121 and NK-6240 due to higher biomass while it did not change in eT+eCO_2 in 900M Gold (Fig.3.1.4.3). The eT decreased the NHI (65.9) while eT+eCO_2 increased it (69.8) as compared to ambient (67.1) in DHM 117 while there was no significant change in 900M Gold (Fig.3.1.4.3).

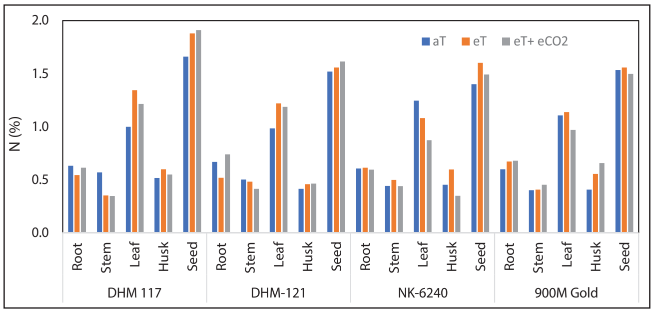


Fig. 3.1.4.1. Nitrogen (per cent) in root, stem, leaf, husk and seed of maize genotypes under aT, eT and eT+ eCO_2 conditions

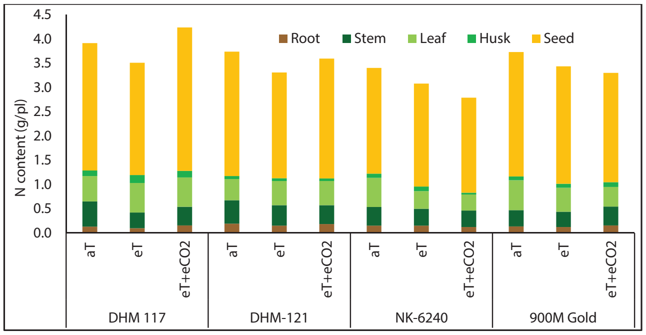


Fig. 3.1.4.2. Nitrogen content (g/pl) in root, stem, leaf, husk and seed of maize genotypes under aT, eT and eT+ eCO_2 conditions

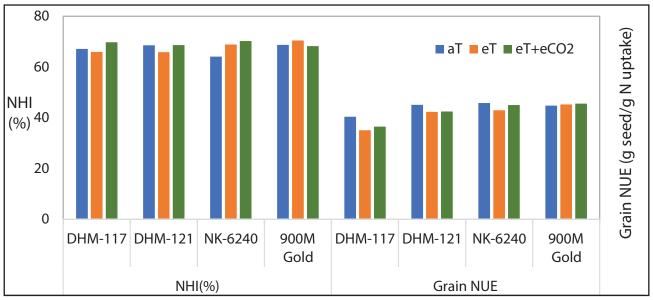


Fig.3.1.4.3. Nitrogen Harvest Index (per cent) and Grain NUE (g seed/g N Uptake) under aT, eT and eT+ eCO$_2$ conditions of maize genotypes

3.1.5. Effect of elevated atmospheric CO$_2$ concentration and high temperature on nutrient quality of dryland crops

Four genotypes DHM 117, DHM 121, NK 6240 and 900M Gold of maize grown under three treatments, namely control, elevated temperature, elevated temperature + elevated CO$_2$, grown under FATE facilities were taken up to study zinc and ash contents of maize grain. This study showed that seed mineral nutrients can be altered by elevated temperature and elevated temperature + elevated CO$_2$. Higher (2.33 g) ash content (Fig.3.1.5.1.) was found in genotypes NK 6240 under eT+eCO$_2$ conditions whereas, lower (1.00 g) ash content was found in DHM 117 and NK 6240 under ambient. Ash content was found to be lower 1.00 – 1.33g under ambient when compared to eT+eCO$_2$ conditions (1.33 – 2.33g). Under eT+eCO$_2$ Zn content (Fig . 3.1.5.2.) was found to be reduced (1.48 – 2.07 mg/100g) when compared to control (2.35 – 2.88 mg/100g) among all the four genotypes.

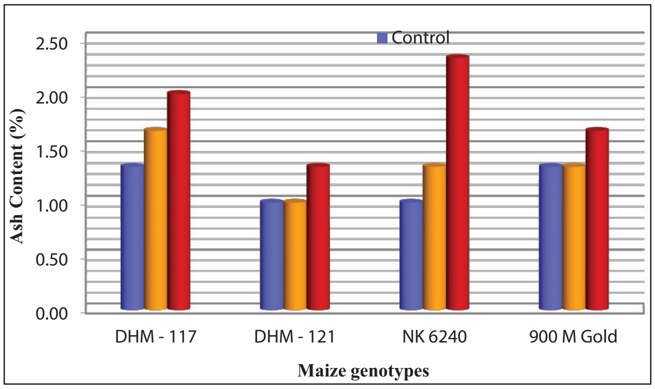


Fig. 3.1.5.1. Effect of eT and eT+eCO$_2$ on ash content of maize genotypes

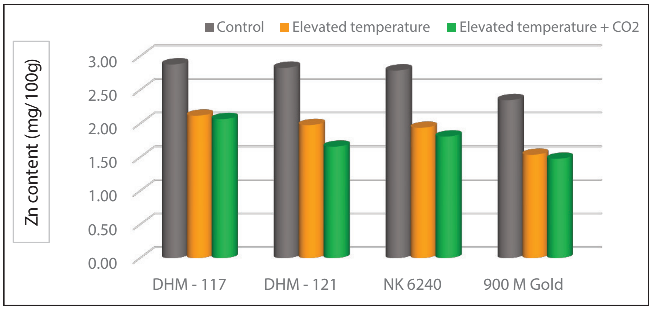


Fig. 3.1.5.2. Effect of eT and eT+eCO$_2$ on Zn content of maize genotype

3.1.6. Impact of eCO$_2$ and eT on quality of crop residues as livestock feed

The projected increase of atmospheric carbon dioxide (CO$_2$) and climate change will have significant impacts on future fodder quality and productivity. A study was conducted to assess the impact of increasing temperature and carbon dioxide on the quality of maize fodder (stems and leaves) grown in the CTGC chambers under four set of environmental conditions (a) Reference (ambient temperature and carbon dioxide i.e., 27±0.5°C and 380 ±25 ppm CO$_2$), (b) Chamber with temperature gradient of 5±0.5°C over reference and referred as elevated temperature (eTemp), (c) Chamber with elevated CO$_2$ concentration of 550±50 ppm with temperature gradient 5±0.5°C over reference referred as elevated carbon dioxide and temperature (eCO$_2$ + eTemp) and (d) Chamber with elevated CO$_2$ concentration of 550±50 ppm referred as elevated carbon dioxide (eCO$_2$). Leaf and stem portion of maize fodder at milking stage were screened by proximate, Vansoest, energy content and in vitro dry matter degradability.

Higher ($P<0.05$) dry matter, ash, acid detergent lignin (ADL), acid detergent fibre (ADF) and cellulose per cent were found both in leaves and stem of the maize fodder grown under elevated temperature (eTemp) environmental conditions. Organic matter and crude protein content (Fig. 3.1.6.1.) were found highest ($P<0.05$) at the ambient temperature. Growing maize under elevated carbon dioxide and temperature (eCO$_2$ + eTemp) environmental conditions increased ($P<0.05$) NDF and hemicellulose content both in leaves and stem. Significantly ($P<0.05$) higher Crude fibre content in stem was found in the maize grown under elevated temperature (Fig. 3.1.6.2.), whereas in leaves under elevated carbon dioxide and temperature (eCO$_2$ + eTemp). A non-significant increase in Ether extract was observed in stem of maize fodder grown under elevated temperature, but it was highest ($P<0.05$) at ambient temperature conditions in leaves. NFE in stem was highest ($P<0.05$) at elevated carbon dioxide, whereas in the leaves highest ($P<0.05$) was found in the maize fodder grown at ambient temperature.

Invitro dry matter degradability (IVDMD) of stem and leaf portion in the maize fodder grown under carbon dioxide and temperature gradient chambers (CTGC) differed significantly ($P<0.05$). Highest IVDMD (per cent) in maize stem was found in the maize fodder grown in eCO_2 (51.1±0.12), whereas lowest (43.6±0.84) under eTemp environmental chamber conditions. Leaf of maize fodder grown at ambient (reference) (55.3±0.12) had highest IVDMD, whereas lowest (50.1±0.43) under eTemp environmental chamber conditions. Among different chambers, highest ($P<0.05$) DE (MJ/kg DM) was found in the stem and leaf of the maize fodder grown in eCO_2 chamber. DE in maize stem and leaf decreased ($P<0.05$) from G1 to G5 as temperature increased in both the eTemp and eCO_2+e Temp chambers. A similar trend was observed in metabolizable energy (ME) content of maize stem.

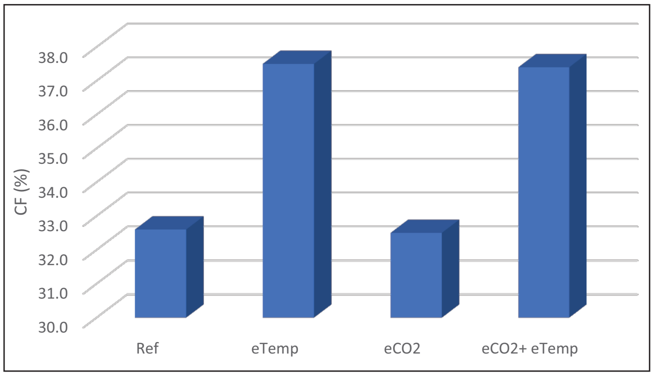


Fig. 3.1.6.1. Crude fibre (CF) percentage in stem portion of the maize fodder grown in CTGC under different environmental conditions

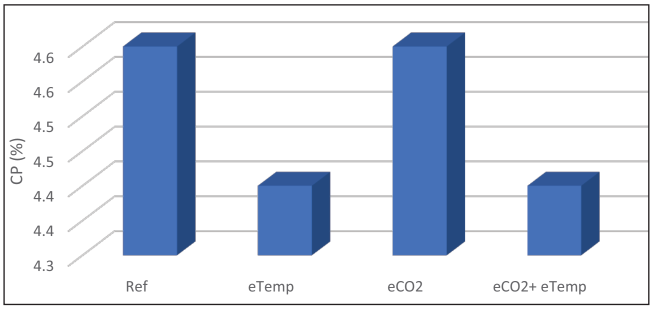


Fig. 3.1.6.2. Crude protein (CP) percentage in stem portion of the maize fodder grown in CTGC under different environmental conditions

3.1.7. Prediction of Pest scenario of *Spodoptera litura* (Fab.) on groundnut under Representative Concentration Pathways (RCPs) based climate change scenarios

Multi-model ensemble of maximum (Tmax) and minimum (Tmin) temperature data of four Representative Concentration Pathways viz., RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5 of Coupled Model Inter comparison Project 5 (CMIP5) models were generated for ten major groundnut growing locations of the India to predict the number of generations of *Spodoptera litura* (Fab.) using Growing Degree Days approach during three future climate viz., Near (NF), Distant (DF) and Very Distant (VDF) periods and were compared over 1976-2005 baseline period (BL). Projections indicate significant increase in Tmax (0.7 to 4.7°C) and Tmin (0.7 to 5.1°C) in NF, DF and VDF periods under the four RCP scenarios at the ten groundnut growing locations. Higher percent increase of the number of generations of *S. litura* was predicted to occur in VDF (6 to 38 per cent) over baseline, followed by DF (5 to 22 per cent) and NF (4 to 9 per cent) periods with reduction of generation time (5 to 26 per cent) across the four RCP scenarios. Reduction of crop duration was higher (12 to 22 days) in long duration groundnut than in medium and short duration groundnut. Decrease in crop duration was higher in VDF (12.1 to 20.8 days) than DF (8.26 to 13.15 days) and NF (4.46 to 6.15 days) climate change periods under RCP 8.5 scenario. Increase in number of generations of *S. litura* was predicted even with altered crop duration of groundnut. Among locations, more number of generations of *S. litura* with reduced generation time are likely at Vridhachalam and Tirupathi locations. Geographical location (74 to 77 per cent) and climate period (15 to 19 per cent), together explained over 90 percent of the total variation in the number of generations and generation time of *S. litura*. These findings suggest that the incidence of *S. litura* on groundnut could be higher in future.

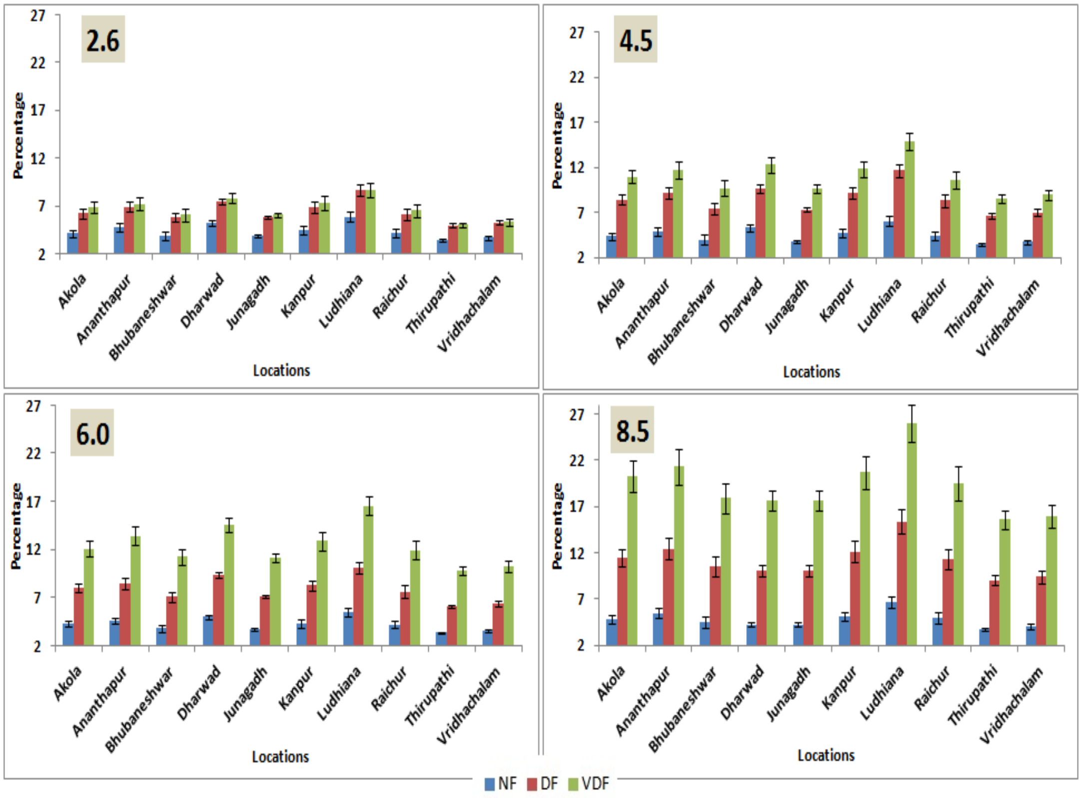


Fig.3.1.7.1. Per cent change in number of generations of S. litura during three Climate change periods (NF: Near Future, DF: Distant Future, VDF: Very Distant Future) over base line in crop growing season

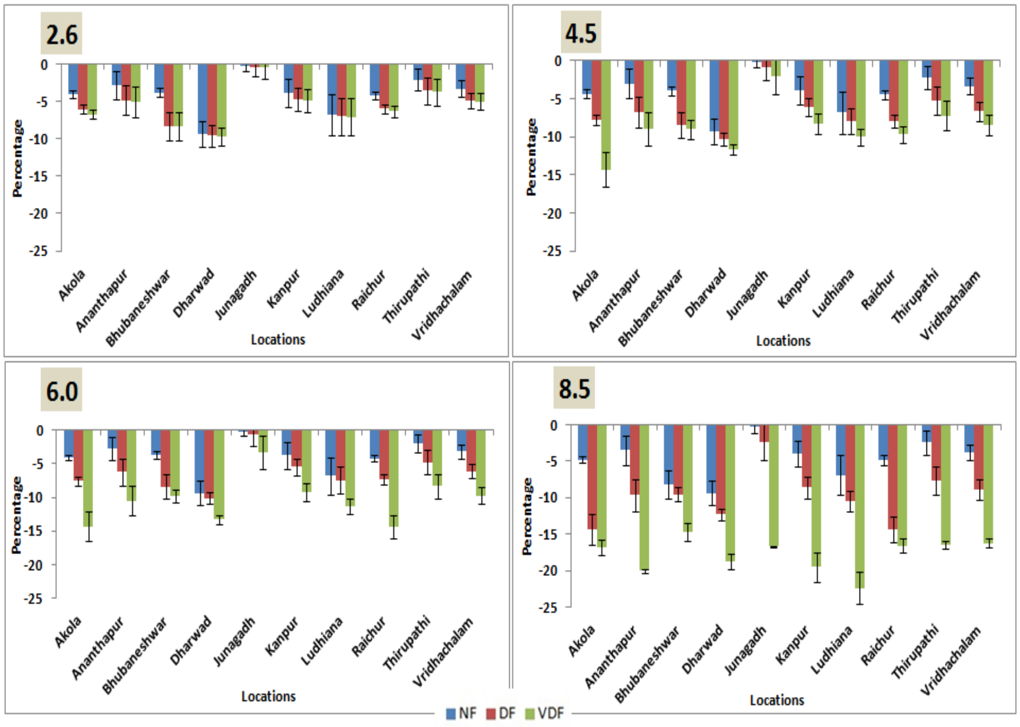


Fig.3.1.7.2. Per cent change in generation time of S.litura during three Climate change periods (NF: Near Future, DF: Distant Future ,VDF : Very Distant Future) over base line in crop growing season

3.1.8. Interactive effects of *e*Temp and *e*CO_2 on efficacy of insecticides against *Spodoptera litura* Fab. on groundnut

Effect on Lethal concentrations

Influence of two dimensions of climate change i.e., elevated temperature (eTemp) and elevated CO_2 (eCO2) on toxicity of insecticides against *Spodoptera litura* Fab. on groundnut using CO_2 Temperature Gradient Chambers (CTGC) was investigated. The insecticides *viz.*, diamides (flubendiamide), avermectins (emamectin benzoate), organophosphates (quinalphos), spinosyns (spinosad) and synthetic pyrethroids (deltamethrin) were tested for their efficacy and persistence toxicity (PT) at *e*Temp and *e*CO_2. Interactive effects of *e*CO_2 and *e*Temp caused the higher LC_{50} values of spinosad and deltamethrin with negative temperature coefficients and showed the 'reduction of toxicity'

Lower LC_{50} values and positive temperature coefficients for flubendiamide (6.67), emamectin benzoate (7.38) and quinalphos (3.04) recorded, indicating the 'higher toxicity' at interactive *e*CO_2 and *e*Temp. The descending order in reduction of PT of insecticides was deltamethrin < quinalphos < flubendiamide < emamectin benzoate < spinosad and these insecticides persisted for shorter period at *e*Temp+*e*CO_2 conditions over reference. Present results indicate the negative impact of *e*Temp and *e*CO_2 on efficacy of spinosad and deltamethrin necessitating their higher requirement than was needed to achieve equal control at reference/ ambient temperature and CO_2.

Emamectin Benzoate

Significant higher mean percent mortality of *S. litura* larvae was noted for emamectin benzoate at lower temperatures ($F_{5, 10}$ = 65.13, P=<0.0001) at elevated CO_2 conditions ($F_{1, 12}$ = 15.10, P =<0.002). The interaction between CO_2 and temperatures with respect to mortality of larvae was significant ($F_{5, 12}$ = 8.95, P =<0.0001). Emamectin benzoate persisted for fewer days at elevated CO_2 conditions ($F_{1,12}$ = 5.57, P =<0.036) and higher temperatures ($F_{5, 10}$ = 23.76, P=<0.0001). However, no significant interaction effect between these two variables was observed ($F_{5, 12}$ = 0.50, P =0.789). Persistence toxicity of the insecticide followed a similar trend, indicating that higher temperatures with *e*CO_2 caused the reduction of toxicity. CO_2 and temperatures influenced the lethal time required to get 50 per cent mortality of *S. litura* larvae (CO_2: $F_{1, 12}$ = 508.76, P =<0.0001; Temperature: $F_{5,10}$ = 2401, P=<0.0001). Lethal time was reduced at *e*CO_2 and at higher temperatures. A significant interaction effect between the two variables ($F_{5, 12}$ = 4.53, P =<0.014) indicated that reductions in lethal time was more evident with higher temperatures and at *e*CO_2 indicating that the effects of temperature were more marked at *e*CO_2 conditions than at *a*CO_2 conditions.

Quinalphos

Significant lower mean percent mortality of *S. litura* larvae was noted for quinalphos at higher temperatures ($F_{5, 10}$ = 136.78, P=<0.0001) at elevated CO_2 conditions ($F_{1, 12}$ = 32.58, P =<0.0001). The interaction between CO_2 and temperatures with respect to mortality of larvae was significant ($F_{5,12}$ = 12.05, P =<0.0001) (Table 2b). Quinalphos persisted for fewer days at elevated CO_2 conditions ($F_{1, 12}$ = 6.82, P =<0.022) and higher temperatures ($F_{5, 10}$ = 4.67, P=<0.018). However, no significant interaction effect between these two variables was observed ($F_{5,12}$ = 0.30, P =0.623). Persistence toxicity of the insecticide followed similar trend, indicating that higher temperatures ($F_{5, 10}$ = 2086, P=<0.0001) and *e*CO_2 ($F_{1, 12}$ = 397.67, P =<0.0001) caused reduction of toxicity. Both the factors, CO_2 ($F_{1, 12}$ = 447.22, P =<0.0001) and temperatures ($F_{5, 10}$ = 2469, P=<0.0001) significantly influenced the lethal time required to get 50 per cent mortality of *S. litura* larvae with reduced lethal time at *e*CO_2 and at higher temperatures. It was noted that significant interaction effect between the two variables ($F_{5, 12}$ = 22.96, P =<0.0001) in lethal time at *e*CO_2 and higher temperatures.

For all the insecticides tested, the highest reduction of persistence toxicity was observed at 34^{o}C with *e*CO_2 followed by 34^{o}C (*e*Temp) but *a*CO_2 evidencing the accentuating effect of *e*CO_2 with *e*Temp conditions (Fig.3.1.8.1.). The toxicity was reduced to less than 20 per cent in a period of 5 days with all five insecticides at 34^{o}C with *e*CO_2 in contrast to the 9 to 12 days required to achieve similar reductions at the standard growing conditions 28 ^{o}C and *a*CO_2 (Fig.3.1.8.2).

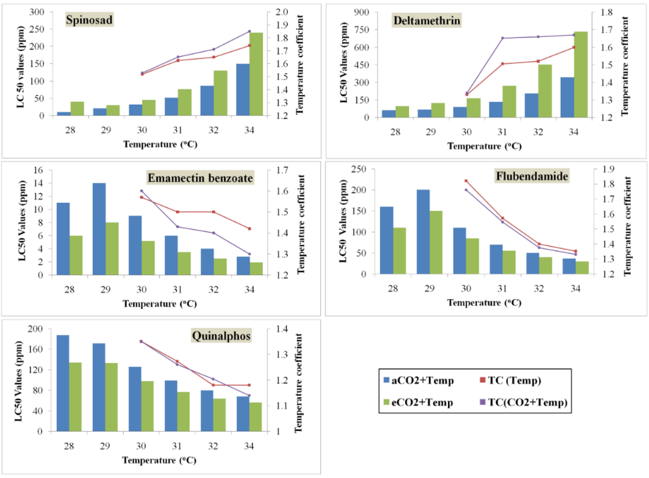


Fig. 3.1.8.1. Interactive effect of eCO$_2$ and eTemp. on lethal concentrations of five insecticides against S. litura on peanut crop

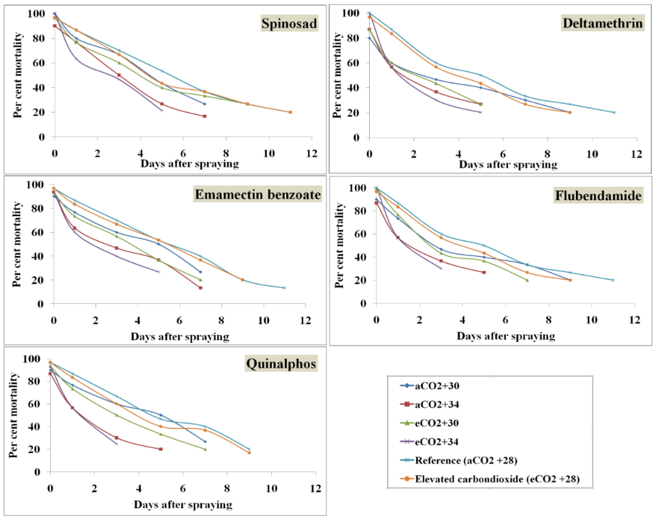


Fig.3.1.8.2. Temporal variation in persistence toxicity of five insecticides due to eCO$_2$ and eTemp against S. litura on peanut crop

3.1.9. Impact of eCO$_2$ and eTemp on rhizo microbiome of black gram (*Vigna mungo* L.) and characterization of efficient *Rhizobium* strain(s)

Rhizobium isolates were isolated from nodules of four black gram genotypes viz., IPU-06-02, PLU-826, PSRJ-95016 and IPU-094-1. All the four black gram genotypes were grown under ambient conditions, elevated temperature (+3°C) and elevated temperature (+3°C) + elevated CO$_2$ (550 ppm) conditions at Free Air Temperature Elevation (FATE) facility. The nodules were surface sterilized, crushed and the sap was streaked onto congo red yeast extract mannitol agar (CRYEMA) plates. Small, round, colourless colonies were selected and restreaked on CRYEMA for purification. Stock cultures were prepared from the purified cultures (Fig.3.1.9.1).

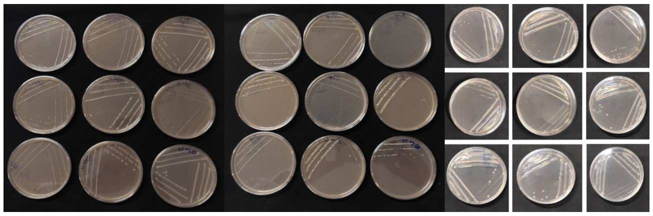


Fig.3.1.9.1 Purified Rhizobium isolates from black gram genotypes

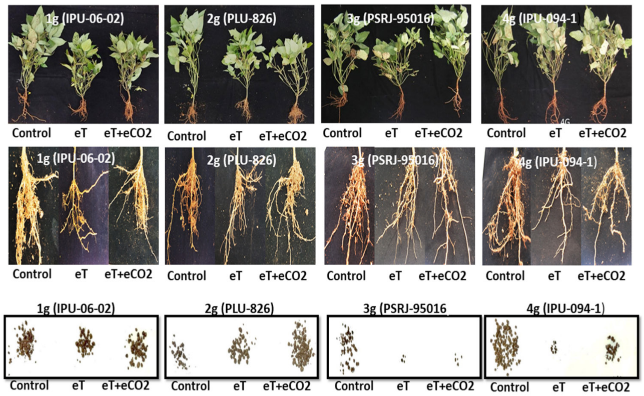


Fig. 3.1.9.2 Variation of plant parameters across black gram genotypes and growth condition

Analysis of nodulation efficiency and plant parameters

Variation in nodule parameters such as no. of nodules, nodule fresh weight and dry weight was observed across different genotypes and environmental conditions. Number of nodules ranged from 3.67 to 76.67, nodule fresh weight varied from 12 to 695.33 mg and nodule dry weight ranged from 4.35 to 380.67 mg. Highest number of nodules were observed in IPU-06-2 genotype (et+eCO2) followed by IPU-094-1 genotype (Control) (Fig 3.1.9.3. and 3.1.9.3a). Differences in plant biomass, shoot length, root length, shoot and root fresh weight were recorded across genotypes and environmental conditions such as ambient, elevated temperature and elevated temperature + elevated CO$_2$ conditions (Fig 3.1.9.3b).

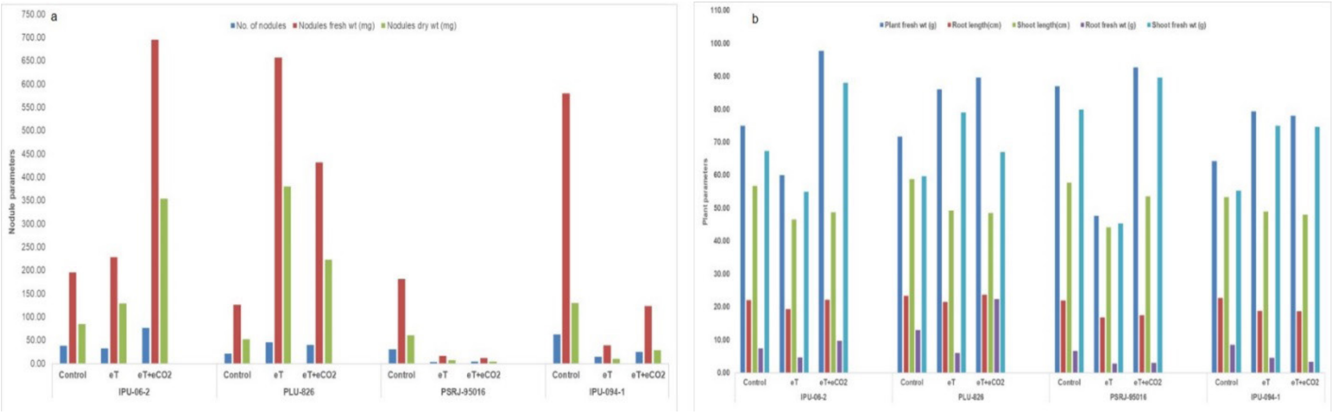


Fig. 3.1.9.3 (a) Nodule and (b) plant growth characteristics across black gram genotypes and growth conditions

3.2. Theme II. Impact of variable rainfall on Soil and Crops

3.2.1. Soil plant water dynamics modelling under eCO2 and eTemp and varying rainfall intensities for rainfed crops

Extreme rainfall analysis for developing intensity-duration-frequency curves for Rangareddy district

Annual Rainfall Data for the duration 1971-2020 (50 Years) has been collected from the Hayatnagar Research Farm, ICAR-CRIDA. The peak rainfall events for *kharif*, *rabi* and off-season were analysed and it was found that both August and September would have 8 events in august and 5 events in September with more than 100mm/day peak rainfall in the season. However, the maximum daily peak rainfall (177.8mm/day) was found in September and 140.8 mm/day in August over 50-year cycle (Fig.3.2.1.1.). The daily peak rainfall of more than 100 mm is likely to occur once in 5 years in the month of August and once in 10 years in September. During *rabi* season (October-December), both October and November have the peak events with three events in October with a maximum of 304.6 mm/day and one event in November with 114 mm/day over 50 years (Fig.3.2.1.2.). During off-season months (January to May), the peak rainfall events are more in May followed by March with less than 70 mm/day (Fig.3.2.1.3.) indicating an opportunity for harvesting runoff from the agriculture catchments in May and useful for pre-sowing irrigation if the onset of monsoon fails during sowing window of rainfed crops.

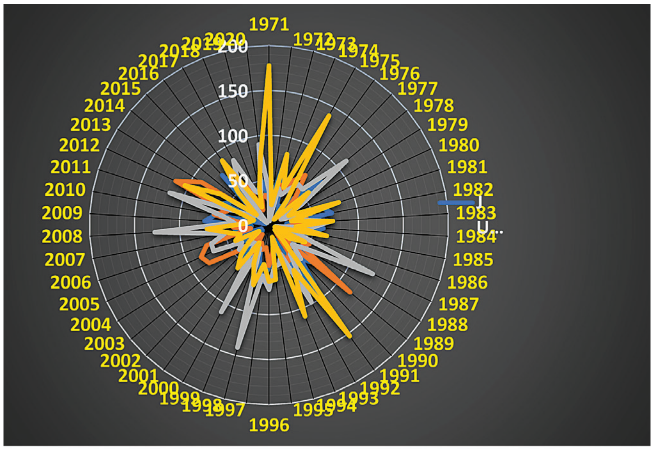


Fig.3.2.1.1. Daily peak rainfall analysis for kharif season (June-September)

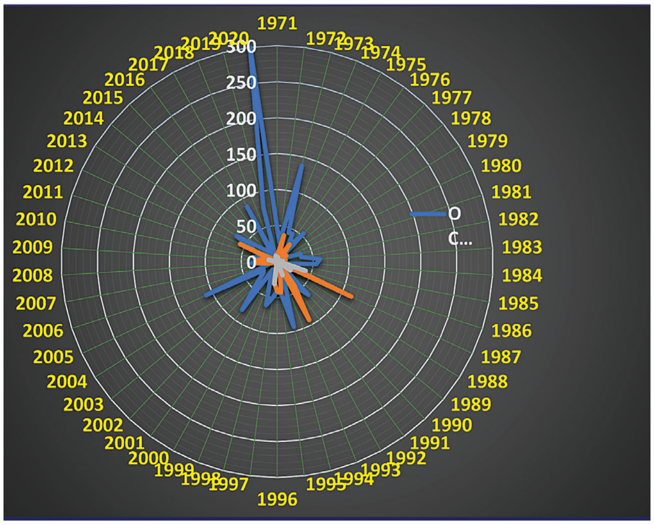


Fig.3.2.1.2. Daily peak rainfall analysis for rabi season (October-December)

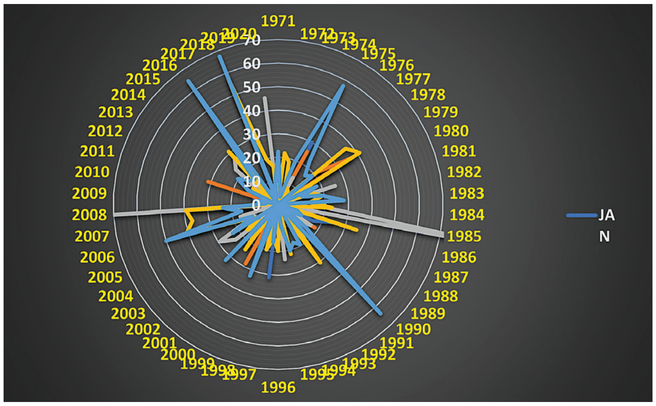


Fig:3.2.1.3. Daily peak rainfall analysis for off season (January-May)

The annual daily peak rainfall was analysed for knowing the frequency of the peak rainfall. The peak rainfall of 76.2, 116.3, 139.0, 147.2, 177.8 and 304.6 mm/day were obtained (Fig.3.2.1.4.) for the recurrence intervals of 2,5,10,15,25 and 50 years. These annual peak rainfall data was split into the rainfall amounts per hour were calculated by using IMD1/3rd rule for different short time duration of 0.25, 0.5, 0.75, 1, 2, 3, 4 and 5 hours as shown in (Fig. 3.2.1.5.)

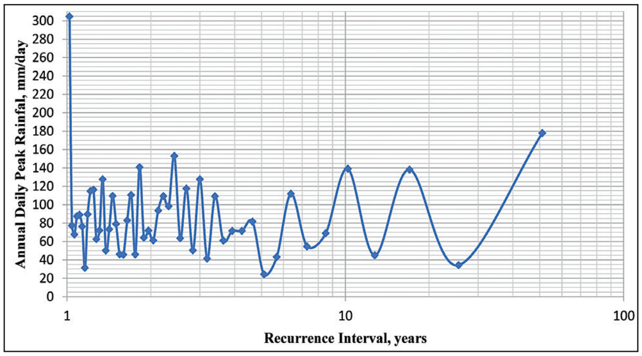


Fig. 3.2.1.4. Semilog plot of Recurrence interval and Annual daily peak rainfall

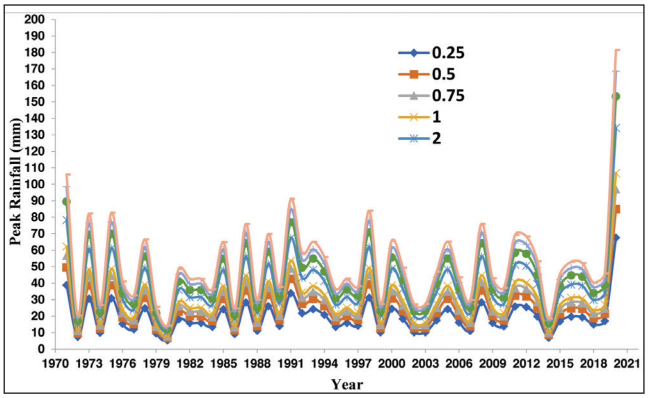


Fig. 3.2.1.5. Daily peak rainfall for different shorter time durations

The mean and standard deviation of the above daily peak rainfall over the 50 years were calculated for determining the rainfall intensity for different frequencies and time duration using Gumbel Extreme Value Distribution with frequency factors of 0.16, 0.72, 1.3, 1.63, 2.04 and 2.61 for the recurrence intervals of 2, 5, 10, 15, 25 and 50 respectively. Using this data, the Intensity-frequency-duration curves are developed (Fig.3.2.1.6.). From these curves, the rainfall intensities with 5-10 years recurrence intervals could be used for rainfall simulation studies with extreme rainfall events.

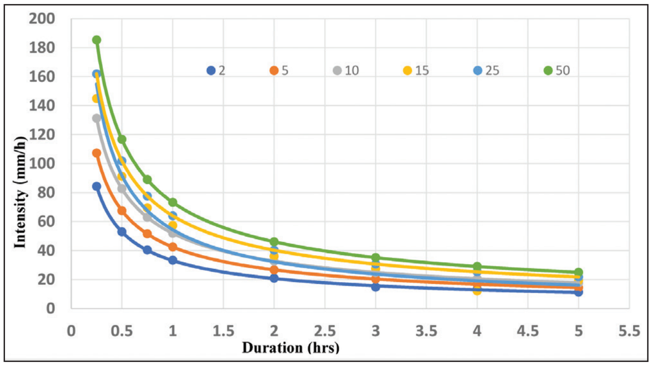


Fig.3.2.1.6. Rainfall intensity-frequency -duration curves for Rangareddy district

3.3. Theme III. Adaptation and mitigation technologies for minimizing impact of climate change in rainfed farming systems.

3.3.1. Adaptation and mitigation of climate change through effective resource management practices in rainfed agriculture

Besides several other factors, severe land degradation and deterioration of soil quality are among the major causes of low productivity in the rainfed regions. In order to increase crop productivity in rainfed Alfisol soils, it is important that land degradation is checked and soil quality is improved through effective soil management practices viz. conservation tillage, residue recycling, conjunctive use of nutrients, optimum levels of fertilizers especially N etc. Keeping in view, the present long-term experiment with sorghum–castor was started in the year 1995 and later approved for inclusion in the NICRA in the year 2021. The objective of the study was to assess the impact of long-term tillage, residue and nutrient management on yield sustainability, stratification of nutrient pools and carbon sequestration potential under sorghum–castor rotation.

To achieve this objective, a field experiment comprising of tillage (conventional (CT) and minimum (MT)), residues (2 t ha^{-1}dry sorghum stover (SS), 2 t ha^{-1} fresh Gliricidia lopping (GL) and no residue (NR)) and nitrogen levels (0 (N_0), 30 (N_{30}), 60 (N_{60}) and 90 (N_{90}) kg N ha^{-1}) under sorghum (*Sorghum vulgare* (L)) and castor (*Ricinus communis* (L)) system was initiated in a strip split-split plot design at Hayathnagar Research Farm during 1995. During the *kharif* season of 2021, sorghum (CSV-20) was the test crop. The effect of tillage, residue and nitrogen treatments on crop yield was studied.

Effect of tillage, residues and N levels on crop yield

Sorghum grain yields: The sorghum grain yield across the treatments varied from 799 to 1233 kg/ ha. Minimum tillage (981 kg/ ha) recorded significantly higher average sorghum grain yields (5 per cent higher) compared to conventional tillage (933 kg/ ha) (Fig.3.3.1. 1.). Among the residues, when averaged over tillage treatments, the application of Gliricidia loppings @ 2t/ha (1033 kg/ ha) and sorghum stover @ 2t/ ha (969 kg/ ha) significantly increased the grain yield by 21 and 12 per cent compared to no residue application (868 kg/ ha). Application of N @ 90 kg/ ha recorded significantly higher grain yield (1096 kg/ ha) followed by N applied @ 60 kg/ ha (1003 kg/ ha) and @ 30 kg/ ha (908 kg/ ha) compared to control (821 kg ha^{-1}). The increase in sorghum grain yield with N applied @ 30 kg/ ha, 60 kg ha^{-1} and a 90 kg ha^{-1} level of nitrogen over control was to the of the extent of 11, 22, and 34 per cent respectively. Significantly higher grain yield (1233 kg/ ha) of sorghum was observed with the application of Gliricidia loppings + N @ 90 kg/ ha + minimum tillage (MTGLN90) followed by Gliricidia loppings + N @ 90 kg/ ha + conventional tillage (1168 kg/ ha) (CTGL N90).

Effect of tillage, residue application and N levels on Organic C at different soil depths

The results of the present study revealed that the **s**oil organic carbon content at different soil depths studied (0-5, 5-15, 15-30 and 30-45 cm) varied from 3.48 to 7.67 g/ kg (Fig.3.3.1.2.). Minimum tillage (6.27, 4.91 and 4.24 g/ kg) showed significantly higher soil organic carbon content (7, 6 and 5 per cent higher, respectively) compared to conventional tillage (5.84, 4.64 and 4.03 g/ kg) at 0-5, 15-30 and 30-45 cm soil depths. Despite, non-significant influence, minimum tillage showed relatively higher soil organic carbon (7 per cent higher) content in soil compared to conventional tillage at 5-15 cm soil depth.

Among the residue treatments, application of gliricidia loppings @ 2t /ha (6.73, 5.95, 5.14, 4.41 g/ kg) and sorghum stover @ 2t/ ha (6.47, 5.68, 4.77, 4.18 g/ kg) significantly increased the soil organic carbon content by 39, 30, 18, 18, 30, 22, 8, and 10 per cent respectively compared to no residue application (4.93, 4.67, 4.42, 3.80 g/ kg) at 0-5, 5-15, 15-30 and 30-45 cm soil depth. Among the four nitrogen levels, the application of N @ 90 kg/ ha recorded significantly higher SOC (6.68, 5.97, 5.18, 4.38 g/ kg) in soils followed by N @ 60 kg/ha (6.21, 5.57, 4.87, 4.19 g/ kg) and 30 kg/ ha (5.85, 5.24, 4.63, 4.05 g/ kg) compared to no nitrogen application (5.48, 4.96, 4.42, 3.91 g/ kg). The increase in SOC with 30, 60 and 90 kg N ha^{-1} was to the tune of 7,6,5,4 and 13, 12, 10, 7 and 22, 20, 17, 12 per cent respectively over the control (no nitrogen application) at 0-5, 5-15, 15-30 and 30-45 cm depth.

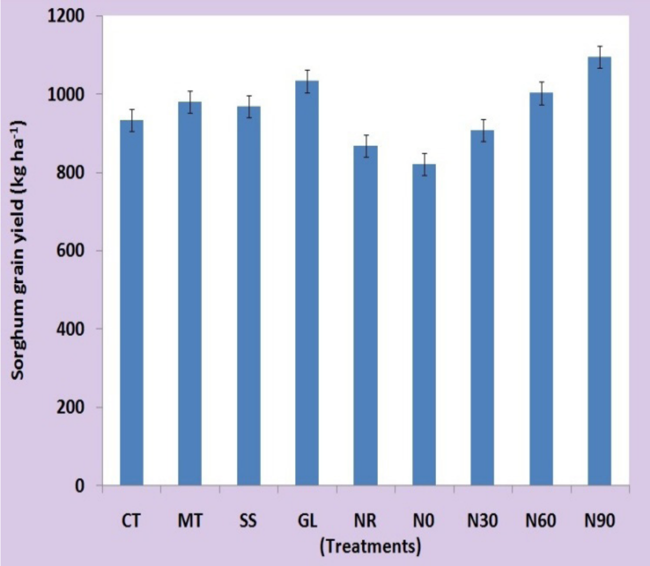


Fig. 3.3.1.1. Effect of tillage, residue application and N levels on sorghum grain yield (kg/ ha) in rainfed Alfisol under Sorghum-Castor system

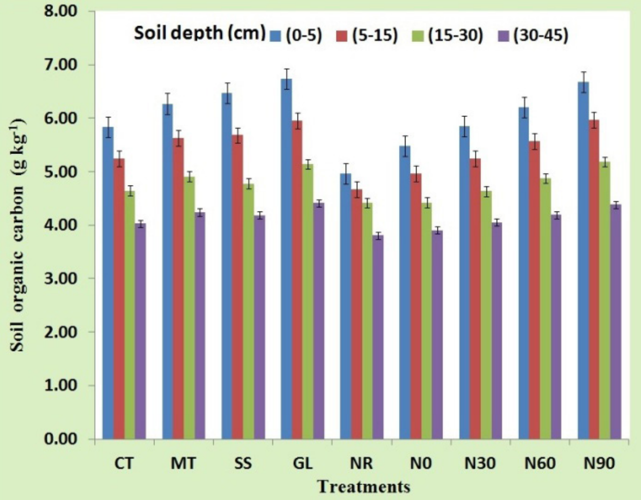


Fig.3.3.1.2. Effect of tillage, residue application and N levels on Organic Carbon (g /kg-) at different soil depths in rainfed Alfisol under sorghum-castor system

3.3.2. Development of sustainable intensification practices for mitigation and adaptation to climate change

Rainfed soils are hungry as well as thirsty. In rainfed semi-arid tropical (SAT) regions 75 per cent of rainfall received is during SW monsoon (June to September – 4 months). These regions are characterised by frequent aberrant weather conditions, erratic distribution, high intense rainfall which causes erosion, and also moisture stress during critical stages. Moreover, the dry spells, droughts are predicted to increase with climate change. Hence *in situ* soil and water conservation plays a great role to alleviate both extremes of rainfall conditions, erosion and drought. Improved storage of soil moisture at root zone. The soils are poor in fertility and the response to the nutrients is poor. Moreover, the nutrients and water are complimentary. **Depend on each other for cumulative effect to increase NUE and WUE. Hence** the integration of *in-situ* moisture conservation and nutrient management is the need of the hour.

Intercropping systems in general and cereal + legume intercropping, in particular, provides greater stability, minimises the risk and may reduce fertilizer requirement. Among the legumes, pigeon pea is an important legume that is drought tolerant, adapted to arid and semi-arid regions, reduce nutrient mining, complementarities with cereals and has the ability to fix nitrogen. Hence a study was initiated to develop pigeon pea + maize intercropping systems to develop sustainable intensification practices with an objective to improve the yield with low environmental impact.

A study was conducted in maize + pigeon pea intercropping system with different *in situ* moisture conservation and nutrient management. The total pigeon pea equivalent yields were higher in in situ moisture conservation system as compared to flat sowing.

Intercrop

Flat sowing (PP + Maize) (1:2)

Flat sowing with Conservation furrow (PP + Maize) (2:2)

Paired row (PP + Maize) (2:2)

Raised bed (PP + Maize) (2:2)

Flat sowing

Conservation furrow at sowing

Raised bed

Flat sowing with live mulch

Conservation furrow at 30-40 DAS

Potential role of *in situ* moisture conservation and nutrient management strategies for sustainable production and resource use efficiency in rainfed areas

An experiment was initiated to study the efficacy of different *in situ* moisture conservation treatments and fertilizer on crop productivity and resource use efficiency in cotton. The lint yield of cotton was influenced by *in situ* moisture conservation and fertilizer treatments. CF at sowing recorded 31 and 30 per cent higher yield as compared to flat sowing and live mulch respectively. CF at 30 DAS recorded higher yield as compared to flat sowing+ live mulch. The higher yield in CF at sowing is due higher soil moisture in this treatment as compared to other treatments. The entire rainfall from sowing till harvest was utilized completely. The crop yield was higher 125 per cent RDF as compared to 100 per cent and 75 per cent RDF. (Fig 3.3.2.1.)

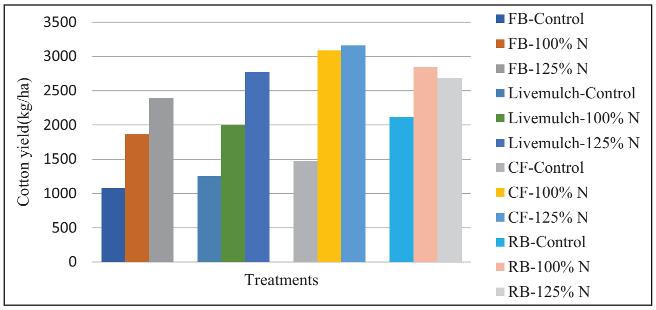


Fig.3.3.2.1. Influence of different treatments on cotton yield (kg/ha)

3.3.3. Potential of organic crop production as a climate change adaptation and mitigation strategy in rainfed agriculture

Organic agriculture is one of the fastest growing sectors of agricultural production, and is reported to have both climate change adaptation and mitigation potential particularly in rainfed agriculture. A field experiment was conducted during *kharif* 2021 at GRF of the institute to evaluate the performance of sunflower, green gram and pigeon pea under organic, inorganic and integrated crop management systems. The experiment was laid out in a strip-plot design with three production systems and three crops. In the plots under organic management, farmyard manure was applied on the N equivalent basis to all the three crops and the P requirement was supplemented through rock phosphate. In the plots under integrated management, 25 per cent of equivalent recommended N was applied through farmyard manure. The remaining 75 per cent N and 100 per cent P and K was applied through chemical fertilizers. The plots under control received recommended dose of chemical fertilizers (20:50 kg N and P_2O_5/ha for pigeon pea and green gram; 60:60:30 kg N, P_2O_5 and K_2O/ha for sunflower).

In general, the seed yields of both green gram and sunflower were less across all the treatments due to a dry spell of 18 days (25th July – 11th August), and heavy rainfall events (115.4 mm) during 4th -7th September coinciding with flowering and seed formation stages. The seed yield of pigeon pea was also less across different treatments due to the occurrence of wilt and no rainfall during pod filling and maturity. The seed yield of sunflower under organic management (943 kg/ha) was similar to that under integrated management (918) but 13.4 per cent higher compared to control (828 kg/ha). Similar results were also recorded for green gram where plots under organic management produced 8 per cent higher seed yield (686 kg/ha) compared to control (638 kg/ha). However, pigeon pea seed yield was similar in the plots under three production systems (348-375 kg/ha) (Fig.3.3.3.1.). In general, the cost of cultivation under organic management was higher by Rs. 2610/ha in pigeon pea and green gram and by Rs. 9790/ha in sunflower compared to that under the integrated production system. Therefore, a price premium of at least 5 per cent for organic green gram and pigeon pea and 30-35 per cent for organic sunflower may be required to offset the higher cost of cultivation compared with integrated production system.

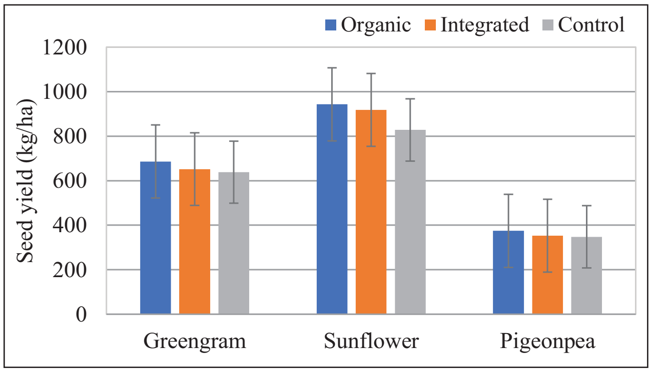


Fig.3.3.3.1. Performance of crops under different production systems

3.3.4. Genotyping of black gram for identifying diverse genetic materials

Black gram or urdbean (*Vigna mungo* L. Hepper 2n = 22) is a short duration grain legume crop with high protein content. It improves soil fertility by capturing atmospheric nitrogen. It ranks fourth in acreage and production after chickpea, pigeon pea and green gram amongst pulse crop in India and is consumed throughout the country. Although urdbean is considerably grown under a large area, the average national productivity is still very low (550 kg/ha) as compared to other pulses. This crop is exposed to drought stress at different stages of its growing period. Drought stress drastically affects the production and productivity of this crop when exposed to stress at flowering and post-flowering adversely affecting various yield related parameters such as pod number, seed number, seed weight and quality and seed yield per plant. Yield is a complex character with high genotype × environment interactions. Hence, there is a need to develop drought-tolerant varieties to improve crop productivity, especially under the changing climate scenario.

A field experiment was conducted in *kharif* 2021 with 40 genotypes of black gram under well-watered and water stressed conditions. Each genotype was sown in two rows of 2 m with three replications. The row to row distance was 45 cm and plant to plant distance was 10 cm. Data on various morpho-physiological traits were recorded in both well-watered and water deficit stress treatments during a dry spell of 10 days coincided with the flowering stage. The parameters recorded were SPAD chlorophyll meter reading (SCMR), normalized difference vegetation index (NDVI), canopy temperature depression (CTD), fv/fm, relative water content (RWC), membrane stability index (MSI), days to flowering, number of plants per row (PN), plant height (PH), number of branches (BN), cluster number (CN), pod length (PL), number of pods (PN), number of seeds per pod (seed/pod), pod yield (PY), fodder yield (FY), seed yield (SY), hundred seed weight (HSW), total biomass (TB) and harvest index (HI). Genomic DNA was isolated from young leaves of all the genotypes at early vegetative stage for using SSR markers genotyping work.

Another field experiment was conducted with 62 germplasm accessions received from NBPGR, New Delhi under rain-fed conditions at CRIDA research farm, HRF with a 2 row plot of 2 m for each genotype. The various parameters recorded were days to flowering (DF), plant height (PH), cluster number (CN), branch number (BN), pod number (PN), pod length (PL), seed/pod (SP), hundred seed weight (HSW), total biomass (TB), seed yield (SY) and harvest index (HI).

In another experiment, genotypic response of black gram to increased 21 hours light duration was carried out using 40 genotypes. The genotypes were sown in germination trays and grown under the controlled environment in plant growth chamber (Conviron). The plant was maintained under light conditions for 21 hrs and the temperature regime was 25 – 28 ^{0}C. A dark phase of 3 hrs was maintained at 22 ^{0}C. The days to flowering, poding, maturity dates were recorded.

The various physiological and yield related traits were affected under water stress conditions as compared to well-watered. The days to flowering ranged between 33 – 37 days under both well-watered and water – deficit stress conditions. The treatment effect was significant for all the traits except plant height, cluster number, pod length, seed / pod and hundred seed weight. Genotypic differences were significant for all the traits. Genotype × treatment effects were significant for all the traits except relative water content, cluster number, pod length, fodder yield, seed yield and total biomass.

Under water deficit stress conditions significant positive correlations were observed between MSI with PN, SPAD with PL and seed/pod, fv/fm with DF, PH and HI, NDVI with SY, DF with PH and PN, PH with BN and PN, BN with PN, PL with seed/pod, PN with SY and HI, FY with PY, SY and TB, PY with SY and TB, SY with TB and HI. The genotypes IPU-10-1, IPU-10-26, IPU-10-33, IPU-11-6, IPU-2-37, IPU-9-13, IPU-94-4 and LBG-623 maintained higher relative water content, membrane stability index and yield both under well-watered and water deficit stress conditions.

Among the 62 accessions evaluated under rain-fed conditions, the days to flowering ranged between 36 – 60 days while SY ranged between 1.73 to 14.4 g/plant. Cluster analysis of the genotypes resulted in the formation of 3 clusters with 40, 15, 7 genotypes in cluster I, II and II respectively. Genotypes in cluster I and III differed in DF, CN, PN, TB and SY. The genotypes IC321704, IC436621, IC546466, IC436567, IC436606, IC343973, IC331251, IC436615 and IC565254, were high yielders ranging between 10.28 - 14.4 g /plant.

In the control environment growth chamber study, genotypes showed differential response to light and temperature regime. Flowering time was advanced by 1-2 days and maturity by 1-8 days in some of the genotypes. Among genotypes IPU 9-16, IPU-13-7, PLU-710 and IPU-2-37 showed advancement in days to flowering and maturity.

Black gram genotypes in plant growth chamber

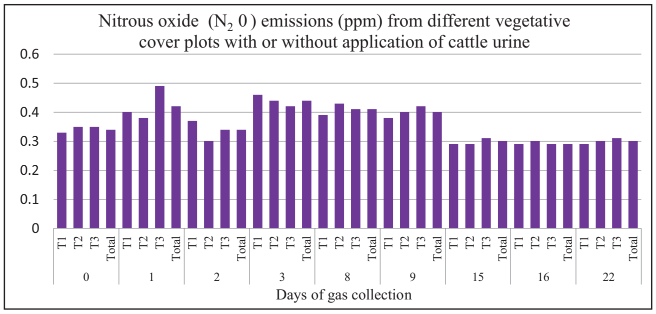
3.3.5. Assessment of nitrous oxide emissions from livestock urine deposited in grazed pastures during different seasons

Ruminant excreta (dung pats and urine) deposited on grazed grasslands are a major source of the greenhouse gas (GHG) nitrous oxide (N_2O). Currently, many countries use the IPCC default emission factor (EF) of 2 per cent to estimate excreta-derived N_2O emissions. However, emissions can vary greatly depending on the type of excreta (dung or urine), soil type and timing of application. Urine patches and dung pats from grazing livestock create hotspots for production and emission of the greenhouse gas, nitrous oxide (N_2O), and represent a large proportion of total N_2O in many national agricultural greenhouse gas inventories. Assessed the effect of added cattle urine at a rate of 0.7 L urine/m^2 on Green House Gases (GHGs) emissions in general and nitrous oxide emissions in particular under low, medium and high pasture cover of the grazing area during rainy season at Hayath Nagar research farm.

Mean daily temperature and relative humidity (RH) varied throughout the experimental period and ranged from 24.18 to 26.91 $^{\circ}$C and 74.88 to 92.93, respectively. Carbon dioxide and methane emissions were significantly ($P<0.05$) higher in the experimental plots received cattle urine than without cattle urine. Mean carbon dioxide was increased linearly with the time i.e., from 0 to 60 minutes of sample collection under different pasture cover blocks and the differences were significantly ($P<0.01$) different. However, no significant difference in carbon dioxide values (ppm) was observed among the low, medium and high pasture cover blocks either at 0 or 15 or 30 or 45 minutes of gas sampling from collection chambers. The differences in mean methane values among the different time intervals (0,15, 30 and 45 minutes) were significantly ($P<0.01$) different and linearly increased with the time, however no significant difference in methane values (ppm) was observed among the low, medium and high pasture cover blocks. The differences in mean nitrous oxide values among the different time intervals (0,15, 30 and 45 minutes) were significantly ($P<0.01$) different. Nitrous oxide emissions were significantly ($P<0.05$) higher in low pasture cover experimental plots than high pasture cover plots. Methane (CH_4) and nitrous oxide (N_2O) emissions were significantly ($P<0.05$) higher in cattle urine applied experimental plots than control.

Cumulative N_2O emission flux from the urine applied plots differed significantly ($P<0.05$) and were higher under low, followed by medium and high pasture blocks of the experimental field. Similarly, cumulative N_2O emission flux from the control plots without urine application were 0.95, 0.79 and 0.70 kg N/ ha, respectively under low, medium and high pasture blocks of the experimental field.

Cumulative N_2O emissions from with urine application were 3.92, 3.40 and 2.38 kg N/ ha, respectively under low, medium and high pasture blocks of the experimental field. Cumulative N_2O emissions from the control plots without urine application were 0.95, 0.79 and 0.70 kg N/ ha, respectively under low, medium and high pasture blocks of the experimental field. Nitrous oxide (N_2O) emissions factor (per cent) of low, medium and high pasture blocks of the experimental field was 0.17, 0.15 and 0.09, respectively.



3.4 Theme IV. Bio-physical and socio-economic aspects of climate resilient technologies

3.4.1. Adaptation targeting and prioritization for climate change

The impact of climate change on productivity of sorghum was examined following panel data regression approach. A regression model was estimated by regressing on sorghum yields on monthly rainfall, temperature and a time trend using the district-wise time series data on crop yield, rainfall and temperature for the period 1971-2005. The climate change impact on yield was then estimated using the regression coefficients and projected climate for 2040-69 for RCP 6.0 scenario. The results showed that rainfall during June positively influenced sorghum yield whereas September temperature had a negative effect. Sorghum yield is projected to decline by 200-300 kg, compared to a 'no climate change' situation in 47 out of 88 districts.

Table. 3.4.1.1. Distribution of sorghum growing districts based on climate change impact on yield

Impact (kg/ha)	Districts
-349 to -300	3: Chitrakut, Bharuch, Nasik
-299 to -250	30: Nandurbar, Betul, Banda, Tikamgarh, Khandwa (East Nimar), Nanded, Khargone (West Nimar), Hingoli, Barwani, Dhar, Jhabua, Mehsana, Hamirpur, Jalgaon, Parbhani, Beed, Fatehpur, Guna, Dhule Akola, Amravati, Washim, Nizamabad, Belgaum, Jalna, Shajapur, Aurangabad, Ahmednagar, Buldhana, Dewas
-249 to -200	17: Yavatmal, Rajgarh, Latur, Osmanabad, Medak, Bhavanagar, Kanpur City, Kanpur (Dehat), Bidar, Solapur, Surendranagar, Rae-Bareily, Rangareddy, Banaskantha, Sangli, Gulbarga, Dharwad
-199 to -150	23: Thiruchirapalli, Madurai, Nalgonda, Bijapur, Dharmapuri, Haveri, Salem, Dindigual, Mahabubnagar, Karur, Raichur, Pali, Bhilwara, Davanagere, Bagalkot, Namakkal, Virudhunagar, Gadag, Koppal, Theni, Chamarajanagar, Mysore, Kurnool
-149 to -100	15: Bellary, Tonk, Anantapur, Faridabad, Alwar, Chitradurga, Bharatpur, Ajmer, Gurgaon, Jodhpur, Jaipur ,Sonipet, Nagaur, Rohtak, Jhajjar

3.4.2. Assessing impact of climate change on major rainfed crops and constructing agro-climatic analogues for adaptation

- An apportioned district database covering time series data on area sown, production and yield for years 1966-67 to 2017-18 was built including crops viz., rice, sorghum, pearl millet, maize, pigeon pea, chick pea, black gram and green gram crops
- Assessed current and future climate at district level: Baseline climate of 1976-2005 with daily scale Precipitation (P), Max T and Min T data at district level (sourced from IMD) and climate projections of multi-model ensemble for Precipitation, Max T and Min T at daily scale for 2030s and 2050s for RCP 4.5 and RCP 6.0 scenarios of CMIP 5 models at district level were used in the study. Computed Potential Evapotranspiration (PE) at district level using Hargreaves method from Max T and Min T data. These PE estimates were calibrated using FAO recommended Penman-Monteith method as standard. Computed moisture index from P and PE and assessed climate at district level (Arid, Semi-arid, Dry sub-humid, Moist sub-humid, Humid and Per humid). Climatic shifts are observed in 24 districts in 2030s and 32 districts in 2050s as per RCP 4.5 and in 15 districts in 2030s and in 22 districts in 2050s as per RCP 6.0 (Table 3.4.2.1. and Fig. 3.4.2.2.). By and large moisture index is projected to rise indicating enhanced moisture availability in future. Climate in future is going to be warmer and wetter but climatic shifts are minimal.

Table 3.4.2.1. Projected Climatic Shifts as per RCP 6.0 Scenario of CMIP 5 Models

Shift from	1976-2005 to 2020-2049		1976-2005 to 2040-2069	
	No. of districts	Districts	No. of districts	Districts
Arid to semi-arid	4	Bhavnagar, Rajkot, Amreli, Jamnagar	4	Bhavnagar, Rajkot, Amreli, Jamnagar
Semi-arid to dry sub-humid	3	Varanasi, Sultanpur, Bhojpur	6	Chandauli, Varanasi, Buxar, Warangal, Sultanpur, Bhojpur
Dry sub-humid to moist sub-humid	2	Burdwan, Maharajganj	4	Purulia, Burdwan, Dang, Maharajganj
Moist sub-humid to dry sub-humid	0	-	2	Lahaul and Spiti, Poonch
Moist sub-humid to humid	3	24-Paraganas (North), Howrah, Pathanamthitta	3	24-Paraganas (North), Howrah, Pathanamthitta
Humid to moist sub-humid	2	Doda, Kodagu	1	Doda
Per humid to humid	1	Sindhudurg	2	West Tripura, Sindhudurg

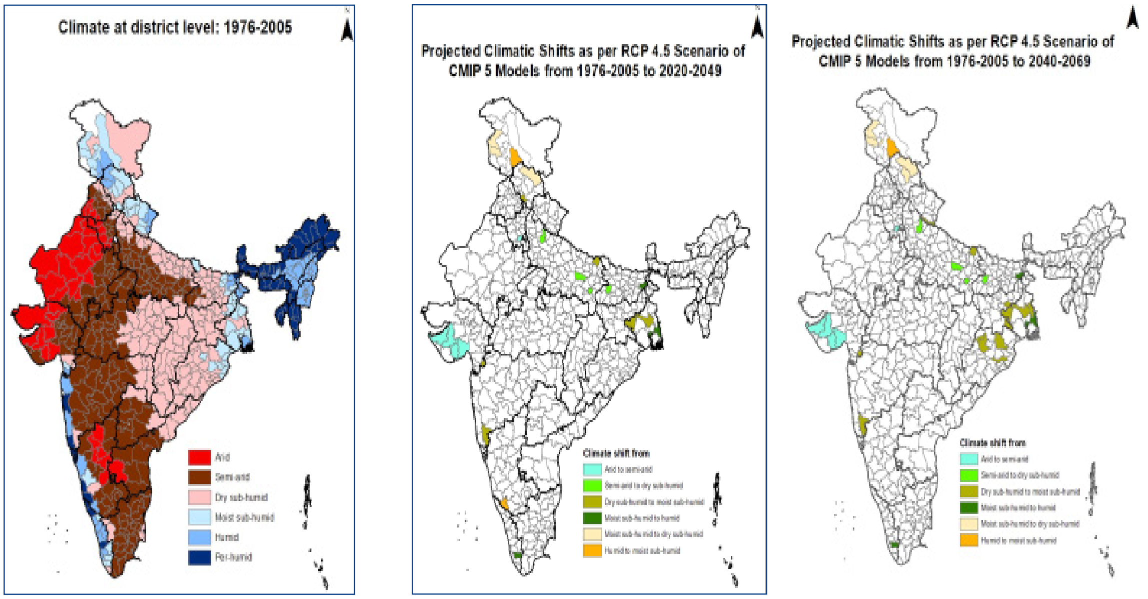


Fig. 3.4.2.1. Climatic shifts in different districts under RCPs

3.5. Theme V. Development of IT based tools for climate change research

3.5.1. District-wise adaptation strategies in rainfed maize under projected climate

Future climate data derived from 30 general circulation models were used in DSSAT-CERES-Maize model to quantify the impact of projected climate on yield of rainfed maize in 16 major growing districts of the country. In the future, there is a projection of significant increase in mean seasonal maximum (0.9–6.0˚C) and minimum temperatures (1.1–6.1˚C). Climate change will lower maize yield by 16 per cent (Tumkur) to 46 per cent (Jalandhar) under RCP 4.5 and 21 per cent (Tumkur) to 80 per cent (Jalandhar) under RCP 8.5 from the baseline period, if adaption measures are not taken up (Fig.3.5.1.1). Only in Dharwad, the yield will be marginally greater or unchanged. The effectiveness of a combination of six adaptation measures delayed sowing by two weeks, an increased dose of nitrogen fertilizer i.e., 150 kg ha^{-1}, additional irrigation (one irrigation of 50 mm during either vegetative state (10-30 days after sowing) or reproductive stage (45-55 days after sowing), was better than the individual measures. For each of the future scenarios, district-specific adaption techniques were identified (Table 3.5.1.1).

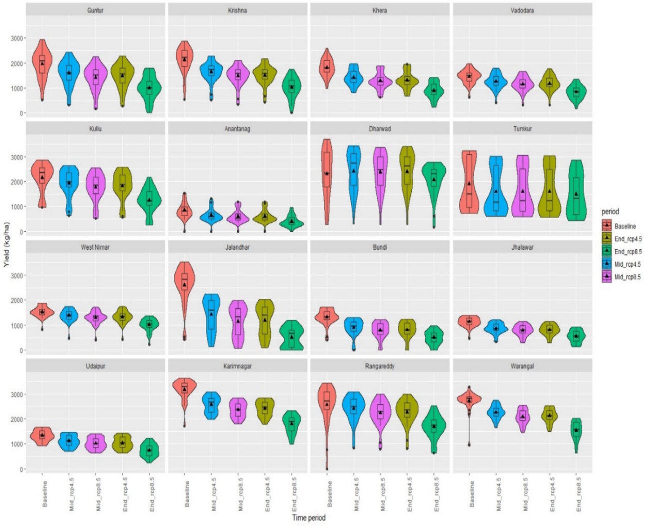


Fig. 3.5.1.1: Simulated maize yield during mid-century (2040-2069) and end-century (2070-2099) under RCPs 4.5 and 8.5 relative to baseline (1980-2009)

Table 3.5.1.1: Ideal adaptation strategies for different future scenarios

District	Adaptation Strategy			
	Mid-Century		End-Century	
	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5
Guntur	NS+F+I	NS+F+I	NS+F+I	NS+F+I
Krishna	NS+F+I	NS+F+I	NS+F+I	NS+F+I
Kheda	NS+F+I	NS+F+I	NS+F+I	NS+F
Vadodara	NS+F+I	NS+F+I	NS+F+I	NS+I
Kullu	DS+I	DS+I	DS+I	DS+I
Anantnag	DS+I	DS+I	DS+I	DS+I
Dharwad	NA	NA	NA	NS+I
Tumkur	NS+F+I	NS+F+I	NS+F+I	NS+F+I
West Nimar	NS+F+I	NS+F+I	NS+F+I	NS+F+I
Jalandhar	DS+F	DS+I	DS+I	DS+I
Bundi	NS+F+I	NS+F+I	NS+F+I	NS+F+I
Jhalawar	DS+I	NS+F+I	NS+F+I	NS+F
Udaipur	NS+F+I	NS+F+I	NS+F+I	NS+F+I
Karimnagar	NS+F+I	NS+F+I	NS+F+I	NS+F
Rangareddy	NS+F+I	NS+F+I	NS+F+I	NS+F+I
Warangal	NS+F+I	NS+F+I	NS+F+I	NS+F+I

(NS-Normal Sowing; F-Increased Fertilizer Dose; I - One Supplemental Irrigation; DS-Delayed Sowing; NA-No Adaptation)

3.5.2. Deep learning based AI models for plant recognition and stress detection from plant digital imageries

The aim of the project is to detect stress in different stages using deep learning-based AI models. As an initial step 3000 different stress digital imageries of black gram, cowpea, finger millet, fodder sorghum, groundnut, horse gram, maize, pigeon pea and sorghum were taken during the crop season from HRF, GRF. Digital imageries were also taken for nitrogen deficiency symptoms in black gram and maize pot experiments grown with Hoagland Solution.

Plant Stress imageries

3.6. Technology Demonstration Component (TDC)

Technology Demonstration Component (TDC) of NICRA aims at enhancing resilience and adaptive capacity of farmers and to minimize the impact of climate variability in risk prone districts of the country. The programme also aims at building capacity of farmers and to generate awareness on climate resilient agriculture and the establishment of institutions in the villages to enable communities to respond to climate stresses in a continuous manner. It is being implemented in 151 village clusters representing 28 states and 5 union territories during 2021. As part of the programme, several technologies are being demonstrated so as to assess them and to enhance adoption of these technologies by farmers. Technologies demonstrated are broadly divided in to natural resource management, crops and animal related technologies depending on the resource endowments of the region and farmers.

3.6.1. Demonstration of climate resilient technologies and their impact

In case of natural resource management, emphasis was given on demonstration of location specific *in situ* and *ex situ* water management and efficient use of harvested water. During the year 2021, in Bhitihara village of Buxar district, Bihar, increase of bund height for paddy was demonstrated in 42 ha. Increase of bund height in paddy fields resulted in harvesting more water and storing for longer days, which helped to minimize the moisture stress during dry spells and resulted in additional paddy yield up to 12 per cent compared to farmers' practice. Sowing of wheat through Happy Seeder helped to reduce the cost of cultivation and also reduced the weed growth compared to farmers' practice. This technology enhanced yields up to 19 per cent compared to farmers' practice (Table 3.6.1.1.). Rising of bund height was spread to 85 ha area involving 64 farmers in the TDC-NICRA village in convergence with MGNREGA.

Table 3.6.1.1. Impact of rising of bund height for paddy and happy seeder sowing for wheat in Bhitihara village of Buxar

Crop	Technology	Yield (kg/ha)	B:C ratio
Paddy	Rising bund height	605	2.30
	Farmers' practice	540	1.99
Wheat	Sowing with Happy Seeder	413	2.44
	Farmers' practice	347	2.21

Enhancing bund height and sowing with happy seeder in Bhitihara village of Buxar, Bihar

In Sitara, Senhti and Mukandpura villages of Bharatpur district, Rajasthan, construction of 82 tube well recharge structures were demonstrated for water harvesting during rainy season. The recharge structures helped to enhance the groundwater level by 15 to 20 feet in bore wells, resulting in additional 2 irrigations for *rabi* crops. This technology also helped in reducing the electric conductivity of the groundwater, which otherwise could not be used due to the higher salt content in irrigation water. The harvested water was used for pre-sowing and supplemental irrigation for *rabi* crops such as wheat, barley and mustard. This technology helped in improving yields by 1400 kg/ha in wheat, 800 kg/ha in barley and 530 kg/ha in mustard crop as compared to farmers' practice (Table 3.6.1.2.). This intervention helped to irrigate 149 ha area benefitting 88 farmers in the TDC-NICRA village.

Table 3.6.1.2. Impact of tube well recharge structures for different *rabi* crops in NICRA cluster of villages of Bharatpur, Rajasthan

Crop	Technology	Yield (kg/ha)	B:C ratio
Wheat	Tube well recharge structure	520	3.1
	Farmers' practice	380	2.5
Barley	Tube well recharge structure	480	2.5
	Farmers' practice	400	2.1
Mustard	Tube well recharge structure	225	3.9
	Farmers' practice	172	3.4


Tube well recharge structure and supplemental irrigation for wheat and mustard crops in Sitara village, Bharatpur, Rajasthan

Improved irrigation methods such as mini sprinkler in wheat and drip irrigation in vegetables were demonstrated in 2 and 4.5 ha area involving 5 and 7 farmers respectively in Chakwas village of Jhunjhunu district, Rajasthan. Improved irrigation methods helped to use harvested water efficiently and saved up to 50 per cent water compared to surface method of irrigation. Technologies helped to get additional yield of 18 per cent in wheat and 19 per cent in cucurbitaceous crops with additional net return of Rs. 16131 per ha from wheat and Rs. 23000 per ha from cucurbitaceous crops was realized over the farmers' practice (Table 3.6.1.3.).

Table 3.6.1.3. Efficient utilization of harvested water through improved irrigation methods in Chakwas village of Jhunjhunu, Rajasthan

Crop	Technology	Yield (kg/ha)	Net return (Rs/ha)	B:C ratio
Wheat	Mini sprinkler	429	65844	2.4
	Farmers' practice	365	49713	2.0
Cucurbitaceous	Drip irrigation	3100	110450	3.5
	Farmers' practice	2600	87450	3.1


Mini sprinkler irrigation in wheat at Chakwas village of Jhunjhunu, Rajasthan

Improved planting methods such as broad bed furrow and ridges and furrows were demonstrated in 4 ha area each involving 20 farmers of Amba village of Ratlam district, Madhya Pradesh during 2021. Improved planting methods in soybean crop helped to conserve moisture for longer days and resulted in minimizing the effect of moisture stress during dry spells and also realized good plant stand and growth of the crop compared to flatbed method of sowing. Sowing of soybean with broad bed furrow and ridges and furrow resulted in additional productivity of 4.4 and 420 kg/ha respectively, over the farmers' practice. These interventions helped to obtain additional net return up to Rs. 13440 per ha over the farmers' practice (Table 3.6.1.4.).

Table 3.6.1.4. Improved planting methods in soybean at Amba village of Ratlam district, Madhya Pradesh

Crop	Technology	Yield (kg/ha)	Net return (Rs/ha)	B:C ratio
Soybean	Broad bed furrow	156	39560	3.4
	Farmers' practice	112	26120	2.8
	Ridges and furrow	154	37850	3.3
		112	26120	2.8

Ridges and furrows and broad bed furrows for soybean at Amba village of Ratlam, Madhya Pradesh

In situ moisture conservation measure such as trench cum bunding was demonstrated in 3 ha area involving 10 farmers in D. Nagenahalli village of Tumkur district, Karnataka. Dry spell of more than 15 days was observed during vegetative stage of the finger millet crop in TDC-NICRA village. Technology helped to conserve moisture and helped to minimize the effect of moisture stress in crops during dry spells. Demonstration of trench cum bund technology helped to get an additional yield of finger millet by 360/ha compared to farmers' practice with an additional net return of Rs. 9540 per ha was realized over the farmers' practice (Table 3.6.1.5.). This technology was adopted in significant area, benefitting more than 150 farmers in the D. Nagenahalli village of Tumkur.

Table 3.6.1.5. Trench cum bund technology at D. Nagenahalli village of Tumkur, Karnataka

Crop	Technology	Yield (kg/ha)	Net return (Rs/ha)	B:C ratio
Finger millet	Trench cum bund	248	34360	2.3
	Farmers' practice	212	24820	2.0

Trench cum bund in finger millet at D. Nagenahalli village of Tumkur district, Karnataka

In Bhitihara village of Buxar district, Bihar, short duration, drought escaping varieties of rice (Swarna Shreya) and chickpea (BGM - 547) were demonstrated in 15 and 10 ha area involving 50 farmers in the village. The improved varieties realized an additional yield of 830 kg/ha and 330 kg/ha, and an additional net return of Rs. 12913 and 13950 per ha respectively in rice and chickpea compared to local varieties during 2021 (Table 3.6.1.6.).

Table 3.6.1.6. Short duration varieties of rice and chickpea crops in Bhitihara village of Buxar

Crop	Technology	Yield (kg/ha)	Net return (Rs./ha)	B:C ratio
Paddy	Swarna Shreya	545	51480	3.1
	Local variety	462	39287	2.8
Chickpea	BGM - 547	165	46950	2.8
	Local variety	132	33000	2.3

Demonstration of short duration varieties of paddy and chickpea at Bhitihara village, Buxar

Flood tolerant rice varieties (Swarna Sub 1 and Gotra Bidhan 1) were demonstrated in 174 ha area involving 350 farmers' in Khagribari village of Cooch Behar district, West Bengal during 2021. High rainfall events cause water stagnation during cropping period in low land area of the village, which resulted in crop damage and yield loss. Swarna Sub-1 and Gotra Bidhan 1 contributed to yield improvement up to 105 and 800 kg/ha, respectively compared to local varieties and correspondingly resulted in additional net return of Rs. 17997 and Rs. 15182 per ha over the farmers' practice (Table 3.6.1.7.).

Table 3.6.1.7. Improved varieties of rice (Swarna Sub-1 and Gotra Bidhan 1) in Khagribari village of Cooch Behar district, West Bengal

Crop	Technology	Yield (kg/ha)	Net returns (Rs. /ha)	B:C ratio
Rice	Swarna Sub-1	405	29502	2.0
	Local variety	300	11505	1.3
	Gotra Bidhan 1	410	33942	2.2
	Local variety	330	18760	1.5

Improved rice varieties (Swarna Sub-1 & Gotra Bidhan 1) at Khagribari village, Cooch Behar

Improved stress tolerant varieties of groundnut (K-6), rice (Sahbhagi and MTU-7029) were demonstrated in upland, midland and lowland respectively, in Bhelwa village of Godda district, Jharkhand. The improved varieties helped in realizing additional yield by 4 to 35 per cent compared to local varieties with an additional net return by Rs. 7150 to 18400 per ha over the farmers' practice (Table 3.6.1.8.). These technologies were adopted in 150 ha area involving 200 farmers in the TDC-NICRA village during 2021.

Table 3.6.1.8. Improved varieties of groundnut and paddy in Bhelwa village of Godda, Jharkhand

Crop	Technology	Yield (kg/ha)	Net return (Rs./ha)	B:C ratio
Groundnut	K-6	123	19800	1.9
	Local variety	91	12650	1.2
Paddy	Sahbhagi	375	25500	1.7
	Local variety	349	17000	1.4
Paddy	MTU-7029	438	51300	2.5
	Local variety	420	32900	1.9

Demonstration of short duration varieties of rice (Sahbhagi and MTU-7029) in Bhelwa village of Godda

In Yagantipalle village of Kurnool district, Andhra Pradesh, drought tolerant variety of pigeon pea (Asha) and chickpea (NBeG-49) crops were demonstrated in 10 ha area each benefitting a total 25 farmers in the TDC-NICRA village during 2021. Improved varieties helped to minimize the effect of moisture stress and helped to obtain additional yield by 14 and 15 per cent respectively, compared to local varieties and correspondingly helped to get addition net return of Rs. 5870 and 10560 per ha over the farmers' practice (Table 3.6.1.9.).

Table 3.6.1.9. Improved varieties of pigeon pea and chickpea in Yagantipalle village of Kurnool

Crop	Technology	Yield (kg/ha)	Net return (Rs./ha)	B:C ratio
Pigeon pea	Asha	108	38200	2.3
	Local variety	95	32330	2.0
Chickpea	NBeG-49	166	50660	2.3
	Local variety	144	40100	1.9

Demonstration of short duration varieties of pigeon pea and chickpea in Yagantipalle village, Kurnool

Improved green fodder variety of Hybrid Napier (CO-3 and CO-4) was demonstrated in 4.3 ha area involving 37 farmers in NICRA village of Buxar district during 2021. Low productivity of milk in diary animals due to shortage of green fodders in the off season is one of the constraints in several villages. Intervention helped to increase the yield by 25 per cent as compared to farmers practice and farmers realized additional return of Rs. 45 per animal per day as compared to earlier practice (Table 3.6.1.10.).

Table 3.6.1.10. Year-round fodder production in Bhitihara village of Buxar district, Bihar

Crop	Technology	Milk yield (l/animal/day)	Net return (Rs/animal/day)
Fodder crops	Hybrid Napier (CO-3/4)	7.5	225
	Local variety	6	180

Year-round fodder production for dairy animals in Bhitihara village of Buxar, Bihar

Breeds of poultry (Kadaknath) and duck (Khaki campbell) were demonstrated for 25 farmers at Gudeliya village in Bhatapara district of Chhattisgarh for higher productivity and returns. This resulted in reduction of mortality rate up to 30 per cent in both ducks and poultry compared to local breeds. Introduction of improved breeds helped to obtain additional body weight gain by 1.5 and 0.95 kg per bird and also increased the number of egg production by 35 and 103 per bird per year in poultry and ducks respectively compared to local breeds (Table 3.6. 1.11.).

Table 3.6.1.11. Improved breeds of poultry (Kadaknath) and duck (Khaki Campbell) at Gudeliya village, Bhatapara

Livestock type	Technology	Body weight (kg/bird)	No. of eggs per bird per year
Poultry	Kadaknath	2.8	95
	Local	1.3	60
Duck	Khaki campbell	2.12	165
	Local	1.2	62

Demonstration of improved breeds of poultry (Kadaknath) and duck (Khaki campbell) at Gudeliya village, Bhatapara

In Pimpri Lokai village of Ahmednagar, Maharashtra, silage preparation was demonstrated with introduction of improved multi cut fodder sorghum (COFS-29) involving 30 farmers during 2021. Silage production made green fodder availability for milch animals during lean season and increase of milk yield by 1.4 l/day/cow and addition return of Rs. 42 per day per cow compared to without feeding of silage. This intervention helped to increase the number of cows and additional employment generation by 1800-man days per annuum.

Silage production system at Pimpri Lokai village of Ahmednagar, Maharashtra

3.6.2. Capacity building of the farmers

During the year 2021, about 1045 capacity building programs were conducted involving 22834 farmers. Trainings were conducted on various aspects of climatic change, impact and adaptation of climate change, natural resource management for enhancing the adaptive capacity, efficient cultivars and cropping systems, nutrient management, IPM practices, breed improvement, feed and fodder management, fish and goat farming, poultry, horticulture, kitchen gardening, nursery raising, vermicompost preparation, value addition etc. in NICRA villages.

Training programme at Tumkur district, Karnataka and Kurnool district of Andhra Pradesh

3.6.3. Annual review and action plan finalization workshops

Annual review workshops were organized for each ATARI during the year 2021 through virtual mode (Table 3.6.3.1.). During the workshop, significant findings during the year were presented and the action plans for the subsequent year were discussed and finalized.

Table 3.6.3.1. ATARI Zone wise annual review and action plan finalization workshops

S.No.	ATARI Zone	Date conducted
1.	ICAR-ATARI Zone-I-Ludhiana	19th June 2021
2.	ICAR-ATARI Zone-II-Jodhpur	25th May, 2021
3.	ICAR-ATARI Zone-III-Kanpur	28th May, 2021
4.	ICAR-ATARI Zone-IV-Patna	22nd June, 2021
5.	ICAR-ATARI Zone-V-Kolkata	23rd June, 2021
6.	ICAR-ATARI Zone-VI-Guwahati	27th May, 2021
7.	ICAR-ATARI Zone-VII-Barapani	26th May, 2021
8.	ICAR-ATARI Zone-VIII-Pune	15th May 2021
9.	ICAR-ATARI Zone-IX-Jabalpur	29th May, 2021
10.	ICAR-ATARI Zone-X-Hyderabad	7th June, 2021
11.	ICAR-ATARI Zone-XI-Bengaluru	26th June, 2021

Coordinated/ Network Projects 4

4.1. All India Coordinated Research Project for Dryland Agriculture (AICRPDA)

The All India Coordinated Research Project for Dryland Agriculture (AICRPDA) has the mandate to generate agro-ecology specific technologies through on-station and on-farm research in the thematic areas of rainwater management, cropping systems, nutrient management, energy management, alternate land use and integrated farming systems. AICRPDA has a network of 31 centers located in diverse rainfed agro-ecologies in the country (Fig. 4.1.1.). Under NICRA, resilient practices and real-time contingency measures are being demonstrated in the farmers' fields. The salient achievements are given below.

Fig.4.1.1. Locations of AICRPDA centres

4.1.1. Rainwater management

- In semiarid Inceptisols at Agra, *in-situ* moisture conservation in okra through ridge planting + polythene mulching recorded higher yield (8770 kg/ha), net returns (Rs. 71735/ha) and RWUE (19.33 kg/ha-mm) compared to flat-bed sowing (3760 kg/ha).

Ridge and furrow method of sowing in okra

- In semiarid Vertisols at Parbhani, subsoiling in alternate year recorded higher seed yield (1117 kg/ha) of soybean, net returns (Rs.23339/ha), B:C ratio (2.16) and RWUE (1.61 kg/ha-mm) followed by subsoiling in every year (1093 kg/ha) than subsoiling once in three years (988 kg/ha). Among horizontal distance of subsoiling, higher seed yield (1109 kg/ha) and RWUE (1.60 kg/ha-mm) was recorded with subsoiling at every 1.5 m distance. However, subsoiling at every 2.0 m distance recorded higher net returns (Rs.22602/ha) and B:C ratio (2.13) compared to other treatments.

Ex situ rainwater management

- In semiarid Vertisols at Arjia, minimum mean weekly water loss was recorded with the pond lined with cement concrete (CC) + 750 μ polythene (10889) (53.6 mm) followed by lining with 500 μ polythene (15351) (54.2 mm) compared to other treatments. However, the cost of lining was higher (Rs.285/m^2) with CC + 750 μ polythene compared to other treatments.

Lining with CC+750 µ polythene (10889)

- In semiarid Vertisols at Akola, two protective irrigations (50 mm each) from harvested rainwater in farm pond, with sprinklers at pod initiation and pod filling stages of soybean recorded 19.6 per cent higher seed yield (1910 kg/ha), with higher WUE (2.73 kg/ha-mm), net returns (Rs.35215/ha) and B:C ratio (2.25) compared to no irrigation (1597 kg/ha).

4.1.2. Cropping systems

- At Rakh Dhiansar, maize + cowpea (1:1) intercropping system recorded significantly highest maize equivalent yield (MEY) (3449 kg/ha), net returns (Rs.45353/ha), LER (1.20), B:C ratio (2.68) and RWUE (7.07 kg/ha-mm); at Rajkot, significantly highest groundnut pod equivalent yield (3316 kg/ha) net returns (Rs 135541 kg/ha) B:C ratio (2.6) and RWUE (2.9 kg/ha-mm) was recorded with paired row planting of groundnut with sweet corn compared to paired row planting of groundnut with pearl millet (1501 kg/ha).

Paired row planting of groundnut with sweet corn

Strip cropping systems

- In semiarid Vertisols at Arjia, strip cropping of maize with 2/3 area + blackgram with 1/3 area gave significantly higher maize grain equivalent yield (3378 kg/ha) compared to sole maize (2998 kg/ha), with highest LER (1.24), net returns (Rs.62031/ha), B:C ratio (3.18) and RWUE (7.03 kg/ha-mm) compared to other treatments.

Strip cropping of maize 2/3 area+ blackgram (1/3) area (row ratio 8:4) 45 cm

- In Subhumid Inceptisols at Ballowal Saunkhri, strip cropping with maize 6 m strip and blackgram 2.4 m strip recorded higher maize equivalent yield (MEY) (3207 kg/ha), LER (1.11), net returns (Rs. 34324/ha) and RWUE (5.79 kg/ha-mm) compared to other treatments. However, the B:C ratio was highest (2.21) with maize strip 3 m and black gram strip width 4.8 m compared to other treatments.

Maize (6 m strip) + blackgram (2.4 m strip) cropping system

Double cropping systems

- At Aklera, soybean-chickpea system recorded significantly higher system productivity (3450 kg/ha), net returns (Rs.77960/ha) and B:C ratio (2.31) followed by soybean-coriander sequence (270 kg/ha) compared to soybean-linseed system (2214 kg/ha).

Microbial consortia for drought tolerance in rainfed crops

- At Anantapuramu, in semiarid Alfisols, groundnut recorded significantly higher pod yield (1595 kg/ha) with soil application of microbial consortia 1 (C_1: *Pseudomonas putida* P7 + *Bacillus subtilis* B 30) compared to other treatments except soil application of microbial consortia 2 (C2: *Pseudomonas putida* P45 + *Bacillus amiloliquefacians* B17) and uninoculated control. Seed treatment + soil application with consortia 2 recorded higher soil organic carbon (0.59 per cent) and higher available N (183 kg/ha). However, higher soil available P (66 kg/ha) was recorded with seed treatment + soil application with consortia 1.

4.1.3. Nutrient management

- In semiarid Alfisols at Bengaluru, in the 41st year of Permanent Manurial Trial (PMT) under monocropping of fingermillet, significantly higher grain and straw yield (4779 and 5964 kg/ha, respectively) was recorded with application of FYM @ 10 t/ha + 100 per cent rec. NPK compared to application of rec. NPK alone (2441 and 3279 kg/ha, respectively). Further, application of FYM @ 10 t/ha with 100 per cent rec. NPK recorded higher net returns (Rs.117511/ha), B:C ratio (5.08), RWUE (7.729 kg/ha-mm) and SYI (0.61) compared to other treatments. Significantly higher organic carbon (0.61 per cent), available N (210.1 kg/ha), P (281.8 kg/ha) and K (182.5 kg/ha) was recorded in the plots under FYM (10 t/ha) + 100 per cent rec. NPK compared to other treatments.
- In semiarid Vertisols at Vijayapura, in Permanent Manurial Trial (PMT) initiated in 2012, in *safflower* + chickpea (2:4) system rotated with *rabi* sorghum every year, in safflower + chickpea (2:4) intercropping system, significantly higher safflower equivalent yield (1107 kg/ha), net returns (Rs.58323/ha), B:C ratio (3.6) and RWUE (9.50 kg/ha-mm) was recorded with application of 50 per cent N through FYM + 50 per cent N through inorganic sources, followed by 50 per cent N through vermicompost+ 50 per cent N through inorganic sources (1010 kg/ha). Different treatments had no significant effect on soil pH. However, organic C and available N, P and K were significantly higher (0.57 per cent, 225.6, 18.7 and 418.3 kg/ha, respectively) with application of 50 per cent N through FYM + 50 per cent N through inorganics compared to other treatments.
- In subhumid Inceptisols at Jagdalpur, in a long term study on effect of inorganic fertilizers and organic manures on soil fertility and productivity of direct seeded rice-field pea system, application of full dose of NPK (60:40:30 kg NPK/ha) + 5 t FYM/ha + ZnSO4 @ 25 kg/ha recorded significantly higher rice grain yield (4763 kg/ha) with higher net returns (Rs.60024/ha) and RWUE (3.68 kg/ha-mm) as compared to other treatments. During *rabi*, higher seed yield (1147 kg/ha), net returns (Rs.36439/ha) and B:C ratio (1.96) of field pea were recorded application of rec. NPK during *Kharif* (100 per cent NPK+5 t FYM+ $ZnSO_4$@ 25 kg/ha).

Rice with 100 per cent NPK + 5 t FYM/ha + $ZnSo_4$@ 25 kg/ha + lime 3 q/ha

4.1.4. Tillage and nutrient management

- In semiarid Vertisols at Vijayapura, low tillage (2 harrowings + 1 hoeing + 1 HW) recorded higher grain yield of *rabi* sorghum (1398 kg/ha), net returns (Rs.25434/ha), B:C ratio (2.5), RWUE (11.99 kg/ha-mm) and energy use efficiency (1.73) as compared to conventional and low tillage. Among nutrient management treatments, farmer's practice + sun hemp green manuring @ 5.0 t/ha recorded significantly higher grain yield (1229 kg/ha) with higher net returns (Rs.26854/ha), B:C ratio (2.5) and RWUE (12.72 kg/ha-mm) compared to other treatments.

Rabi sorghum under CT + (sun hemp incorporation @ 2.5 t/ha + 50 per cent RDF through fertilizer)

- In semiarid Vertisols at Parbhani, in soybean + pigeonpea (4:2) intercropping system, conventional tillage recorded significantly higher soybean seed equivalent yield (1463 kg/ha), net returns (Rs.53284/ha), B:C ratio (2.66) and RWUE (2.10 kg/ha-mm) compared to reduced tillage + herbicide and reduced tillage + interculture. Among nutrient sources, application of RDF (50 per cent) + vermicompost (1.5 t/ha) recorded significantly higher soybean seed equivalent yield (1601 kg/ha), net returns (Rs.63097/ha), B:C ratio (3.09) and RWUE (2.15 kg/ha-mm) compared to other nutrient sources.

4.1.5. Energy management

- At Arjia, tractor operated interculture implement recorded higher grain yield of maize (3432 kg/ha) followed by interculture with bike operated weeder and interculture with bullock drawn implements + herbicides application. Interculture with bike operated weeder gave maximum saving in cost (40 per cent) as compared to intercultural by power weeder (Rs.7000/ha).

- At Parbhani, complete mechanization in soybean recorded significantly higher soybean seed yield (1462 kg/ha), net returns (Rs.33240/ha), B:C ratio (2.58) and RWUE (2.56 kg/ha-mm) than traditional low mechanization (973 kg/ha).

4.1.6. Alternate land use

- At Jagdalpur, among mango based agri-horti systems, mango + horse gram (var. IK-1) system gave higher mango equivalent yield (11.29 t/ha), net returns (Rs.193350/ha) and B:C ratio (2.78) compared to sole mango (4.23 t/ha).

- At Rajkot, under guava based alternate land use systems, significantly highest guava equivalent yield (6833 kg/ha), net returns (Rs.85025/ha), B:C ratio (1.1) and RWUE (5.9 kg/ha-mm) was recorded with guava + groundnut system compared to sole guava (491 kg/ha).

Guava + groundnut agri-horti system

- At Chianki, significantly higher aonla equivalent yield (9.30 t/ha) was recorded in aonla + aerobic rice system with highest net returns (Rs.153800/ha), B:C ratio (5.0) and RWUE (9.73 kg/ha-mm) followed by aonla + black gram system (8.30 t/ha).

4.1.7. Research at ARS/KVKs

The rainfed agriculture research base was expanded by conducting experiments at another 16 Agriculture Research Stations and 2 KVKs within the domain agriculture zones of 18 AICRPDA centres.

- At ARS Kanker (Jagdalpur), two supplemental irrigations (sprinkler) in field pea from harvested rainwater in farm pond gave higher seed yield (2417 kg/ha) but was on par with that of farmers' practice (flood irrigation) (2281 kg/ha). The cost of cultivation was higher with farmer's practice (Rs.24715/ha) whereas higher net returns was recorded with two supplemental irrigations in field pea (Rs.62642/ha) with higher B:C ratio (2.97), and WUE (4.27 kg/ha-mm).

Field pea with two supplemental irrigations (sprinkler)

- At ARS, Velayuthapuram (Kovilpatti), pigeon pea + kodo millet (2:6) intercropping system recorded significantly higher pigeonpea equivalent yield (570 kg/ha) with higher net returns (Rs.6400/ha), B: C ratio (1.26), RWUE (1.20) and LER (1.11) compared to other treatments.

Pigeon pea + kodo millet (2:6) intercropping system

4.1.8. Rainfed integrated farming systems

- At Sunderpura and Kocharia villages in Bhilwara district (Rajasthan), in rainfed farming system, introduction of improved crop varieties, integrated nutrient management, *in-situ* moisture conservation, mineral nutrition to livestock and cultivation of fodder grass on bunds improved the system productivity in case of marginal category by 22.9 per cent compared to traditional farming system and gave higher net returns (Rs 77106/year) and employment generation (232 man-days/year) and in case of small farmers category by 31.2 per cent compared to traditional farming system and gave higher net returns (Rs 1063655/year) and employment generation (286 man-days/year).
- At Parbhani, in a study on integrated farming systems (1.0 ha), among crops and cropping systems, soybean – *rabi* sorghum and soybean - chickpea system recorded soybean yield of 243 and 234 kg/plot. Intercropping of soybean + pigeonpea (4:2) recorded soybean equivalent yield of 453 kg/plot, while cotton + soybean (1:1) intercropping resulted in soybean equivalent yield of 427 kg/plot. The net returns for soybean–*rabi* sorghum and soybean–chickpea systems were Rs.8192 and Rs.8151 respectively and for intercropping systems of soybean + pigeonpea (4:2) and cotton + soybean (1:1) was Rs.11686 and Rs.10081, respectively. The total net income generated from 1 ha rainfed integrated farming system module in the second year after establishment was Rs.82250.
- In an integrated farming system model of 1.7 ha established in Jamujhory and Sitalapani of Khajuripada block in Phulbani district (Odisha), different components such as agricultural crop, vegetable crops, fruit crops, and livestock, vermi-composting were implemented in the IFS model for both rainfed and partially irrigated condition. In rainfed condition, the farmer got net profit of 66500 and employment generation of around 128 man-days/year in small category. However, in partially irrigated situation the farmer got net profit of 86500 and employment generation of around 156 man-days/year in small category.

4.1.9. AICRPDA-NICRA

The 23 Centers of All India Coordinated Research Project for Dryland Agriculture (AICRPDA) are conducting on-station and on-farm demonstrations/trials under National Innovations in Climate Resilient Agriculture (NICRA) with the focus on real time contingency plan (RTCP) implementation and preparedness to cope with weather aberrations. The RTCPs implementation has been in a two-pronged approach i.e. i) Real-time contingency measures and ii) Preparedness. During 2020-21, the interventions to cope with delayed onset of monsoon and seasonal drought (early, mid-season and terminal) were demonstrated in more than 1709 farmers' fields in 23 village clusters (55 villages) in 24 districts across 15 states.

Real-time contingency planning

Early season drought

At Mudalapalaya village (Bengaluru rural district, Karnataka), a dry spell of 10 days occurred at vegetative stage crops. Opening of conservation furrow between paired rows of pigeon pea in finger millet (MR-1) + pigeon pea (BRG-5) (8:2) intercropping system recorded 22 per cent higher finger millet grain equivalent yield (3099 kg/ha), net returns (Rs.59060/ha), B:C ratio (2.60) and RWUE (5.90 kg/ha-mm) compared to farmers' practice of growing finger millet + *Akkadi* cropping.

At Gandhu village (Banaskantha district, Gujarat), a dry spell of 18 days occurred at seedling to vegetative stage of greengram and blackgram. Weeding and interculture with wheel how gave 25.9 and 23.3 per cent higher yields (481 and 429 kg/ha), net returns (Rs.22378 and 15415/ha), B:C ratio (3.63 and 2.93) and RWUE (0.48 and 0.43 kg/ha-mm) compared to farmers' practice of no weeding and interculture (382 and 348 kg/ha).


Greengram with weeding/ interculture

Mid-season drought

At Vannedoddi and Bachupalli villages (Anantapuramu district, Andhra Pradesh) a dry spell of 67 days occurred and groundnut crop (Kadiri 6) was subjected to severe moisture stress due to scanty rainfall during peg penetration to pod initiation. Foliar spray of KNO_3 @ 0.5 per cent during peg penetration stage recorded higher groundnut pod yield (582 and 594 kg/ha, respectively at Vannedoddi and Bachupalli villages) with higher net returns (Rs.8789 and 9558/ha), B:C ratio (1.28 and 1.31) and RWUE (0.81 and 0.83 kg/ha-mm) compared to farmers' practice of no foliar spray (476 and 498 kg/ha).


Foliar spray of KNO3 @ 0.5 per cent in groundnut

At Danti/Tedha village (Mirzapur district, Uttar Pradesh), a dry spell of 10 days occurred coinciding with the vegetative stage of rice. Supplemental irrigation (50 mm) during the dry spell recorded higher grain yield (4380 and 4422 kg/ha, at Danti and Tedha villages respectively), net returns (Rs.54718 and 55503/ha), B:C ratio (2.02 and 2.05) and RWUE (5.73 and 5.78 kg/ha-mm) compared no supplemental irrigation (3965 and 4010 kg/ha).

At Dagoliya ka Kheda village (Rajasmand district, Rajasthan), supplemental irrigation from harvested rainwater in farm pond during dry spell at 45 DAS gave 25.8 per cent higher maize grain equivalent yield of maize + blackgram (2:2) intercropping system (3245 kg/ha) with higher net returns (Rs.48999/ha), B:C ratio (3.56) and RWUE (6.56 kg/ha-mm) compared to farmers' practice without any supplemental irrigation (2579 kg/ha).

Maize + black gram (2:2) intercropping system with supplemental irrigation

At Honnutagi and Kavalagi villages (Vijayapura district, Karnataka) three dry spells of 14 and 11 days occurred during 18 – 31 August and 29 September to 09 October coinciding with flowering and pod initiation stage of pigeonpea and greengram. Two supplemental irrigations of 40 mm each with sprinklers from harvested rainwater recharged and stored in open wells gave an average of 60 and 43.5 per cent higher yields in pigeon pea (1700 kg/ha) and green gram (900 kg/ha) respectively, over farmers' practice of no supplemental irrigation.

Performance of pigeon pea with supplemental irrigation

Terminal drought

At Warkhed village (Akola district, Maharashtra), a dry spell of 16 days occurred coinciding with the boll development stage of cotton crop. Foliar spray of 2 per cent urea at flowering and 2 per cent KCl at boll development stage gave 18.2 per cent higher yield (2000 kg/ha) with higher net returns (Rs.61465/ha), B:C ratio (2.29) and RWUE (2.21 kg/ha-mm) compared to farmers' practice of no foliar spray (1693 kg/ha).

Foliar spray in cotton

At Ganghu village (Banaskantha district, Gujarat) a dry spell of 7 and >25 days occurred at flower initiation to capsule development stage of castor. Supplemental irrigation (60 mm each) twice through micro irrigation after flowering to capsule development stage gave 22.8 per cent higher yield (1362 kg/ha), net returns (Rs.43342/ha), B:C ratio (3.74) and RWUE (1.35 kg/ha-mm) compared to farmers' practice of no supplemental irrigation (1109 kg/ha).

Castor with supplemental irrigation

At Tahkapal village (Bastar district, Chhattisgarh), a dry spell of 12 days occurred during 19-31 October coinciding with grain filling stage of rice. Lifesaving irrigation of 2 cm from harvested rainwater gave highest grain yield (2257 kg/ha), net returns (Rs.12787/ha), B:C ratio (2.26) and WUE (3.47 kg/ha-mm) compared to control (1719 kg/ha).

Preparedness

Rainwater management

At Vannedoddi village (Anantapuramu district, Andhra Pradesh), deep ploughing using chisel plough after pre-monsoon showers recorded higher groundnut pod and haulm yield (1480 and 3667 kg/ha), net returns (Rs.62400/ha), B:C ratio (2.77) and RWUE (1.82 kg/ha-mm) compared to the farmers' practice of no deep ploughing (1250 and 2850 kg/ha).

At Babhulgaon village (Parbhani district, Maharashtra), *in-situ* moisture conservation practice of BBF sowing recorded higher soybean seed yield (1332 kg/ha), net returns (Rs.33181/ha), B:C ratio (2.79) and RWUE (1.98 kg/ha-mm) compared to farmers' practice of flatbed sowing (1006 kg/ha).

At Nagla Dulhe Khan (Agra district, Uttar Pradesh), deep ploughing in summer recorded higher seed yield of mustard (2230 kg/ha) with higher net returns (Rs.102526/ha) and B:C ratio (6.50) as compared to without deep ploughing (1765 kg/ha).

Castor with supplemental irrigation

Castor with supplemental irrigation

Cropping systems

At Warkhed village (Akola district, Maharashtra), soybean + pigeonpea (4:2) intercropping system recorded 26.7 per cent higher soybean equivalent yield (2632 kg/ha) with higher net returns (Rs.77258/ha), B:C ratio (3.48) and RWUE (2.55 kg/ha-mm) as compared to farmers' practice of soybean + pigeonpea (6:1) system (2077 kg/ha).

Soybean + pigeonpea (4:2) intercropping system

At Borkhet village (Lakhimpur district, Assam), introduction of rice (TTB-404) – toria (TS-38) double cropping system recorded higher main crop equivalent yield (2278 kg/ha), net returns (Rs.106410/ha), B:C ratio (3.7) and RWUE (2.48 kg/ha-mm) compared to farmers' practice monocropping of *Sali* rice.

Rice- toria cropping sequence under medium land situation

At Toppureddiapatti village (Thoothukkudi district, Tamil Nadu), among cotton based intercropping systems, cotton + cluster bean (2:1) intercropping system recorded higher cotton equivalent yield (1663 kg/ha), net returns (Rs.41850/ha), B:C ratio (4.23) and RWUE (3.43 kg/ha-mm) followed by cotton + onion (2:1) intercropping system (1567 kg/ha) compared to sole cotton (920 kg/ha).

At Dagoliya ka Kheda (Rajasmand district, Rajasthan), improved variety of groundnut, TG- 37A gave 39.5 per cent higher pod yield (1260 kg/ha) over the local cultivar (903 kg/ha) with higher net returns (Rs.61727/ha), B:C ratio (4.5) and RWUE (2.55 kg/ha-mm).

Groundnut var TG-37A

Nutrient management

At Balawas and Nalwa villages (Bhiwani district, Haryana), application of RDF (40 kg N + 20 kg P_2O_5/ha) recorded higher mustard seed yield (1990 kg/ha), net returns (Rs.61485/ha), B:C ratio (2.98) and RWUE (57.68 kg/ha-mm) compared to farmers' practice (1804/ha).

At Nagla Dulhe Khan (Agra district, Uttar Pradesh), green manuring during *kharif* increased mustard yield by 27.1 per cent (2193 kg/ha) with higher net returns of Rs.100682/ha and B:C ratio of 6.41 compared to farmers' practice of no green manuring (1725 kg/ha).

Mustard with green manuring

Mustard without green manuring

Energy management

At Mudalapalaya village (Bengaluru rural district, Karnataka), Sowing of finger millet with modified bullock drawn seed drill recorded higher grain yield (2850 kg/ha), net returns (Rs.59316/ha), B:C ratio (2.80) and RWUE (4.91 kg/ha-mm) compared to traditional sowing (2630 kg/ha).

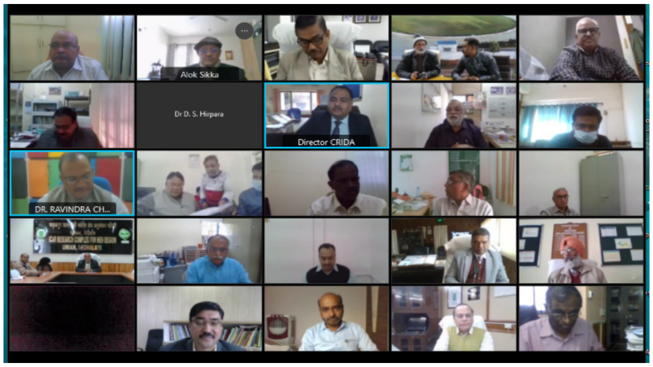
Sowing of finger millet with modified seed drill

At Achalpur, Nainwan and Bhawanipur villages (Hoshiarpur district, Punjab), sowing of maize using maize planter recorded higher grain yield of 4498 kg/ha with net returns of Rs.58573/ha, B:C ratio of 2.53 and RWUE of 6.57 kg/ha-mm compared to farmers' practice of Kera method (4285 kg/ha).

4.1.10. Meetings/seminars organized

Virtual brain storming session on Rainwater Harvesting Models Organized

A virtual brainstorming session was held on 21st December 2021 at 10:30 am organized by ICAR-CRIDA. In the inaugural session, DR. S.K Chaudhari, DDG, NRM, ICAR was the chief guest and Dr. A.K. Sikka, Country Representative, IWMI and Former DDG, NRM was guest of honour. The participants include ADGs of NRM Division, Directors of ICAR Institutes (CRIDA, IIWM, IISWC, CAZRI, ICAR-NEHR-RC) and ATARIs, Project Coordinators AICRPDA and AICRPAM, Directors of Research from SAUs, senior officials from NRAA, NABARD, DAC and FW, MoAFW, State Departments, WoTR, WASSAN, BAIF and scientists from CRIDA, AICRPDA centres. Dr. G. Ravindra Chary, PC, AICRPDA welcomed the dignitaries and participants. Dr. V.K. Singh, Director, ICAR-CRIDA briefed about the purpose of meeting. Dr. S.K. Chaudhari, DDG (NRM) emphasized to sensitize states for rainwater harvesting suitability along with field crops and horticultural crops suitability, ecological benefits from soil and water conservation at regional scale. Dr. Sikka suggested to prepare location specific manuals considering both surface and groundwater harvesting and utilization. Directors of ICAR Institutes made presentations on Rainwater harvesting models – Technologies, Experiences, Impacts, Issues and Policies. This was followed by interaction.



National Webinar on Food and Nutritional Security: Challenges and Opportunities in Rainfed areas

Commemorating the *Azadi ka Amrut Mahotsav* and 50 Years of All India Coordinated Research Project for Dryland Agriculture celebrations, ICAR-CRIDA in collaboration with Indian Society of Dryland Agriculture (ISDA) organized one-day **National Webinar on Food and Nutritional Security: Challenges and Opportunities in Rainfed areas on 16th August 2021.** Dr. Ashok Dalwai, I.A.S., CEO, National Rainfed Area Authority and Chairman the Inaugural and Session-I, Dr. S.K. Chaudhari, DDG, NRM (Chief Guest), Dr. V. Praveen Rao, VC, PJTSAU, Dr. S. Bhaskar, ADG (AAFCC), Dr. V.K. Singh, Director, CRIDA, Dr. A. Vishnuvardhan Reddy, VC, ANGRAU, Dr. V. Tonapi, Director, IIMR, Dr. G. Ravindra Chary, President, ISDA, Directors of Research, Project Coordinators, Heads of Divisions, chief scientists and scientist from AICRPDA and AICRPAM, scientist from ICAR institutes and SAUs, officials from Departments participated in the webinar.

Dr. V.K. Singh, Director ICAR-CRIDA briefed on the background and context of the webinar. Dr. Vishnuvardhan Reddy and Dr. Vilas Tonapi presented key lectures on the challenges, opportunities and strategies on augmenting production and productivity of oilseeds and millets in rainfed areas, respectively. The Webinar also dwelt up on the key technological and policy options for enhanced food and nutritional security in rainfed areas viz. guidelines for new generation watersheds, climate services, credit and role of FPOs, policy interventions and market interventions. Dr. Ashok Dalwai advocated for ecosystem approach with suitable components, policy interventions, infrastructure and a synergy between science-technology-policy towards achieving food and nutritional security in rainfed areas. Dr. S. K. Chaudhari suggested major focus should be on NRM interventions and ecosystem services in augmenting production and productivity of pulses, oilseeds and millets in rainfed areas.

The major recommendations of the webinar were: research strategies for enhancing the productivity of millets and oilseeds with agroecology-specific NRM interventions in rainfed areas; aligning new guidelines of watersheds, as landscape approach , in an integrated farming systems mode, for eco-restoration and enhanced income generation with value addition and institutional arrangements; real-time agromet advisories and climate services at individual farmers level; more investments in rainfed agriculture for research, development, NRM interventions, infrastructure, marketing and mechanization; designing and executing timebound action plan in rainfed areas with a multi-institutional, multi-stakeholder and multi-disciplinary approach to address the national programmes such as Doubling the farmers income, land degradation neutrality, achieving food and nutritional security, further to achieve SDGs.

4.1.11. Awards/Recognition

- AICRPDA received ICAR-Chaudhary Devi Lal Outstanding AICRP Award – 2020
- AICRPDA centre, Indore received ICAR - Vasantarao Naik Award for outstanding research applications in dryland farming systems - 2020


ICAR
Indian Council of Agricultural Research

National Award of Excellence for Agricultural Institutions

CHAUDHARY DEVI LAL OUTSTANDING
ALL INDIA COORDINATED RESEARCH
PROJECT AWARD 2020
(Best AICRP)

is presented to

All India Coordinated Research Project for Dryland Agriculture
ICAR–Central Research Institute for Dryland Agriculture, Hyderabad, Telangana

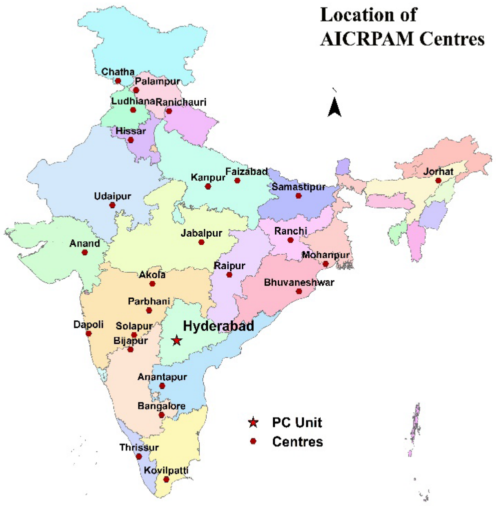
16 July, 2021
New Delhi

(T. Mohapatra)
Secretary (DARE)
Director General (ICAR)

(Narendra Singh Tomar)
Union Minister of Agriculture & Farmers Welfare
Govt. of India

4.2. All India Coordinated Research Project on Agrometeorology (AICRPAM)

The All India Coordinated Research Project on Agrometeorology (AICRPAM) was initiated by ICAR in May 1983 with the establishment of Coordinating Cell at the Central Research Institute for Dryland Agriculture, Hyderabad and 12 Cooperating Centres at various State Agricultural Universities. After a detailed review and evaluation on the progress made by the project and realizing the importance of agrometeorological research support for enhancing food production, ICAR had extended the Cooperating Centres to the remaining 13 Agricultural Universities of the country w.e.f. April 1995. The 25 Cooperating Centres of the AICRPAM network are: Akola, Anantapur, Anand, Bengaluru, Bhubaneswar, Chatha, Dapoli, Faizabad, Hisar, Jabalpur, Jorhat, Kanpur, Kovilpatti, Ludhiana, Mohanpur, Palampur, Parbhani, Raipur, Ranchi, Ranichauri, Samastipur, Solapur, Thrissur, Udaipur and Vijayapura (Fig. 4.2.1). These coordinating centres of the AICRPAM have been conducting research in four thematic areas viz., Agroclimatic characterization, Crop Weather Relationship, Crop Growth Modelling, Weather effects on pest and diseases. The centres also contribute in preparation and dissemination of agromet advisories at various levels. The highlights of the research activities carried out at Project Coordinating Unit and cooperating centres during 2021 are furnished below.

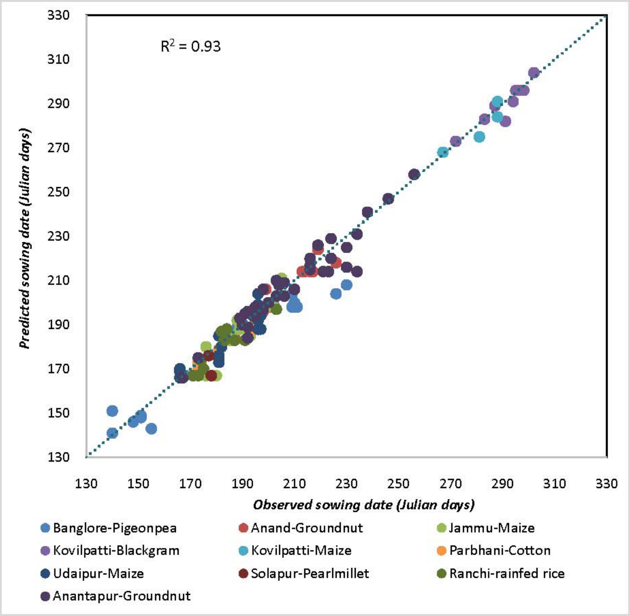


Location map of 25 Cooperating centers and Project Coordinating Unit of AICRPAM

Research activities at Project Coordinating Unit

Development of dynamic crop weather calendar

Crop Weather Calendars (CWC) are tools that help farmers make crop management decisions. CWCs, on the other hand, are not dynamic because they were created based on normal sowing dates and the occurrence and duration of phenological stages in rainfed crops. Sowing dates vary due to monsoon onset uncertainty, and phenology varies depending on crop duration and stresses endured. Recognizing the limitations of the CWC for issuing accurate agromet advisories, the All India Coordinated Research Project on Agrometeorology (AICRPAM) developed a Dynamic Crop Weather Calendar (DCWC) protocol (AICRPAM). Using current and anticipated weather, the DCWC plans to automate agromet advisories. Using long-term data of major crops at nine AICRPAM centres in eight Indian states, different modules of DCWC, such as sowing and irrigation schedules, crop contingency plans, phenophase-wise crop advisory, and harvest advisory, were developed.



Validation of DCWC with respect to sowing dates

Modules for predicting sowing dates and phenology were evaluated at several sites for major crops and varieties. The predicted sowing dates of major crops spread across nine centres were found to be closely related to observed values (R^2 of 0.93) (Fig.4.2.2.1.). Except for cotton at Parbhani and pigeon pea at Bangalore, predicted phenology matched observed phenology in all crops.

Development of frost prediction models

Frost prediction models were developed using multivariate statistical techniques like logistic regression, artificial neural network model and thumb rules for two diverse locations of India (Palampur and Ludhiana). In these statistical models, eight daily meteorological parameters viz., maximum temperature (Tmax), minimum temperature (Tmin), wind speed, precipitation, sunshine duration, cumulative pan evaporation, morning relative humidity (RH_1), and afternoon relative humidity (RH_2) 1 to 5 days preceding the frost events for the period of 2004–2016 and 1982–2013 at Palampur and Ludhiana, respectively were used. Principal Component Analysis was performed to select the weather parameter that has maximum effect on the occurrence of frost event. Ten different skill scores like accuracy, bias, and probability of false detection were used to evaluate the accuracy of frost prediction models (Fig.4.2.1.2.). The Mann–Kendall trend test showed a significant increasing annual trend in the number of frost events at Ludhiana, with a remarkable increase in December.

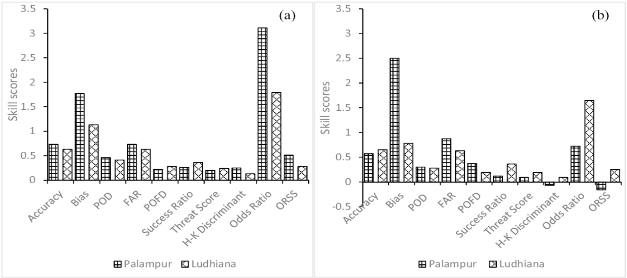


Fig. 4.2.1.2. Skill scores for verification of frost prediction using thumb rule a user-defined, and b standard deviation based at Palampur and Ludhiana

The results also showed that lower afternoon relative humidity 1-day preceding the frost event at Palampur and calm wind and lower evaporation 1-day preceding at Ludhiana augmented the occurrence of frost events. Among the techniques for developing frost prediction models, the logistic regression model performed better over artificial neural network and thumb rule-based models. The logistic regression model performed better for the plain region (Ludhiana) than for the hilly area (Palampur). The developed models are most suitable for predicting the radiation frost.

Theme-wise salient research findings from Cooperating Centres

4.2.1. Agro-climatic characterization

- Trend analysis of one-day extreme rainfall using Mann-Kendall test for 118 tehsils located in the Vidarbha region, Maharashtra during 1971-2020 was carried out. Results showed that on annual basis, two tehsils (Mangrupir in Washim and Koparna Gadchiroli district) showed significant positive trend and 12 tehsils showed significant negative trend in one-day rainfall event of 75-100 mm. In the case of one-day rainfall events > 100 mm on annual basis, two tehsils showed significant positive trend and two tehsils showed significant negative trend. During southwest monsoon, same result was observed.
- Magnitude and variation in meteorological drought incidence during monsoon (June-September) period was computed using drought indices like SPI and SPEI at selected locations in the Gujarat state (Anand, Bhuj, Junagadh, Navsari and SK Nagar). Results indicated that use of SPEI or SPI does not have marked different in quantification of the severity of the drought at most part of the state and hence in Gujarat state, SPI should be preferred as it requires only rainfall data than SPEI.
- During south west monsoon season, the average rainfall recorded was below normal in most of locations of Jammu region under the influence of El Niño episodes except Batote, Banihal and Rajouri districts, which showed the slightly increase in rainfall. The decrease in rainfall was highest (25.1 per cent) in Kathua district.
- Monthly PET values using three methods viz., Hargreaves-Samani, Turc and Makkink were estimated for new alluvial zone of West Bengal during 2010-2020. Results indicated that all the three methods estimated the highest PET during

May, though there was a difference in the magnitude. In general, the highest mean monthly PET was recorded by Hargreaves-Samani method, followed by Turc and Makkink methods.

- Trend in number of dew days at Palampur, Himachal Pradesh during the period 1985-2020 showed a linear increase with a high R^2 value of 0.69.
- Climatic water balance was calculated for ten locations in Western Maharashtra using daily weather data for the period 1961-2015 to identify the length of growing season. The length of the growing season is the highest in Kohapur and Nashik (22 weeks) and lowest in Jalgon and Nandurbar (16 weeks).
- The initial and conditional probability for getting weekly rainfall of 25 mm was worked out for Vellanikkara, Thrissur using Weathercock software. More than 50 per cent probability to get 25 mm rainfall in a week was noticed from 20 SMW to 45 SMW and during this period land preparation/ sowing/transplanting and rice cultivation without irrigation is possible.
- Mann-Kendall trend analysis was carried out using block level rainfall data of 30 years (1991 – 2020) of Deogarh district of Odisha. The annual rainfall showed increasing trend in two blocks namely Barkote and Reamal while Tileibani block showed declining trend. At the same time, Deogarh district as a whole showed non-significant increasing trend during the study period.
- Analysis of monsoon rainfall data for the past 120 years (1901-2020) at Ludhiana showed seasonality with a slight increasing trend of 1.3 mm/year. Results showed that there was below normal monsoon rainfall during 64 years and in many occasions extended period (> 2 years) with below normal monsoon was experienced. In this region, both excess or deficit monsoon rainfall is one of the major abiotic components responsible in determining the water resources and crop productivity.
- Probabilities of having dry spell of successive two weeks during kharif season in different districts of Bihar have been worked out. Analysis revealed that the probability for two consecutive weeks of dry spells are less during July and August (1-6 per cent) and higher during June (1-30 per cent) and September (0-19 per cent). Compared to the western districts, the probability for dry spells are higher in eastern districts of Bihar.

4.2.2. Crop weather relationship studies

- Crop weather relationship between effect of three sowing environments (10 June, 25 June and 10 July) and three basmati rice cultivars (Pusa-1121, SJR-129, Basmati 370) was conducted at Chatha, Jammu. The maximum RUE (0.73 g/ MJ/ m^2) was found in crop sown on 10 June and for Basmati 370 cultivar. Results also indicated that rainfall had significant positive relation during the milking and hard dough stage.
- At Mohanpur centre, effect of different dates of sowing (19 June, 3 July 17 July and 31 July) and cultivars (Nayanmani, Satabdi and Swarna) on absorbed PAR and radiation use efficiency was studied. It was observed that the absorption percentage of PAR increased (25 per cent) from tillering to panicle initiation stage for all the dates of transplantations, except 19 June. Crop transplanted on 19 June recorded highest grain yield (5422 kg/ ha) and RUE (0.45 g/ MJ).
- Correlation between phenophase-wise mean weather parameters and grain yield of rice cultivars MTU-1010, Rajesshwari and CG Sugandhit Bhog was undertaken at Raipur centre. Results revealed that mean Tmax and BSS during milking to maturity phase showed significant positive correlation with grain yield while rainfall and RH-2 had significant negative relation.
- Impact of growing environments (5 July, 15 July and 25 July) and maize cultivars (Kanchan, Azad hybrid-1 and Azad hybrid-2) on yield and heat use efficiency in maize was studied at Faizabad centre. The results indicated that the crop sown on 05 July and maize cultivar Kanchan recorded higher yield and HUE.
- At Anand centre, step-wise regression model was fitted between phase-wise mean weather parameters

and *kharif* pearl millet yield was studied. Results showed that stepwise regression model (adjusted R^2=0.88) retained rainfall, maximum temperature and relative humidity during emergence to booting phase, sunshine hours during 50 per cent-100 per cent flowering and rainfall during 100 per cent flowering to grain filling.

- Experiment to understand the effect of different sowing environments and cultivars on chlorophyll concentration index (CCI) of *kharif* pearl millet was conducted at Hisar. From the results it was observed that both growing environments and cultivars did not significantly influence the CCI at all growth stages.
- Effect of dates of sowing on radiation use efficiency (RUE) of sunflower using pooled data analysis (2015-2020) was carried out at Solapur. Results indicated that crop sown on 2nd fortnight of June had higher RUE during vegetative stage while crop sown on 2nd fortnight of July recorded higher RUE during reproductive stage. Among the cultivars, Phule Bhaskar recorded higher RUE under all the three dates of sowing.
- At Thrissur, field experiment was conducted to find the effect of different mulching conditions (white polythene, black polythene, paddy straw and green leaves) on turmeric yield. It was noticed that turmeric yield was on par under paddy straw and green leave mulch treatments and the least yield was recorded in black polythene mulch.
- Multiple regression models to predict the guava yield for rainy, winter and spring seasons using experimental data of 2013-14 to 2019-20 and the models were validated with observed yield of 2020-21. The model for rainy season underestimated (-13.1 per cent) the guava yield, whereas, for winter and spring season model overestimated the yield by 8.8 and 15.5 per cent, respectively.
- An experiment on influence of different sowing environments on chickpea phenology, heat use efficiency and yield at Akola revealed that the seed, biomass yield of chickpea as well as heat use efficiency was significantly higher for the crop sown on November 03 and for the JAKI-9218 cultivar.
- At Ranchi, experiment was conducted to find out the response of chickpea to varied weather conditions on heat and radiation use efficiency. The results showed that the higher heat and radiation use efficiencies was noticed in early sowing crop (Nov 10) and for the cultivar Birsa Chana 3.
- Crop weather relationship in mustard crop was carried out at Anand and it was observed that sowing mustard crop on 10th October provided favourable growing environment and the mustard yield declined linearly with delay in sowing. Stepwise regression model (adjusted R^2=0.74) indicated morning relative humidity during emergence to early vegetative, maximum temperature during early vegetative to flowering initiation phase and pod initiation to seed development had been used to predict the mustard yield.
- Influence of different sowing environments on wheat yield at Kanpur centre showed that significantly higher grain yield was recorded for the crop sown on 25th November (4560 kg/ha) and delay in sowing time resulted in decline in wheat grain yield by 16.9 per cent and 26.5 per cent, when crop sown on 10th and 25th December, respectively.
- At Hisar, it was observed that significantly higher barley grain yield was recorded in early sown crop i.e. November 30th and for the barley variety BH 946.
- Effect of micro environments on phenology, thermal requirements and grain yield of *rabi* maize hybrids under rainfed condition was studied at Kovilpatti. Yield and yield attributes were significantly higher for the maize hybrid COHM6 and the early sowing environment (39 SMW) when compared to later sowing environments and hybrids.
- The experiment on crop weather relationship showed that maize varieties Shaktiman 4 and 3522 Pio sown on November 10th produced higher grain yield during *rabi* season at Samastipur.
- At Solapur, study on interaction between consumptive use of moisture, moisture use efficiency, radiation use efficiency and grain yield of *rabi* sorghum indicated that crop sown during C*hitra Nakshtras*

(Oct 1th -7th), utilized the moisture more efficiently than other dates of sowings.

- Linear relation between seasonal evapotranspiration and green gram yield was observed at Mohanpur centre. It alone can explain green gram yield variation up to 86 per cent irrespective of varieties and dates of sowing and per unit increase in seasonal evapotranspiration can increase the yield by 15.3 kg/ha.

4.2.3. Crop growth modeling

- SUBSTOR-Potato module of DSSAT (v4.7) was used to find the optimum sowing date for potato at Hisar. The model simulated phenological events and tuber yield were in satisfactory with the observed values and it was found that second fortnight of October is optimum for potato planting in sub-tropical region.
- Simulation study was carried out at Ludhiana using the CERES-Wheat model (for PBW343 cultivar) and results showed that the harmful effects of continual heat stress on wheat productivity can be reduced by sowing the wheat crop by 15th November and with additional application of nitrogen i.e.150 per cent (188 kg/ha) of recommended N in two equal splits at 0 and 30 DAS.
- At Mohanpur, DSSAT-CERES simulation model was used to quantify the effect of temperature and CO_2 increase on duration and the yield of popular rice cultivars viz., Satabdi, IR-36 and Khitish. Results showed that duration was not influenced by elevated CO_2 alone. However, duration of Satabdi, IR 36 and Khitish varieties was reduced by 4-13 days under 1°C, 2°C and 3°C temperature enhanced condition. Further, Satabdi variety is more susceptible to temperature increase compare to IR- 36 and Khitish varieties. The positive impact of elevated CO_2 is better attributed by IR-36 and Khitish varieties compared to Satabdi.
- Genetic coefficients of *rabi* maize variety Shaktiman 3 were worked out at Samastipur through DSSAT Maize model.
- DSSAT-CROPGRO Peanut model was calibrated and genetic coefficients have been generated for TNAU CO-6 variety at Thrissur centre. Statistical analysis indicated that performance of the model was better to predict the groundnut pod yield when compared to predicting the phenological evens and hence the model requires further refinement.
- At Jorhat, impact of climate change on growth, development and yield of Sali rice cultivars Mahsuri, Swarna Sub-1 and TTB-404 were studied under different Representative Concentration Pathway (RCP) scenarios. Results revealed that irrespective of the RCPs, the grain yield of Mahsuri cultivar varied from 9.4-11.5 per cent, 8.1-9.2 per cent and 4.4-7.3 per cent during early (2025), mid-part (2050) and end-part of the century (2080), respectively. Similar types of observations observed for Swarna Sub-1 and TTB-404 cultivars.

4.2.4. Weather effects on pests and diseases

- Correlation between weather parameters and pigeon pea spotted borer incidence were studied at Anantapuramu centre. It was noticed that the number of web and larvae/m^2 showed negative correlation with mean temperature and sunshine hours and positive correlation with relative humidity.
- At Hisar, correlation between infestation of white fly and jassids in two cotton varieties viz., HS-6 and RCH-650 was studied.
- Correlation analysis between mustard aphid population and weather parameters at Anand centre revealed that there wasn't significant association of aphid intensity to any weather parameter that prevailed during lead periods. However, it was found that correlation coefficient reduces with longer lead time. Further, seed yields of mustard were found higher (≥ 1500 kg/ ha) when aphid intensities were lower than 1.7.
- Multiple regression models were developed to predict the Karnal bunt disease of wheat using 35 years data for Karnal (1981-82 to 2015-16, 35 seasons), 36 years for Hisar (1980-81 to 2015-16, 36 seasons) and 27 years for Rewari (1989-90 to 2015-16, 27 seasons). Results indicated that during 6-12 SMWs, a temperature range of 16 – 23.8°C; one or two rainy days and a morning relative humidity of 91-96 per

cent during 1-5 SMWs causes development of the disease.

- At Jabalpur, study on weather insect-pest relationship between gram pod borer and weather parameters among different chickpea species (desi, gulabi and kabuli types) sown at different sowing dates was carried out. A significant positive correlation existed only between larval population and bright sunshine hours in JG14 desi variety.
- The correlation study between cotton leaf hopper and weather elements showed that, maximum temperature, sunshine hours, wind velocity and evaporation had negatively influenced the leaf hopper population significantly. At the same time, relative humidity (significant) and rainfall (non-significant) had positive impact on population build up.

4.2.5. Agromet advisory services

- New mobile application 'Mewar Ritu' was developed by AICRPAM-Udaipur centre for effective dissemination of Agromet Advisory Bulletins for the benefit of farmers of Rajasthan state.

मेवाड़-ऋतु

Maharana Pratap University of Agriculture and Technology

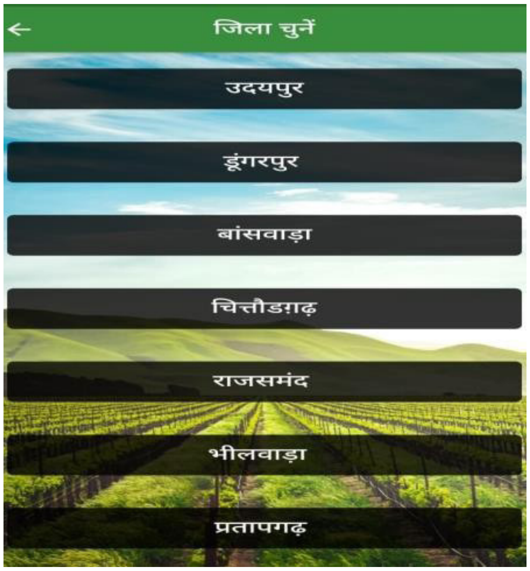
डेशबोर्ड

अधिक जानकारी

डॉ. एन. एस. सोलंकी एवं निकिता जैन द्वारा डिजाइन और विकसित

हमारे बारे में

महाराणा प्रताप कृषि एवं प्रौद्योगिकी विश्वविद्यालय



जिला चुनें

उदयपुर

डूंगरपुर

बांसवाड़ा

चित्तौड़गढ़

राजसमंद

भीलवाड़ा

प्रतापगढ़

उदयपुर

03-08-2021

न्यूनतम 23°C | अधिकतम 26°C

हवा की गति 25कि.मी./घंटा

हवा की दिशा पश्चिम से दक्षिण पश्चिम

आद्रता 91 %

वर्षा 19 मि.मी.

मौसम पूर्वानुमान

कृषि सलाह

चेतावनी

कृषि सलाह

सोयाबीन
उदयपुर

विशिष्ट सलाह
उदयपुर

मिर्च
उदयपुर

तिल
उदयपुर

दालें
उदयपुर

Krishi Vigyan Kendra - Ranga Reddy District

5

Krishi Vigyan Kendra (KVK), Ranga Reddy district, Telangana state was established at CRIDA in 1976 and currently adopted Nyamatapur village of Kadtal Mandal and Aakuthotapally Chintalpally villages of Amangal mandal and Chowderpally, Darmanuguda of Yacharam mandal.

5.1. On Farm Testing (OFT)

Assessed 13 technologies on varietal, ICM, horticulture, agricultural engineering and livestock management in the adopted villages during 2021

5.1.1. Agronomy and Horticulture

Technology	No. of Trials	Yield (t/ha)		Net returns (Rs.)	B:C Ratio
		Farmers Practice	Improved Practice		
Assessment of high yielding and disease tolerant black seeded variety of horse gram - CRHG-22	3	510	820	23800	3.64
Integrated pest management for *Tuta absoluta* in tomato	5	31.1	40.7	119800	2.10
Adoption of soil test based fertigation in bottle gourd guard	5	28.3	39.7	304500	4.29
Assessment of multiple disease resistant tomato hybrid, Arka Abhed (H-397) in comparison with local hybrid	5	31.8	39.5	173150	2.49
Assessment of ridge gourd variety Arka Prasan in comparison with local hybrid	5	23.5	28.7	206900	2.75

5.1.2. Animal Science

Technology	No. of Trials	Thematic area	Farmers Practice	Improved Practice	Results
Efficacy of coated vitamin and chelated minerals in reproductive problems	5	Nutrition management	Natural grazing with dry paddy straw	Natural grazing + complete balanced ration with supplementation of coated vitamins, chelated minerals (Garbhamin) Dosage: 1 bolus daily till desired effects or 14 days Janova – 3 capsules for 2 days	Animals showed estrous signs in time and attained good 58 per cent conception rate
Assessment of area specific mineral mixture in dairy cattle	25	Nutrition management	Natural grazing with dry roughages	Natural grazing + complete balanced ration with area specific mineral mixtures (Ca, P, S, Cu, Zn, Co, I)	Quantity of milk and fat was enhanced by 42 per cent and 69 per cent respectively. Revenue through sale of milk. Income increased by 42 per cent through sale of milk

Technology	No. of Trials	Thematic area	Farmers Practice	Improved Practice	Results
Assessment of enhancing milk fat and SNF by Sodium bicarbonate and yeast in cross bred cattle	5	Animal production	Natural grazing with improper concentrate ration	Supplementation of Yeast 2-3 bolus day/animal or Sodium bicarbonate (60-65 gms/day/animal) along with balanced ration	Increased milk yield (20-24 per cent) and fat per cent (1.6-1.9). Farmers utilized agriculture by products effectively and reduced the feed cost
Assessment of ethno veterinary practices on Parasitic infestation in calves	5	Animal Health	Neem oil only	Custard Apple, Neem, Eucalyptus leaf pulp, Turmeric powder extract diluted up to 50 per cent in vegetable oil base and apply over the body for 5 days, twice a day	Controlled ticks, lice, mite problem in livestock effectively

5.1.3. Home science

On Farm Trials	No. of Trials	Remarks
Use of dried green leafy vegetables in regular diet for better nutrition and eradication of hidden hunger	10	• 50 per cent increase in hemoglobin and 100 per cent reduction in drudgery in utilizing the green leafy vegetables in daily cooking. • Value addition of food products with dehydrated green leafy vegetables can be advocated as a feasible food-based approach to combat micronutrient malnutrition like anemia and osteoporosis. • Easy to preserve, feasibility, convenience and offseason availability are some of the advantages of dehydrated GLV. It can can be incorporated into traditional products at the household level. • Green leafy vegetable powders retained good amounts of proteins, fiber and minerals (Ca, Mg, Fe) and fair amounts of ascorbic acid and β-carotene.
Assessment of triple layer PICS bags for storing cereal grains/pulses/ millets/primary processed products	5	Pest incidence was lower (15 per cent in second month and 30 per cent in 3rd month) between triple layer bag and farmer`s practice

5.1.4. Agricultural Engineering

Technology	No. of Trials	Yield (t/ha)		Net returns (Rs.)	B:C Ratio
		Farmers Practice	Improved Practice		
Assessment of CRIDA Variable Width **Raised Bed Planter**	3	Yield increase: 15-25 per cent	Saving in seed and fertilizer: 20-30 per cent	Rs. 1000/ha	2.5
Assessment of scheduling in **Drip Irrigation System** for orchard crops	3	Yield increased 10 to 15 per cent	Water saved 30 to 40 per cent	Rs 15000/ha	3.2

5.2. Front Line Demonstrations (FLDs)

459 FLDs were conducted on 22 technologies on field crops, vegetables, fruit crops, livestock, farm mechanization, soil and water conservation and drudgery reduction on.

5.2.1. Agronomy and Horticulture

Crop	Technology	Demos	Yield (kg/ha)		per cent Increase
			Farmers Practice	Improved Practice	
Pigeon pea	Cluster Frontline demonstrations on pigeon pea variety PRG176 with production technologies	25	943	1286	36.37
Bengal gram (Chickpea)	Cluster Frontline demonstrations on Bengal gram variety NBeG49 with production technologies	25	Crop is yet to be harvested		
Bitter gourd	Control of fruit fly with IPM	10 (4 ha)	25400	29600	16.5
Mango	Integrated crop management	10	8500	11300	32.9
Tuberose	Demonstration of Arka Prajwal variety	5	6500	11800	81.5
Tomato	Use of micronutrients for higher flower and fruit set in vegetables	10 (4 ha)	32600	36100	10.7
Guava	Control of fruit fly in guava through mass trapping with fruit fly traps	10 (4ha)	21800	25200	15.5
Chilly	Plastic mulching in chilly	10	10100	14200	40.5

5.2.2. Animal Science

Intervention	Farmers Practice	Improved Practice	Increase over FP
Demonstration of perennial fodder variety Super Napier (10 demos)	Yield: 135 t/ha	Yield: Co-5 162 t/ha	20.0 per cent more green fodder yield
Demonstration of mineral licks for grazing sheep and goat (12 demos)	18 kg live weight	21kg live weight	16 per cent more weight gain
Demonstration of Total Mixed Ration (TMR) to milch animals (10 demos)	Poor nutrients with agricultural byproducts and no supplementation of minerals	Balanced ration with supplementation of mineral and vitamins	8.2 per cent increase in milk yield
Demonstration of model fodder block as package – Multicut fodder sorghum (CO-FS-29, perennial legume (Hedge lucerne), fodder legume tree (moringa) (15 demos)	Single cut sorghum, green fodder yield 20 t/ha	3-4 cut sorghum green fodder yield of 42 t /ha	110 per cent more green fodder along with protein rich legume fodder availability for supplementation

Intervention	Farmers Practice	Improved Practice	Increase over FP
Demonstration of artificial insemination with sexed semen in dairy cows (15 demos)	Low female calves	More female calves	10 female calves born
Demonstration of improved backyard poultry birds var. Rajasri as sustainable livelihood income (201 demos)	Poor egg and meat production	Increased egg and meat production	Increased income by 76.4 per cent

5.2.3. Home science

FLD	Observations recorded	Remarks
Nutrition garden (10 demos)	• Money saved and consumption of vegetables increased there by more consumption of nutrients and better health	Reduces the micro nutrient deficiency in farm families
Cotton knitted hand gloves (10 demos)	• Reduction in drudgery • Increased safety	Awareness spread to 10 villages in Ranga Reddy district
Dryland weeders (10 demos)	• 80 per cent reduction in time • 80 per cent reduction in labour expenditure	Awareness spread to 10 villages in Ranga Reddy district

5.2.4 Agricultural Engineering

Crop	Technology	Demos	Yield (kg/ha)		per cent Increase
			Farmers Practice	Improved Practice	
Watermelon	Assessment of Multipurpose Plastic Mulch sheet laying machine for watermelon.	6	10 to 15	20 to 25	50
Pigeon pea	Demonstration of CRIDA designed Nine Row planter for different crops in CFLD.	20	3000	5300	40
Cotton and Pigeon pea	Demonstration of Tractor Operated Crop Stalk Slasher for standing crop stalk.	10	Saves time, energy, labour and money Cutting and spreading straw and residues of crop on soil surface Used successfully for green manuring of crops in different tillage operations		
Vegetables	Demonstration of Micro Sprinklers for leafy vegetables	5	Water saving up to 30-50 per cent		
Crops and vegetables	Demonstration of Power Operated weeder for rainfed crops	10	Manual weeding in vegetables required around 8 labours and the labour cost was of Rs.3000	Power weeder weeding time was 3 hrs and the cost was around Rs1000	Saving of cost Rs 2000 and time 6 hrs

5.3. Training Programmes

Organized 65 need based and skill oriented training programmes on various aspects of improved technologies to 3032 clientele farmers, farm women, rural youth and field level extension workers.

Clientele	No. of Courses	Male	Female	Total participants
Farmers and farm women/rural youths	56	1959	433	2392
Extension functionaries	7	337	210	547
Sponsored Training	2	67	26	93
Vocational Training	0	0	0	0
Total	**65**	**2363**	**669**	**3032**

5.4. TV/Radio talks/shows

S.No	Date	Activity	Place
G. Sri Krishna	15-11-2021	Hydroponics, Fish, Poly House (https://youtu.be/LcEd5I9jAp0)	V9
G. Sri Krishna	17-12-2021	Vertical Pillar gardening for leafy vegetables (https://youtu.be/wGHZGpbtszE)	HMTV
G. Sri Krishna	21-12-2021	Field bean-as alternative crop for paddy for high net returns (anapa sagu in telugu) (https://youtu.be/pwPAO9tPFN0)	HMTV
G. Sri Krishna	24-12-2021	Terrace Garden (https://youtu.be/RhoiE2D7_OE)	HMTV
G. Sri Krishna	11-01-2022	Measures in Mango flowering and Fruiting Radio Talk (recorded on 6-01-2022)	AIR Hyderabad
D.Sudheer	08-02-2022	Sustainable livelihood income through backyard poultry farming	Suman TV
Er. S. Vijaya Kumar	15.05.2021	Vana neetini vadisi pattu -pragati bataku metlu kattu- serial -episode 7- Interview	AIR, Namaplly
Er. S. Vijaya Kumar	18.09.2021	Neeti samrakshana- paddtuli- Interview	AIR, Namaplly
Er. S. Vijaya Kumar	15.05.2021	Vana neetini vadisi pattu - pragati bataku metlu kattu - Interview https://youtu.be/i4S2kPI11Og	You tube channel by AIR, Namaplly

5.5. Participation of SMS in conferences, meetings, workshops and symposia

SMS	Topic	Period	Venue
G. Sri Krishna	Good management practices in horticulture crops in association with ICL	26th April 2021	Online (ICL)
G. Sri Krishna	Participated online FIG (Farmer Interest Group) interaction on Mango pest management, Marketing strategies to mitigate current COVID-19 situation	25th May 2021	DoH, RR, Dist

SMS	Topic	Period	Venue
G. Sri Krishna	Organic farming for Sustainable agriculture	1st - 5th June 2021	Online EEI-MANAGE, Hyderabad
G. Sri Krishna	Resource person for District level training and visit programme organised by Dept of Agriculture	23rd September 2021	Raithu Vedika, Abdullpurmet mandal
G. Sri Krishna	Resource person for division level training on Crop diversification and alternative crops for paddy	9th December 2021	AMC, Ibrahimpatnam
G. Sri Krishna	Delivered a lecture training on management practices in mango, banana and pomegranate	28th December 2021	NIPHM, Hyderabad
G. Sri Krishna	Resource person for training on management practices in mango flowering and fruiting season	5th January 2022	DoH, RR Dist Pettulla village, Yacharm mandal
G. Sri Krishna	Webinar on Vertical Farming – Urban Farming: A sustainable innovation and business approach"	12th January, 2022	ICAR-CTCRI
Dr S.M. Vidya Sekhar, CTO	Webinar : Generic online training on cyber security	July 29th ,2021	Ministry of Electronics and Information Technology, CDAC, Hyderabad (Virtual Mode)
Dr S.M. Vidya Sekhar, CTO	Advances in web and mobile application development	December 6th -10th , 2021	ICAR-NAARM, Hyderabad (Virtual Mode)
D.Sudheer	Resource person- Grama bharathi NGO- Fodder production technologies-availability of fodder /conservation of fodder	July 18, 2021	Virtual online KVK CRIDA
D.Sudheer	Resource person- Grama bharathi NGO- Scientific profitable dairy farming	July 25th, 2021	Virtual online KVK CRIDA
D.Sudheer	Resource person- Gramabharathi – NGO- Ram lab production-Sheep and goat rearing practices	August 1st, 2021	Virtual online- KVK CRIDA
D.Sudheer	Resource person-Gramabharathi-NGO-Sustainable rural livelihood income through backyard poultry farming	August 8th, 2021	Virtual online KVK CRIDA
D.Sudheer	Resource person-Gramabharathi-NGO-Important livestock diseases of cattle, sheep and goat and poultry and precaution ,preventive measures and treatment	October 10th , 2021	Virtual online KVK CRIDA
Er. S. Vijaya Kumar	Online training programme on Mechanized weed management in different field crops"	01st -03rd November, 2021	ICAR-Directorate of Weed Research, Jabalpur (MP)

5.6. Seed Hub

During 2021-22, under Seed Hub project, 107 quintals of pigeonpea foundation seed of variety PRG -176 and 1.5 quintals of horse gram seed of variety CRHG-22 was procured from farmers/ HRF and processed at Seed Hub facility. Approximately 10 - 15 quintals of green gram certified seed of variety WGG-42 will be procured from farmers in *rabi* 2021-22. The seed will be distributed to farmers through sales in *kharif* 2022. Approximately 15.00 lakhs revenue will be generated through sales of seed.

5.7. Soil Testing

During 2020-21, a total of 115 soil samples were collected from three villages for soil analysis. 38 soil health cards were distributed so far to the beneficiary farmers. The number of water sample analyzed during the same period was two.

5.8. Major events organized by KVK, CRIDA

5.8.1. World Soil Day

World Soil day 2021 was celebrated by ICAR- Central Research Institute for Dryland Agriculture and CRIDA-KVK in association with IFFCO in Nymatapur Village, Kadthal mandal of Ranga Reddy district. Dr. V.K. Singh, Director, ICAR-CRIDA presided over the world soil day celebrations as Chief Guest. Dr. DBV Ramana, OIC, KVK has briefed the famers about the importance of world soil day. Dr. S.M. Vidya Sekhar, SMS, KVK has explained the farmers on interpretation of soil testing results and Soil health reports. Sh. G. Sri Krishna, SMS, KVK has informed the farmers about the importance of bio-fertilizer. Sh Maruthi Rao and Sh Kripa Shankar, State IFFCO officers explained farmers on IFFCO products and importance of Nano Urea usage on crops. ADA, Maheswaram Division Smt. Sujata envisaged the alternate cropping and crop diversification aspects in place of rice for the forthcoming season. The posters and bulletins of Department of Agriculture on crop diversification were released by Director, CRIDA and other dignitaries. 25 Soil health cards prepared by CRIDA-KVK were also issued to the village farmers by the Director, CRIDA. The village Sarpanch Sh J. Ravindrra Reddy requested farmers to follow the suggestions of scientists on soil health management. Dr. V.K. Singh, Director, CRIDA in his message opined about the importance of plant nutrition, soil testing, soil health management, nutri gardens, cost reduction in inputs and Integrated Farming systems to be followed by farmers. 122 farmers and farm women along with MPTC Sh Gopal participated in the event. KVK staff Er. S. Vijay Kumar, Mandal Agricultural Officer, AEO, IFFCO officer Sh Chandranna , Village Gram Panchayat Secretary , Ward Members and students are the other participants in the event. The event ended with the distribution of woolen blankets to old and poor farmers and farm women in the village sponsored by IFFCO. Exhibition stalls were displayed by CRIDA-KVK and IFFCO for technology dissemination to farmers.

మెళకువలతో అధిక దిగుబడి సాధించొచ్చు

కేంద్రియ మెట్ట వ్యవసాయ డైరెక్టర్ వి.కే సింగ్

మన తెలంగాణ/ఆమనగల్లు/కడ్తాల్ : ప్రతి రైతు వ్యవసాయంలో సరైన మెలకువలు పాటించడం ద్వారా అధిక దిగుబడి సాధించవచ్చునని కేంద్రీయ మెట్ట వ్యవసాయ పరిశోధన సంస్థ డాక్టర్ వికే సింగ్ అన్నారు. తక్కువ పెట్టుబడితో అధిక దిగుబడి సాధించేందుకు రైతులు కృషి చేయాలని ఆయన కోరారు. కడ్తాల్ మండలం న్యామతాపూర్‌లో రంగారెడ్డి జిల్లా కృషి విజ్ఞాన కేంద్రం, కేంద్రీయ మెట్ట వ్యవసాయ పరిశోధన సంస్థ(క్రీడా)ల ఆధ్వర్యంలో శనివారం భూసార పరిరక్షణ ప్రథమ కర్తవ్యం, పంట మార్పిడిపై రైతు అవగాహన సదస్సును నిర్వహించారు. సదస్సుకు వికే సింగ్ ముఖ్య అతిథిగా హాజరయ్యారు. భూసార పరీక్షల ప్రాధాన్యత, ఆవశ్యకతలపై రైతులకు అవగాహన కల్పించారు. పంటలకు సుమారు 16 పోషకాలు అవసరం అని వీటి లభ్యత నేలలో ఎంత వరకు ఉందని తెలుసుకుని దానికి అనుగుణ పద్ధతుల్లో ఎరువులను మోతాదులో సరైన సమయంలో సరైన పద్ధతుల్లో వాడడం ద్వారా పంట సాగు ఖర్చు తగ్గించడమేకాక అధిక దిగుబడులు సాధించవచ్చునని ఆయన తెలిపారు. అనంతరం గ్రామంలో సుమారు 25 మంది రైతుల పొలాల్లో భూసార పరీక్షలు నిర్వహించి వాటి ఫలితాలను హెల్త్ కార్డుల రూపంలో రైతులకు అందచేశారు. వేప పూత, ఎరువులు, యూరియా ఉత్పత్తుల గురించి రైతులకు అవగాహన కల్పించారు. కార్యక్రమంలో ఐఎఫ్ఎఫ్‌సిఓ సంస్థ ప్రతినిధులు మారుతి రావు, కృపశంకర్, కేవికె శాస్త్రవేత్తలు విద్యాశేఖర్, శ్రీ కృష్ణ, హెడ్ డాక్టర్ రమణ, మహేశ్వరం ఏడి ఎం. సుజాత, కడ్తాల్ ఏఓ శ్రీలత, ఏఈఓలు తేజస్విని, గ్రామ సర్పంచ్ రవీందర్ రెడ్డి, ఎంపీటీసీ గోపాల్, పంచాయతీ కార్యదర్శి జగన్, ఉప సర్పంచ్ యాదగిరి, వార్డు సభ్యులు తదితరులు ఉన్నారు.

మన తెలంగాణ
Sun, 05 December 2021
https://epaper.manatelangana.news/c/64757761

5.8.2. Poshan Vatika Abhiyan and Tree Plantation

Krishi Vigyan Kendra, CRIDA has organized Poshan Vatika Abhiyan and Tree Plantation in Shadnagar of Ranga Reddy District of Telangana in colloboration with Women and Child Welfare Department wherein local Shadnagar MLA Sh Y Anjaiah Yadav, MPP, MPTC, ZPTC , Other local public representatives, Scientists of CRIDA, KVK staff, Officers from State government (Women and Child welfare department), ADA of State Department of Agriculture and Horticulture, IFFCO officials and KRIBHKO officials, Anganwadi staff, farmers and School children participated. About 600 plants (mango, guava and lemon) were planted. Plantations were also carried out at CRIDA Research Farm of Hayathngar and Gunegal with 450 Plants (mango, guava, lemon, sapota, pomegranate, custard apple). 1050 plants were distributed to farmers and farm women. Several events like Exhibition on Nutrition aspects, competitions for school children on Poshan Abhiyan, Exhibition stalls of IFFCO, KVK on liquid fertilizers and income generation activities, cultural events etc., were organized. 130 Kitchen garden Nutri Seed kits received from IFFCO were distributed to women farmers and Nutrition teachers in villages (Anganwadi). 100 Liquid fertilizers were given to Farmers. Nutri Jowar kits and millet biscuits received from Indian Institute of Millet Research, Hyderabad were also distributed to the women famers, adolescent girls and school children. 250 farmers and farm women, 75 adolescent girls and 30 officials and public representatives participated in the event.

5.8.3. DDG (Agricultural Extension) visit to KVK, CRIDA

Hon'ble DDG (Agricultural Extension) Dr.A.K.Singh visited Krishi Vigyan Kendra, on 27.11.2021 along with Director, CRIDA Dr. V.K. Singh and Director, ATARI Dr. J.V. Prasad. He has reviewed KVK activities in detailed and visited the exhibits and demonstration units of KVK. He interacted with KVK farmers on technologies disseminated by KVK.

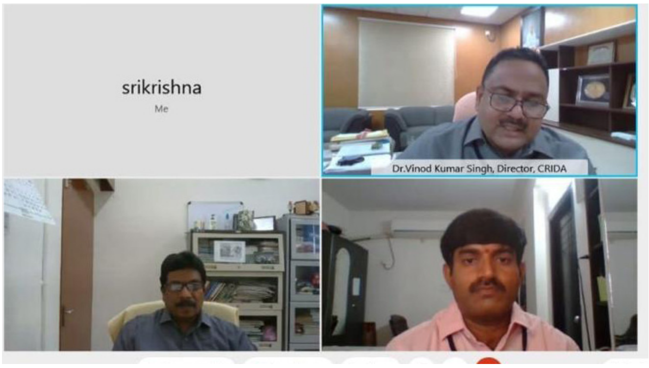
5.8.4. Training on fruit fly surveillance and management

NIPHM, Hyderabad sponsored collaborative training on Fruit Fly Surveillance and Management conducted through online from 28-30 April, 2021. Trainees who are working in extension field were selected (61 members) from Andhra Pradesh and Telangana viz., Subject matter Specialists from Krishi Vigyan Kendras, District Horticulture and Sericulture Officers, Asst. Directors of Horticulture, Mandal Agriculture Officers, Agriculture extension Officers and representatives from NGOs.

Dr. Vinod Kumar Singh, Director, ICAR-CRIDA during the inaugural session emphasized the severity of the damage from the fruit fly in tune with millions of rupees is lost for management of the most devastating pest not only in India but also in other countries. Most of the horticulture crops like mango, guava, citrus and cucurbits are prone to the damage caused due to fruit fly. There is a need of hour to integrate the all possible management practices like cultural, mechanical, biological, chemical practices to menace the pest for benefit of the farmers. There is also possibility of climatic factors which influence the population of fruit fly and exploration of best possible ways to avoid the damage is needed.

Dr. Sagar Hanuman Sigh, IPoS, Director General, NIPHM addressed trainees that the information shared by the experts during the technical sessions should reach the farmers immediately because this is the right time where the major fruit crop in two states like mango is at maturity stage which is more prone to fruit fly infestation. NIPHM is also working with many institutions to spread the technologies through trainings, demonstrations and collaborative projects at district and state levels.

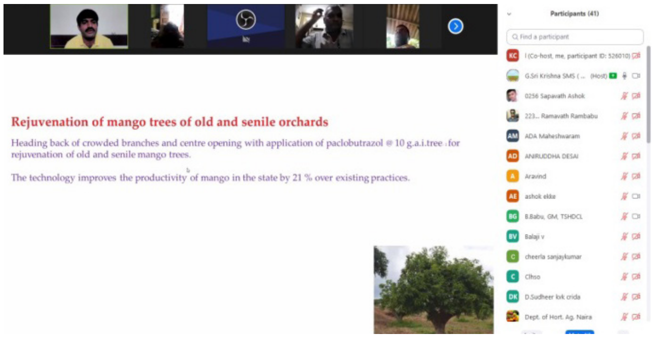
Participants interacted with experts in the discussion and expressed issues like efficacy of pesticides, time of application, residual effect of chemicals, resistant varieties to be developed with crop improvement techniques, assessment of indigenous technical knowledge in control of fruit fly, climatic factors influencing the extent of damage. Dr. DBV Ramana, Principal Scientist & OIC, Dr.SM Vidhyashekar, CTO, G. Sri Krishna, Subject Matter Specialist (Horticulture) from KVK-ICAR CRIDA and Dr.Pyla Jyothi, Asst. Director, NIPHM coordinated this three days training programme with the help of Agriculture Knowledge Management Unit of CRIDA.



5.8.5. Celebrated 93rd ICAR Foundation Day Celebrations & Training on Importance of Tree Plantation-Kisaan e-gosthi

KVK Ranga Reddy District, ICAR-CRIDA organized 93rd ICAR Foundation Day Celebrations at KVK farm on 16th July, 2021. Bund plantation and border plantation of multi purpose crops like custard apple, jamun, sesbania, mango, conocarpus are planted in an area of 2.5 acres covering all bunds and boarders. B.Sc. Final year Students and farmers were attended the programme. Dr.D.B.V. Ramana, OIC, KVK emphasized the role and contribution of tree plantation on environment in terms of reduction of pollution and greenhouse gas mitigation, role of farming community in environmental protection. SMSs created awareness about the positive impact of tree plantation on improvement of soil health, soil fertility, soil and water conservation for pure environment.

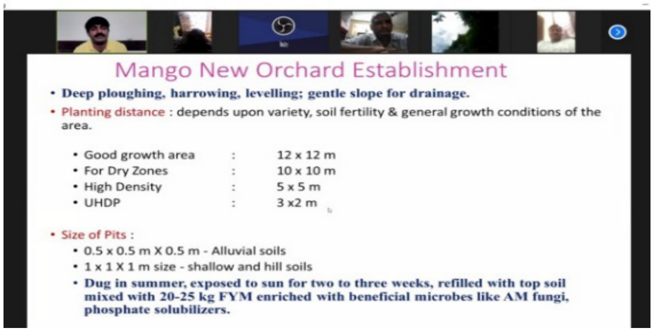
Kisan e ghosti and online webinar on "Good Management Practices in mango for higher productivity and net returns through ZOOM meeting also organized by G. Sri Krishna, SMS (Horticulture) in interaction with farmers and experts from line departments. About 48 mango growing farmers participated in the session and got clarified queries on planting to harvest (varieties, nursery, planting, nutrition, irrigation, pest & disease management, training & pruning, rejuvenation of senile orchards, top working, crop regulation, harvesting, post-harvest management, *etc*). Farmers also expressed that the plantation of multipurpose trees will provide ample opportunities to the farmers not only livelihood but also environmental protection. Farmers motivated towards tree plantation along with bunds, wastelands, barren/ unused lands during Kisan Ghosti. Dr.D. Sudheer, SMS (Veterinary Science), Er.S.Vijaya Kumar, SMS (Agricultural Engineering), Dr.K.Venkanna, Farm Superintendent, Students, Farmers participated in this programme.



Rejuvenation of mango trees of old and senile orchards

Heading back of crowded branches and centre opening with application of paclobutrazol @ 10 g.a.i.tree for rejuvenation of old and senile mango trees.

The technology improves the productivity of mango in the state by 21 % over existing practices.



Mango New Orchard Establishment

- **Deep ploughing, harrowing, levelling; gentle slope for drainage.**
- Planting distance : depends upon variety, soil fertility & general growth conditions of the area.
  - Good growth area : 12 x 12 m
  - For Dry Zones : 10 x 10 m
  - High Density : 5 x 5 m
  - UHDP : 3 x2 m
- Size of Pits :
  - 0.5 x 0.5 m X 0.5 m - Alluvial soils
  - 1 x 1 X 1 m size - shallow and hill soils
  - **Dug in summer, exposed to sun for two to three weeks, refilled with top soil mixed with 20-25 kg FYM enriched with beneficial microbes like AM fungi, phosphate solubilizers.**

5.8.6. Conducted *Azadi Ka Amruth Mahotsav* and Horticulture block plantation

Azadi Ka Amruth Mahotsav and Horticulture block plantation programme conducted at Hayathnagar Research Farm, CRIDA on 1st September, 2021. Commercially grown fruit crops with improved varieties viz mango (Mallika, Kesar, Dasheri, Baneshan), guava (Allahabad Safeda, Lucknow-49), dragon fruit (Pink Fleshed), lemon (Balaji), custard apple (Balanagar), sapota (Kalipatti, Pala), pomegranate (Bhagwa), jackfruit (Varikka) are planted in an area of 10 acres through identification of soil and climatic requirements of the crops. Dr.V.K Singh, Director, ICAR-CRIDA addressed the staff of CRIDA and emphasized the role and contribution of fruit crops in doubling the farmers income. Fruit plantation in HRF is not only for production and yield but also for income generation through production of plant materials for sustainability. It has to be evolved as a model for multiple crops for higher net returns and showcased for the farming community in future. The positive impact of tree plantation on improvement of soil health, soil fertility, soil and water conservation for pure environment to be spread among the farmers for better society.

The Director, CRIDA initiated ***Azadi Ka Amruth Mahotsav*** programme through fruit crops plantation in 10 acres with mango (2.0 ac), Guava (1.0 ac), sapota (1.0 ac), dragon Fruit (1.0 ac), lemon (1.0 ac), jack fruit (1.0 ac), pomegranate (0.5 ac), custard apple 1.5 ac).

All the Heads of Divisions (DRM, DCS, ACRIPDA, ACRIPAM), OICs of HRF, GRF and KVK, Scientists, Technical Staff, Administrative staff from CRIDA and KVK, students, SLTS and contractual staff of CRIDA (nearly 250 members) participated in this programme.

5.8.7. National Level Campaign on "Food and Nutrition for Farmers" on 26.08.2021

As a part of ICAR National Level Campaign on "Food and Nutrition for Farmers" under 'Azadi Ka Amrit Mahotsav', was organized by Krishi Vigyan Kendra, Ranga Reddy District, ICAR-CRIDA on 26.8.2021 with the participation of farmers and students in KVK premises. Several events were conducted viz., Training and awareness for farmers on food and nutrition, Ghosti on nutritional aspect of Bio-fortified varieties of crops, exhibition cum exposure to technologies at the KVK and CRIDA. The training was addressed by the Dr. DBV Ramana, Head, KVK and Principal Scientist, CRIDA on Nutritive values of eggs, milk and meat products to farmers for enhancing their immunity and maintaining good health. Importance of Bio-fortified varieties in crops was also enlightened to farmers. A brief discussion on nutritive crops and vegetable and their role in healthy diet was organized. KVK experts shown the farmers the exhibits of various technologies in CRIDA viz., Farm Implements, Back yard poultry, crop cafeteria with bio-fortified varieties, fodder cafeteria etc. A total of 72 famers and students participated in the event.

5.8.8. Farmers scientists interface on climate resilient varieties, technologies and practices

As a part of web telecasting of Hon'ble Prime Minister's Message and Interaction with Farmers, "Farmers Scientists Interface on Climate Resilient Varieties, Technologies and Practices" has been organized by Krishi Vigyan Kendra, Ranga Reddy District, ICAR-Central Research Institute for Dryland Agriculture (ICAR-CRIDA) on 28.09.2021 with the participation of 109 farmers from Bhadradri Kothagudem, Yadhadri and Ranga Reddy districts of Telangana and 11 other VIPs from Telangana in KVK-Ranga Reddy premises. Dr. G. Prathibha, Dr. K.V. Rao, Dr.D.B.V. Ramana from ICAR-CRIDA along with Dr. S.M.V. Vidya Sekahar, Dr. D. Sudheer, Sri. G. Srikrishna and Er. S. Vijay Kumar from KVK-Ranga Reddy participated in the programme and interacted with farmers on topics like resilient crop varieties, Diversified crops and intercropping systems, farm machinery for efficient use of soil moisture and energy conservation, water harvesting and efficient use & efficient methods of irrigation, improved breeds, health, nutrition & shelter management practices for dairy and small ruminants, soil health management interventions, better practices for backyard poultry and good management practices for higher production from horticulture. Shown the farmers the exhibits of various climate resilient technologies of NICRA project and also exposed to farm implements, back yard poultry, crop cafeteria with bio-fortified varieties, fodder cafeteria etc.

5.8.9. *Mahila Kisan Diwas*

KVK-Ranga Reddy District, ICAR-CRIDA organised *Mahila Kisan Divas* at Annaboina Palle village, Madgula Mandal of Rangareddy district on 15th October 2021 aiming to empower women in the field of agriculture and allied sectors with the theme "Equality and Empowerment". This day was celebrated by organizing training programme, exhibition, Kisan Ghosti and Rally in the village on empowering women through income generation avenues in agriculture and allied sectors.

Dr. Vinod Kumar Singh, Director, ICAR-CRIDA explained about the empowerment of women in terms of contribution in production of crops and need of the hour to farm FPOs to combat the present difficulties in farming. Farm women has been enlighted with good management practices viz. importance of soil test, balanced fertilizer application with reference to soil test, soil health management, application of microbial consortia, adoption of organic farming practices, use of crop residues for composting to create waste to wealth, integrated farming systems with livestock components, integrated pest and disease management of crops to reduce cost of cultivation, farm mechanization for reduction of drudgery specifically in farm women, encourage nutri/kitchen garden and their maintenance for nutritional security, formation and registration guidelines of FPOs. Explained different women oriented Schemes for Small scale enterprises establishment and at the same time explained about the Integrated Farming System models for additional and sustainable income. Scientists from ICAR-CRIDA Dr. Sammireddy, Dr. C.A. Ramarao, Dr. D.B.V Ramana, Dr S.S. Balloli, Dr. K.A. Gopinath, Dr. K. Ravishankar, Dr. B. Narasimhulu, Dr. Sridhar, Dr. V. Visha Kumari, participated in this programme and actively interacted with farm women.

As part of the programme exhibition was arranged with posters, inputs, information brochures and also distributed 100 Nutri garden vegetable seed kits to farm women.

Smt. Kala, Sarpanch, Sri Sricharan, Officer, FPOs registration, Sri G Goutham, Mandal Agriculture Officer, Smt Navya, AEO, Smt Chandra Kala, Officer, Organic certification agency and 82 farm women and farmers participated in the programme.




5.8.10. Visit of Dr. S.K.Chaudhary, DDG (NRM) KVK & HRF

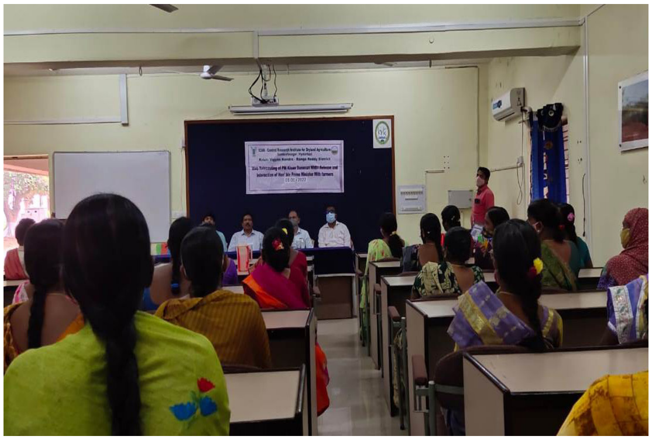
Dr. S.K. Chaudhary, DDG (NRM), ICAR visited KVK Ranga Reddy and inaugurated Integrated Urban Farming model which includes components like hydroponic vegetable cultivation, vertical pillars, multipurpose net house with grow bags & foggers, micro greens, leafy veggies in raised beds with drip, micro sprinklers and fish culture at KVK instructional farm in the presence of Dr.V.K. Singh, Director, ICAR-CRIDA. The unit is established to educate and train the people about the importance of growing vegetables in chemical residue free environment on terrace or in gardens. All the heads of divisions, principal scientists, staff of KVK, farmers, farm women participated in this programme.

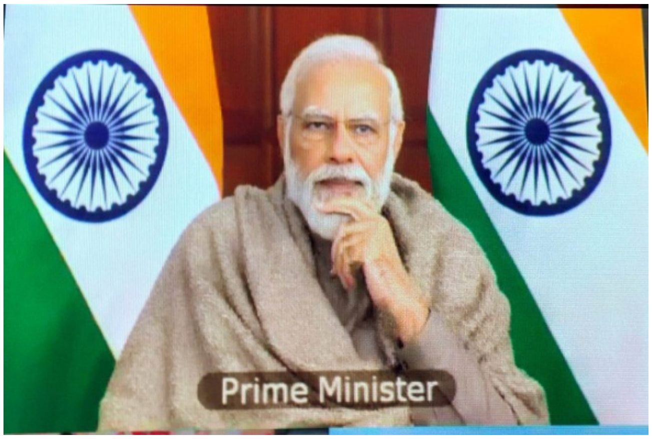


Dr. S.K. Chaudhari, Deputy Director General (Natural Resource Management), ICAR, inaugurated Farm Pond Based Solar Powered Micro Irrigation system block at KVK watershed area in the presence of Dr.V.K.Singh, Director, ICAR-CRIDA. Dr. DBV Ramana, Head KVK briefed about different micro irrigation systems like inline drip, online drip, mini sprinklers, micro sprinklers, laser drip/rain drip for leafy vegetable, vegetable and fruit crops.

5.8.11. *Webcasting of Hon'ble Prime Minister on the occasion of PM Kisan Samman Nidhi Fund*

KVK, Ranga Reddy District, ICAR-CRIDA organized the event on Webcasting of Hon'ble Prime Minster on the occasion of release of PM Kisan Samman Nidhi fund to farmers on 01.01.2022 with the farmers from Hyathnagar mandal and KVK, HRF staff. Dr. I Srinivas, OIC, HRF and Dr. D.B.V. Ramana, OIC, KVK has briefed the farmers about the PM Kisan Samman Nidhi fund release and proper utilization of the amount for procuring inputs during the current cropping season. The briefing given by Hon'ble Agriculture Minister Shri N.S. Tomar, Ministry of Agriculture and Farmers' Welfare and the message given by Hon'ble Prime Minster of India Shri Narendra Modi was webcasted to the Farmers attended in the event. A total of 78 farmers and 15 staff members of CRIDA and KVK have participated in the Webcasting event.





5.8.12. Training cum awareness programme on profitable dairy farming and livestock management

Three-day training cum awareness programme on profitable dairy farming and livestock management was organized for 40 practicing farmers and farm women of Ranga Reddy district at KVK- Hayatnagar farm from 16-18th December, 2021. Dr. D B V Ramana, Head, KVK welcomed all the participants and Dr. Vinod Kumar Singh, Director CRIDA who presided as Chief Guest and explained importance of integration of livestock in rainfed areas. At the outset, the farmers introduced themselves and share their farming experiences, main constraints in rearing, marketing, health management aspects encountered. Farmers were exposed to different fodder production and conservation technologies, scientific feeding, nutritional management of different age group of animals, contingency measures during weather aberrations, concentrate feed making using locally available ingredients, silage making, importance of timely immunization, mastitis control, calf rearing practices etc. Hands on training on concentrate mixture preparation, silage making, enrichment of crop residues, UMMB preparation etc., were given. Field exposure to NARMUL milk dairy processing plant at Hayatnagar, commercial dairy unit at Hayatnagar, and integrated farming system (IFS) model at Gaddimallaiguda village at Yacharam mandal has been provided.

Several issues like best practices to adopt for profitable dairy farming and good management practices to adopt in rearing calves, health care precaution to be taken during pre-monsoon period, prevailing diseases during present situation, poisoning cases measures to be adopted to minimize the mortality in animals, vaccination and deworming schedule to be followed during calendar year etc., were also discussed in length and clarified the doubts.

5.8.13. Training cum distribution of Rajasri variety backyard poultry chicks for empowerment of SC women farmers in KVK adopted village

KVK-Ranga Reddy, ICAR-CRIDA, Hyderabad organized training cum distribution of day old Rajasri variety chicks to 65 identified SC beneficiaries under SC sub plan in KVK adopted villages- Akuthotapalli, Gouraram and Nymathapur villages of Amangal and Kadthal Mandal, Ranga Reddy district on 20-12-2021. Sri. Narayana, MPTC and Rythu Samanyva Samithi President of Amangal division grace the occasion as chief guest and stressed need of the backyard poultry farming -a sustainable tool for rural livelihood and provide nutritional food security at house hold level and its contribution in women empowerment.

Dr.D.Sudheer SMS (Veterinary Science) KVK CRIDA, Dr. Vijay Kumar, Dr. Madan Kumar Local veterinary doctor of Amangal and Kadathal Division and para veterinarian actively participated.

5.8.14. SAC meeting of KVK-Ranga Reddy ICAR-CRIDA

Scientific Advisory Council (SAC) meeting of KVK-Ranga Reddy, ICAR-CRIDA was held on 24.03.2021 at KVK Farmers training Hall, Hayathnagar Research Farm under the Chairmanship of the Director, Dr. V.K. Singh. SAC members/representative's Sri B. Singh, Director, RFS, Smt. Geetha Reddy, District Agriculture Officer, Smt. Divya Jyothi, Project Director (ATMA), Sri. Sanjeev Kumar, Assistant Director (Horticulture), Dr. S.V. Ramana Rao, Pr. Scientist (Agricultural Extension), IIOR, Dr. P. Baswa Reddy, Pr. Scientist (NRC on Meat), Dr.D.B.V. Ramana, OIC (KVK), Sri. N. Krishna, WOTR, and farmers representatives (Sri. K. Ramulu, Sri. Ravindra Reddy, Sri. M. Subash Reddy, Sri. P. Mallaih) participated in the meeting. From ICAR-CRIDA, Dr. G. Ravindra Chary, Project Coordinator (Dryland Agriculture), Dr. K. Sammi Reddy, Head (DRM), Dr. C.A. Rama Rao, Head (D &A), Dr. K.S. Reddy, Pr. Scientist (SWC), Dr. S.K. Bal, Project Coordinator (Agrometeorology) and Dr. I. Srinivas, OIC (HRF) also participated. The programme was also attended by KVK subject matter specialists Dr.S.M.Vidya Shekar, Dr Sudheer, Er. S. Vijay Kumar, Mr. Srikrishna and Mrs.A.Vidhyaadhari. Director, welcomed the SAC members and emphasized working in Science with Extension approach, redefining the strategies with changing climate and considering farmers perceptions & resources while developing the action plan. OIC (KVK) presented the overall progress report and also action taken report. Later, every subject matter specialist presented progress report (2020-21) and action plan (2021-22). Establishment of FPO, developing soil fertility map with GPS coordinates, nutria-gardens and IFS models, communication of technologies and advisories through various mass communication tools, and intensification of systems etc., were discussed in depth. At the end Director felicitated Mrs.A.Vidhyaadhari and Sri. G. Kristaiah who are going to retire during this year.

SAC meeting of KVK-Ranga Reddy ICAR-CRIDA

5.8.15. Awareness training programme on Mechanization cum Manual Weeders Distribution to the SC farmers

KVK- Rangareddy, ICAR- CRIDA organized off campus training programme cum manual weeder distribution at Nayamathapur Village, Kadthal, Rangareddy District. Training organized in collaboration with Department of Agriculture on broad bed Planter, weeders and nine row planter for 40 farmers on 06th

July 2021. Dr D.B.V.Ramana, OIC KVK and Principal Scientist (Livestock Production & Management), S.Vijaya Kumar, SMS (Agricultural Engineering), D. Sudheer, SMS (Veterinary Science), Smt Sujata ADA, Smt Srilatha Mandal Agricultural Officer, AEO's, Sri Srinivasa Reddy, Sarpanch, Field officer and others participated in the event and distributed manual weeders for identified 10 farmers. Dr. D.B.V.Ramana, stressed the importance of mechanization in different crops, ADA briefed about importance of mulching sheet and micro irrigation system in vegetable crops, S.Vijaya Kumar, arranged field visits and given lecture on the farm machinery for different operations in rainfed areas.

5.8.16. Field training programme to B.Sc (Agriculture) students at Naymathapur and Akuthotapalli

Field training for BSc Agriculture final year students to know about village situations under Rural Agricultural Work Experience (RAWE) program has been provided for 15 days for 25 students so as to acquaint with different crops, managemental aspects including INM and IPM techniques and the problems faced by the farmer under rural conditions. Hands on training on operation of various farm machinery, micro-irrigation systems, rainfall data monitoring, watershed operations, farm pond technologies etc., were provided by S.Vijayakumar SMS (Agricultural Engineering) and D. Sudheer, SMS (Veterinary Science) at Naymathapur and Akuthotapalli villages in Kadthal mandal of Rangareddy district.

Training and Capacity Building 6

6.1. Participation in Trainings

Name	Title	Duration	Venue
Scientific staff			
K. Srinivas	DST Sponsored National Online Training Programme on "Integrated Nutrient Management and Nutrient Budgeting through Advanced Models to Improve Crop Productivity"	January 18th - 22nd, 2021	ICAR-IISWC, Research Centre, Udhagamandalam-Vitual
K. Srinivas	Online Training Programme on "Geospatial Analysis using QGIS and R"	February 15th -20th , 2021	ICAR-NAARM, Hyderabad Virtual
N S Raju	Online training programme on "Applications of Artificial Intelligence and cloud computing in Agriculture"	February 15th -20th , 2021	NAARM, Hyderabad Virtual
Josily Samuel Pushpanjali	Five days online workshop on Climate Resilient Precision Agriculture to Enhance the Natural Capital in Developing Countries: An Inclusive Wealth Approach	March 8th -12th , 2021	NIT, Surathkal, Karnataka Virtual
N S Raju, S. Kundu	Online Training Program on"Cyber Security"	March 25th, 2021	C-DAC Hyderabad Virtual
N. Manikandan	Online Training Program on Enhancing Agricultural Resilience through Index-based Flood Insurance and Post-flood Management Interventions in India	June 29th -30th, 2021	ICAR-Indian Institute of Water Management (IIWM), Bhubaneswar, Virtual
Pushpanjali	Generic Online Training in Cyber Security Assessment	July 9th, 2021	Ministry of Electronics and Information Technology (MEITY), Government of India, Virtual
Salini K	Training in SNP mining, GWAS and Genomic selection	December 16th - 21th , 2021	Virtual
Josily Samuel	'Impact Assessment of Agricultural Research and Technologies'	December 18th - 22nd , 2021	NAARM, Hyderabad, Virtual

6.2. Post graduate research (On-going)

Scientist	Student	Degree	Discipline	Institute/University
K.S Reddy	J Ranjith Kumar	M.Tech	Agricultural Engineering (Soil and Water Engineering)	PJTSAU, Kandi
K.S Reddy	K Hemchandra Reddy	Ph.D	Agricultural Engineering (Soil and Water Engineering)	MPUAT, Udaipur
DBV Ramana	N.Shruthilaya	Ph.D	Livestock Production and Management	PVNRTVU, Rajendranagar
DBV Ramana	B.Thulasamma	Ph.D	Livestock Production and Management	PVNRTVU, Rajendranagar
DBV Ramana	S. Katyayani	Ph.D	Livestock Production and Management	PVNRTVU, Rajendranagar
K Nagasree	K Priyanka	M.Sc.	Agricultural Extension	PJTSAU, Hyderabad
SK Yadav	Yogesh Kumar Tiwari	Ph.D	Bio-Chemistry	JNTU, Hyderabad
M Vanaja	P. Sathish	Ph.D	Genetics	Osmania University, Hyderabad
M Vanaja	G. Sandhya	Ph.D	Biotechnology	Osmania University, Hyderabad
M Vanaja	P. Shobharani	Ph.D.	Genetics	Osmania University, Hyderabad
M Vanaja	P. Venkatesh	M.Sc.	Crop Physiology	PJTSAU, Hyderabad
M Srinivas Rao	D.V. Sravan Kumar	Ph.D	Agricultural Entomology	ANGRAU, Bapatla
R.Rejani	Bangi Nirmala	M.Tech	Soil and Water Engineering	College of Agricultural Engineering PJTSAU, Sangareddy
B.Sanjeeva Reddy	B. Raj Kiran	Ph.D	Farm Machinery and Power Engineering	ANGRAU, Guntur
B.Sanjeeva Reddy	Sravan Kumar Chintha	Ph.D	Farm Machinery and Power Engineering	UAS-R, Raichur
K.A. Gopinath	M. Manu Kumar	M.Sc	Agronomy	PJTSAU, Hyderabad

6.3. Human resource development (HRD)

Category	Attended trainings (No.)
Scientists	15
Technical staff	5
Administrative & Finance staff	2
Total	22

Women in Agriculture 7

7.1 International Women's Day Celebration

ICAR-CRIDA celebrated "International Women's Day" on the theme "Women leadership in agriculture: entrepreneurship, equity and empowerment" on March 8, 2021. On this occasion, live webcast of the virtual programme of ICAR was organized for the women staff of the institute. It was followed by the inauguration of three days training programme for women farmers in sustainable rice production under SCSP. Dr. V. K Singh, Director, ICAR-CRIDA in his address highlighted the increasing participation of women farmers in agriculture and allied sectors. He praised the women farmers for their hard work in every sphere. He encouraged and motivated the women farmers to take up entrepreneurial activities in agriculture also. A lecture on topic "Recommendations of Dietary Allowance (RDA) for women" was also delivered by Dr. Sreedevi Shankar, Principal Scientist (Food and nutrition).

Celebration of International Women's Day at CRIDA Campus

KVK-CRIDA also organised the International women's day programme. Dr. V.K Singh, Director, CRIDA attended the programme and addressed the women farmers. He spoke about empowerment of women. Later, five women farmers of Gaddamallaiah Guda and Dharmanna Guda villages were given best farm women award. Dr. D.B.V. Ramana Principal Scientist and OIC, KVK and Dr. I. Srinivas, Principal Scientist and OIC, HRF also addressed the participants. The programme was attended by 60 farm women and 20 farmers.

Celebration of International Women's day at KVK-CRIDA, Hayatnagar

Under Farmer FIRST project, International Women's Day programme was organized at Gangupally, Vikarabad District, FFP adopted village. On this occasion Dr. G Nirmala, PI, FFP, spoke about the role of women in agriculture and welcomed the women entrepreneurs. Ms Sai Geeta, entrepreneur Jute handicraft and Ms Rama Devi, President of Women Farmer Society explained about the importance of women organizing themselves for economic activities. They motivated the farm women to engage in some entrepreneurial activities.

Celebration of International Women's Day under FFP at Gangupally village Vikarabad district

Awards and Recognition 8

8.1. Awards/Recognition from Professional Societies and other organizations

Dr.V.K.Singh, Director ICAR- CRIDA won the prestigious Rafi Ahmed Kidwai Award for Outstanding Research in Agricultural Sciences (2020) in the field of Natural Resource Management. The award carries a cash prize of ₹ 5 lakh in addition to the citation and certificate.

Dr. Prabhat Kumar Pankaj, Principal Scientist (Livestock & Production Management) was honoured with Life Time Achievement Award by Agriculture Letters, Karnataka on the occasion of the International conference on New Paradigms for Agriculture, Food and Sustainability concerns from 26-28 February, 2021.

Dr. K. Ravi Shankar, Principal Scientist (Agricultural Extension) received Excellence in Extension Scientist Award 2021 from Agro-Environmental Development Society (AEDS), Rampur, Uttar Pradesh on the occasion of 4th International Conference on "Current Approaches in Agricultural, Animal Husbandry & Allied Sciences for Successful Entrepreneurship (CAAHASSE-2021)" during March 13-15, 2021.

Dr. A.G.K. Reddy, Scientist (Horticulture) received the Best Speaker Award on the occasion of ICAR-CRIDA 37th foundation day.

Dr. B. M. K. Raju, Principal Scientist (Agricultural Statistics) received Best Oral Presentation Award in Global Conference on 'Innovative Approaches for Enhancing Water Productivity in Agriculture including Horticulture' held during 16-19 September, 2021 at PJTSAU Rajendranagar, Hyderabad, Telangana, India.

Dr. M. Srinivasa Rao, Principal Scientist (Entomology) received the Outstanding Agriculture Scientist award from B. Vasanthraj David Foundation, Chennai for the year 2021.

Dr. K.S. Reddy, Principal Scientist (Soil & Water Conservation Engineering) was honoured with the Global Eminent Scientist award by Vij TRUST, Tamil Nadu in June 2021 and Life Time Achievement Award by VDGOOD Professional Association, Coimbatore, Tamil Nadu in September 2021.

Dr. D. B. V. Ramana, Principal Scientist (Livestock Production & Management) & OIC, KVK has become an "Expert Reviewer" for the Biotechnology Industry Research Assistance Council (BIRAC) Schemes, Dept. of Biotechnology, Govt. of India.

Dr. J.V.N.S Prasad Principal Scientist (Agronomy) and Dr. Prathibha, Principal Scientist (Agronomy) was conferred with ISA Gold Medal Award at 5th Agronomy Congress at PJTSAU, Hyderabad from 23-27 November 2021.

Dr. Sumanta Kundu Scientist (Agronomy) and Dr. V. Visha Kumari, Scientist (Agronomy) received the Best Oral Presentation Award at 5th Agronomy Congress at PJTSAU, Hyderabad from 23-27 November 2021.

Dr. M.A. Sarath Chandran, Scientist (Agricultural Meteorology) and Er. Ashish S. Dhimate (Farm Machinery and Power) secured the Best Poster Award at 5th Agronomy Congress at PJTSAU, Hyderabad from 23-27 November 2021.

Er. Ashish S Dhimate (Farm Machinery and Power) received Appreciation Certificate from organizer for acting as Rapporteur in Technical session on "Scientist-Industry-Farmer Interface" during the Fifth International Agronomy Congress held at PJTSAU, Hyderabad during 23-27 November 2021.

Dr. R. Nagarjuna Kumar, Senior Scientist (Computer Application in Agriculture) received NESA Distinguished Award 2021 in Computer Applications in Agriculture from National Environmental Science Academy, New Delhi in the International Conference on Promoting Environmental Technologies for Waste Management and Sustainable Development (WMSD-2021) held at Kalinga Institute of Industrial Technology, Bhubaneswar, Odisha during 12-13, December 2021.

Dr. M. Manjunath, Scientist (Agricultural Microbiology) received Best Oral Presentation Award at International Web Conference (GRISAAS-2021) held during 13-15 December 2021.

Dr. M. Manjunath, Scientist (Agricultural Microbiology) is recognized as a faculty at Professor Jayashankar Telangana State Agricultural University, Hyderabad to guide M.Sc and Ph.D students in the discipline of Agricultural Microbiology.

Dr. M. Vanaja, Principal Scientist (Plant Physiology) was nominated as an external expert member of the Academic Council of University College for Women, Koti, Osmania University, Hyderabad.

Dr. M. Vanaja, Principal Scientist (Plant Physiology) has become a Member of the Board of Studies of Botany (UG), under the Faculty of Science, Osmania University, Hyderabad.

Dr. M. Vanaja, Principal Scientist (Plant Physiology) was accredited to teach courses & guide M.Sc., and Ph.D. students in Crop Physiology of PJTSAU, Rajendranagar, Hyderabad.

Dr. K. Sammi Reddy, Head, DRM has been nominated as the Member, Research Advisory Committee (RAC) of ICAR – Central Agro-Forestry Research Institute (CAFRI), Jhansi.

Dr. K. Sammi Reddy, Head, DRM has been nominated as the Member of Institute Management Committee (IMC) of ICAR- Indian Institute of Oilseeds Research (IIOR), Hyderabad and ICAR- Indian Institute of Rice Research (IIRR), Hyderabad.

Dr. K. Sammi Reddy, Head, DRM acted as the Expert Member in Departmental Promotion Committees (DPC) at ICAR-IIHR, Bengaluru and PJTSAU, Hyderabad. He was also an expert member to review the research work of PJTSAU, Hyderabad.

Dr. Manoranjan Kumar, **Principal Scientist (Soil and** Water Conservation Engineering) was nominated as an observer for conducting combined NET, ARS (Preliminary) and STO (T-6) Examination during 2021 including mock test.

Dr. Manoranjan Kumar, **Principal Scientist (Soil and** Water Conservation Engineering) was nominated as an external examiner for Masters's degree (CAU Imphal) and for Ph.D. students (IARI, New Delhi and GBPUAT, Pantnagar).

Dr. Prabhat Kumar Pankaj, Principal Scientist (Livestock & Production Management) received First Prize under Hindi publication for Scientific and Technical subject by ICAR-National Dairy Research Institute, Karnal on 19th December, 2021.

Dr. Prabhat Kumar Pankaj, Principal Scientist (Livestock & Production Management) received Promotional Award for the Best Hindi publication competition by TOLIC, Karnal on 31st December, 2021.

8.2 Fellowships

Dr. M. Srinivasa Rao, Principal Scientist (Entomology) was honored with Fellow of Royal Entomological Society, London in July 2021 and Fellow of Linnean Society of London in October 2021.

Dr. K. S. Reddy, Principal Scientist (Soil and Water Conservation Engineering) was awarded the Fellow of National Environmental Science Academy, New Delhi in 2021.

Dr. Sumanata Kundu, Scientist (Agronomy) received Associate Fellow of Andhra Pradesh Academy of Sciences (APAS) in 2021.

8.3 Chief Editor/ Editor of NAAS rated Journals

Dr. K. Sammi Reddy, Head, Division of Resource Management (DRM), is the Editor for the Journal of Research ANGRAU, Guntur, Andhra Pradesh and for the Journal of the Indian Society of Soil Science (JISSS), New Delhi.

Dr. R. Rejani, Principal Scientist (Soil & Water Conservation Engineering) is the Editor for the Indian Journal of Soil Conservation, (IASWC), Dehradun.

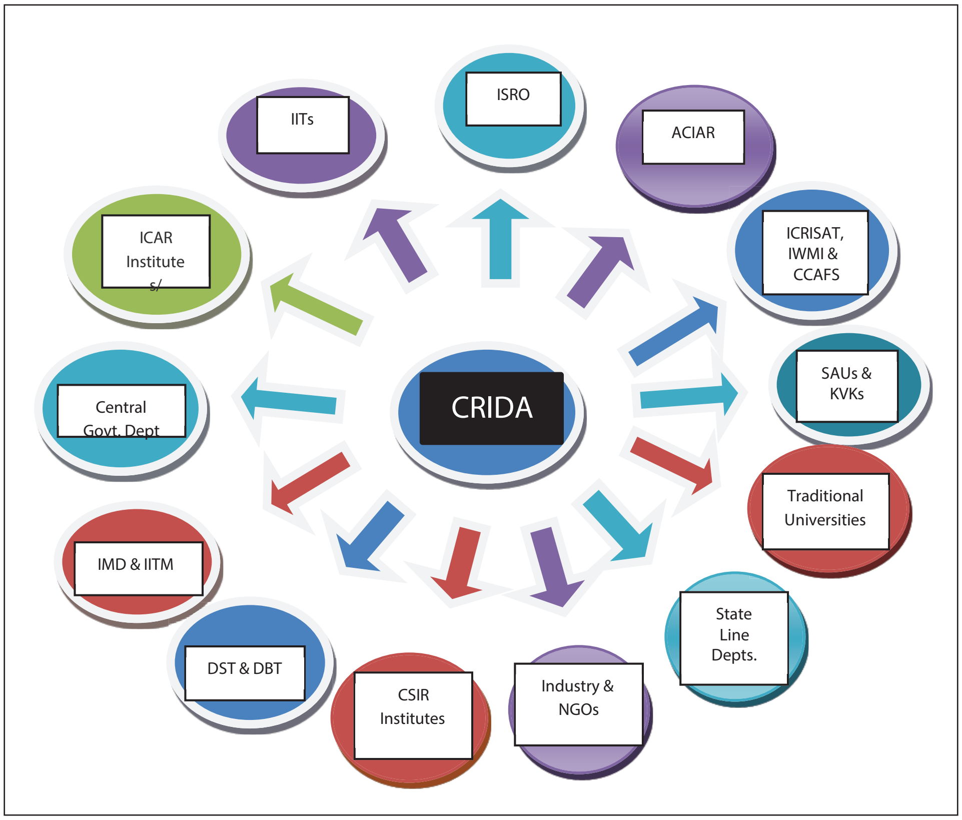
Dr. A.K. Shanker, Principal Scientist (Plant Physiology) is the Academic Editor of Plos One, Scientific Reports, Plant Physiology Reports and is the in the Editorial Board of Environmental and Experimental Botany.

All India Coordinated Research Project on Dryland Agriculture (AICRPDA) received **ICAR-Chaudhary Devilal Outstanding AICRP Award – 2020.**

AICRPDA cooperating center Indore received **ICAR - Vasantarao Naik Award for outstanding research applications in dryland farming systems – 2020.**

Linkage and Collaborations 9

ICAR-CRIDA continually endeavours to explore new linkages with stakeholders while renewing and strengthening old ones. ICAR-CRIDA promotes action oriented research in public-private partnership mode through a consortium approach. It has strong collaboration with International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), International Livestock Research Institute (ILRI), International Water Management Institute (IWMI), Indian Institute of Tropical Meteorology (IITM), Prof. Jayashankar Telangana State Agricultural University (PJTSAU) and other State Agricultural Universities (SAUs), Jawaharlal Nehru Technological University (JNTU), Osmania University and other Universities and Non-Governmental organizations (NGOs) for developing and refining technologies for improving profitability in rainfed agriculture. ICAR-CRIDA also plays a role in advising agencies such as central/state line departments in formulating science based policies on rainfed agriculture. The Institute undertakes specific basic, applied, strategic and anticipatory research programmes in fulfilling mandates of both itself and donor agencies. The partners in this mode include Council of Scientific and Industrial Research (CSIR), Department of Biotechnology (DBT), Department of Science and Technology (DST), Indian Institute of Technology (IITs) and the Govt. of Telangana. ICAR-CRIDA also takes up consultancy programmes for specific tasks from different institutes/organizations. ICAR-CRIDA takes inputs from India Meteorological department (IMD) and National Centre for Medium Range Weather Forecasting (NCMRWF) and generates value added outputs for the benefit of the rainfed farmers.



Linkages and Co- operations of ICAR- CRIDA

Publications 10

10.1. Research papers

Bal, S.K., Dhakar, R., Mishra, A., Vijaya Kumar, P. Sandeep, V.M. Pramod V.P., Sarath Chandran, M.A., Subba Rao, A.V.M, Gill K.K. and Rajendra Prasad. 2021. Developing frost prediction models using multivariate statistical techniques for two diverse locations of Northern India. *Theoretical and Applied Climatology*. 146: 1097-1110.

Bal, S.K., Wakchaure, G.C., Potekar, S., Choudhury, B.U., Choudhary, R.L. and Sahoo, R.N., 2021. Spectral signature-based water stress characterization and prediction of wheat yield under varied irrigation and plant bio-regulator management practices. *Journal of the Indian Society of Remote Sensing*, 49(6), pp.1427-1438.

Bal, S.K., Rao, K.V., Sarath Chandran, M.A., Sasmal S. and Singh, V.K. 2021. Weather forecast, agriculture contingency plan and agromet advisory services for climate resilient agriculture. *Indian Journal of Agronomy*, 66 (5th IAC Special issue): S1-S14.

Banerjee, P., Mukherjee, B., Venugopalan, V. K., Nath, R., Chandran, M. A. S., Dessoky, E. S., Ismail, I. A., El-Hallous, E. I., Hossain A. 2021.Thermal response of spring–summer-grown black gram (*Vigna mungo* L. Hepper) in Indian subtropics. *Atmosphere*. 12(11):1489.

Bhokre, S. M., Rajanna, N., Sarat Chandra, A., Nagalakshmi, D., Ramana, D.B.V., and Sashi Kumar, M. 2021. Effect of Inclusion of *Moringa Oleifera* leaf meal on the growth performance, nutrient digestibility and carcass characteristics of Deccani lambs. *Asian Journal of Dairy and Food Research*. https://**doi.**10.18805/ajdfr.DR-1686

Bidhubhusan Mahapatra, Monika Walia, Chitiprolu Anantha Rama Rao, Bellapukonda Murali Krishna Raju, Niranjan Saggurti. 2021.Vulnerability of agriculture to climate change increases the risk of child malnutrition: Evidence from a large-scale observational study in India. *PLOS ONE*. https://doi.org/10.1371/journal.pibe,0253637, June 28, 2021

Chandana P., Madhavi Lata A., Prasad J.V.N.S., and Aariff Khan MA. 2021. Greenhouse gas emissions from integrated nutrient management practices in pear millet + *Melia dubia* agri-silvi system. *Current Science*. 121 (5): 704-708.

Chandran, M. A., Banerjee, S., Mukherjee, A., Nanda, M. K., Mondal, S. and Kumari, V. 2021. Evaluating the impact of projected climate on rice–wheat-groundnut cropping sequence in lower Gangetic plains of India: A study using multiple GCMs, DSSAT model, and long-term sequence analysis. *Theoretical and Applied Climatology*. 145: 1243-1258.

Ravindra Charry, G., Gopinath,, K.A., Ratna Kumar, P., Bhaskar, S. Singh, V.K., Deepika, S., Visha Kumari, V., Sridhar, K.B., Narsimlu, B., Raj Kumar and Abdul Rasul., 2021. Management of major abiotic stresses in field crops. *Indian Journal of Agronomy*. 66 (5th IAC Speial issue) 66, 258–278.

Fand, V.S, Nagrare, B.B., Bal, S.K., Naik, V.C.B., Naikwadi, B.V., Mahule, Nandini, D., Gokte-Narkhedkar and Waghmare, V.N. 2021. Degree day-based model predicts pink bollworm phenology across geographical locations of subtropics and semi-arid tropics of India. *Scientific Reports,* 11(1): 1-18.

Girija Veni, V. 2021 Co-application of rock phosphate and zeolite can mitigate phosphorus deficiency in soils. *Acta Scientific Agriculture*, 5 (10): 27

Indoria, A. K., Siyag, R. S., Sammi Reddy, K., Srinivas, K. and Sharma, K. L. 2021. Quantitative assessment of nickel phytoremediation potential of some Brassica species in nickel enriched soil as influenced by organic amendments. *International Journal of Chemical Studies,* 9(1): 3690-3696.

Jagriti Rohit, G Nirmala, Anshida Beevi, K Ravi Shankar, K Nagasree, P.K. Pankaj, K. Sindhu and V.K. Singh. 2021. Structural analysis of social network among farmers for information acquisition in rainfed Areas: A study on farmers' information acquisition

dynamics. *Indian Journal of Extension Education*, 57(1): 1-6.

Kakde, N.A., Manjunath, M., Hanwate, G.R. and Gourkhede, P.H. 2020. Influence of microbial consortia on yield of *kharif* sorghum (*Sorghum bicolor* L.) and soil Parameters under rainfed conditions. *Indian Journal of Dryland Agricultural Research and Development*. 35(2): 54-56.

Maheswari M., Varalaxmi Y., Sarkar B., Ravikumar N., Vanaja M. Yadav S.K., Jyothi Lakshmi N., Vijaya Lakshmi T., Savita S.K., Srinivasa Rao M., Shankar A.K., Mohapatra T. 2021. Tolerance mechanisms in maize identified through phenotyping and transcriptome analysis in response to water deficit stress. *Physiology and Molecular Biology of Plants* 27(6):1377–1394.

Manimanjari, D. and M Srinivasa Rao. 2021. Host – mediated effects of elevated CO_2 on the performance of *Spodoptera litura* Hub. feeding on sunflower (*Helianthus annuus* L.) *Phytoparasitica (*Springer Nature) 2021,1-15.

Maruthi, V., Reddy, K.S., Pankaj, P.K., Reddy, A.G.K., Srikrishna, G. and Vidya Sekhar, S.M. 2021. Off-season short-duration leafy coriander (*Coriandrum sativum*) with peri-urban market linkage model for small holders in drylands, *Current Science*, 120(3): 461-463.

Miles W. Ingwers, Clinton J. Steketee, Sushil K. Yadav and Zenglu Li. 2021. Relationships among carbon isotope composition, growth, and foliar nitrogen in soybean, *Journal of Crop Improvement*. DOI: 10.1080/15427528.2021.1910092

Muralikrishnan, L., Manikandan, N., Prasanth Tej Kumar, J., Yumnam, A., Seyie, A., Tomar, M. and Venkatesh, P. 2021. Participatory GIS (PGIS) Approach for the development of community-based climate smart sustainable agriculture models in the semiarid regions of southern India. *Current J. Applied Science and Technology*, 40(5): 1-13.

Nagarjuna Kumar, R., Rama Rao, C.A., Raju, B.M.K., Samuel, Josily, Nirmala, G. and Sailaja, B. 2021. Monitoring and evaluation using digital tools. *International Journal of Agricultural Science* 17 (2): 765-774.

Nagarjuna Kumar, R., Rama Rao, C.A., Raju, B.M.K., Srinivasa Rao, M., Sailaja, B. 2021. AI and IOT in smart farming. *Agro Science Today*. Vol.2., Issue 7, July 31, 2021. Pp. 0185-0188

Nagesh Kumar, M.V., Ramya, V., Govindaraj, M., Sameer Kumar, C.V., Maheswaramma, S., Seshu, G., Prabhakar, M., Krishna, H., Sridhar, M., Venkata ramana, M., Avil Kumar, K. and Jagadeeswar, R., 2021. Harnessing sorghum landraces to breed high-yielding, grain mold-tolerant cultivars with high protein for drought-prone environments. *Frontiers in Plant Science*. doi.10.3389/fpls.2021.659874.

Prabhakar, M. and Thirupathi, M. 2021. Remote sensing for pest damage: Present status and potential application – case studies from India. *The J. Res. PJTSAU.* 49(3) 1-15.

Prabhakar, M., Gopinath, K.A., Ravi Kumar, N., Thirupathi, M., Sai Sravan, U., Sravan Kumar, G., Samba Siva, G., Meghalakshmi, Guddad and Vennila, S. 2021. Detecting the invasive fall armyworm pest incidence in farm fields of southern India using Sentinel-2A satellite data. *Geocarto International*. https://doi.org/10.1080/10106049.2020.1869330.

Prasad, T.V., Srinivasa Rao, M., Rao, K.V., Bal, S.K., Muttapa, Y., Choudhary, J.S., Singh, V.K. 2021. Temperature-based phenology model for predicting the present and future establishment and distribution of recently invasive *Spodoptera frugiperda* (J. E. Smith) in India. *Bulletin of Entomological Research.* 1–15.

Prasad, Y.G., Gayathri, M., Sailaja, V., Prabhakar, M., Ramachandra Rao, G., Rekha G. and Vennila, S. 2021. Evaluation of linear and nonlinear models for temperature driven development of *Spodoptera litura* (Fabricius) on soybean crop. *Journal of Agrometeorology*. 23 (2): 1-2.

Pratibha, G., Hati, K.M., Mishra, J.S., Sharma, K.L., Srinivas, K., Prasad, J.V.N.S., Kundu, S., Indoria, A.K., Rao, K.V., Srinivas, I., Srinivas Rao, M., Desai, S., Manjunath, M., Sammi Reddy, K., Raju, B.M.K., Somasundaram J., Vishwakarma, A.K., Choudhary, R.S., Jha, P., Singh, R.K., Mudalagiriyappa, Patode, R., Arunakumari, H., Biswas, A.K., Patra, A.K., and

Chaudhari, S.K. 2021. India's Consortium Research Platform on Conservation Agriculture: Recent advancements and lessons learnt in rainfed semi-arid ecologies. *Journal of Agricultural Physics.* 21(1):85-112.

Pratibha. G, Rao, K. V., Srinivas, I., Raju, B. M.K. Arun K. Shanker, Madhavi, M. Indoria, A. K., Srinivasa Rao, M., Keshava Murthy, Sammi Reddy, K., Srinivas Rao, Ch. Biswas, A. K. and Chaudhari, S.K. 2021. Weed shift and community diversity in conservation and conventional agriculture systems in pigeon pea-castor systems under rainfed semi-arid tropics. *Soil & Tillage Research* 212:105075. https://doi.org/10.1016/j.still.2021.105075

Purabi Banerjee., Ananya Ghosh., Visha Kumari, V and Rajib Nath. 2021. Effect of canopy temperature on physiological processes of grass pea as influenced by seed priming and foliar fertilization. *Journal of Agrometeorology.* 23(3): 340-343.

Purabi Banerjee., Visha Kumari, V., Rajib Nath., Yusuf, S., Althobaiti., Ahmed Gaber., Hatim Al-Yasi and Akbar Hossain. 2021. Physiology, growth and productivity of spring-summer black gram (*Vigna Mungo L. Hepper*) as influenced by heat and moisture stresses in different dates of sowing and nutrient management conditions. *Agronomy.* 11: 2329.

Pushpanjali, Josily Samuel, Rama Rao, C.A, Raju B.M.K. 2021. Spatial estimation and climate projected change of cover-management factor in semi-arid region of India, *Indian Journal of Agricultural Sciences.* 91 (4), 521-525.

Pushpanjali, Samuel, J., Sharma, K.L., Pankaj, P.K., Karthikeyan, K. and Sammi Reddy, K. 2021. Evaluation of RISAT-1 data for soil moisture retrieval in semi-arid tropics of India. *Indian Journal of Agricultural Sciences.* 91(12), 1753-1757.

Raj Kiran, B; B. Sanjeeva Reddy, C. Ramana, H.V. and Hema Kumar, Y. Bindiya and B. Hari Babu. 2021. Selection of dibble radius in automatic dibble type vegetable transplanter based on zero velocity condition in planting. *The Pharma Innovation Journal.* 10(5): 1507-1513

Ramavath Priyanka, A. Gopala Krishna Reddy, Veena Joshi and M. Sreedhar.2021. Effect of organic and inorganic sources of nutrients on shelf life and yield attributes of guava cv. Allahabad safeda. *International Journal of Current Microbiology and Applied Sciences*, 10(06): 91-96.

Ravi Kumar, N., Desai, S, Ravi Shankar, H., Gopinath, K.A., Prabhakar, M., Srinivas, K., Jyothilakshmi, N. and Singh, V.K. 2021. Artificial intelligence in delivery of improved agronomic technologies. *Indian Journal of Agronomy*, 66 (5th IAC Special issue): 226-236.

Razia Sultana Janampet, Sarat Chandra Amaravadhi, Ramana, D.B.V., Raghunandan Thirunahari, Gnana Prakash Manthani and Venkateswarlu Malisetty. 2021. Effect of dietary chromium, vitamin E and selenium supplementation on growth performance and cost economics of Holstein Friesian calves under heat stress. *Journal of Animal Research*,11 (3):387-392

Reddy, A.A., Bhattacharya, A., Reddy, S.V and Ricart S. 2021. Farmers' Distress Index: An Approach for an Action Plan to Reduce Vulnerability in the Drylands of India, Land 10 (11), 1236: 1-24.https://doi.org/10.3390/land10111236

Reddy, A A. and Singh, V. 2021. Do Parents' Education Predict Child Education and Occupation?, IASSI Quarterly 40 (4): 644-663.

Reddy, A. A., Singha Roy, N., and Pradeep, D. 2021. Has India's Employment Guarantee Program Achieved Intended Targets?. Sage Open, 11(4): 1-19. https://doi.org/10.1177/21582440211052281

Reddy, A. A., Surabhi M., Singha Roy N, and Sanghamitra Kanjilal-Bhaduri. 2021. "Time Allocation between Paid and Unpaid Work among Men and Women: An Empirical Study of Indian Villages" Sustainability 13(5): 2671: 1-17. https://doi.org/10.3390/su13052671

Reddy P. Baswa, Ramana D.B.V, Naveena, B.M. and Sen, A.R.2021. Effect of dietary supplementation of different levels of zinc on feed intake, growth performance, carcass characteristics and physical quality of meat in sheep, *Journal of Meat Science*, 15(1):45-49

Sammi Reddy, K., Kundu, S., Arunakumari, H. and

Sharma, K L. (2021). Potential nutrient stock and emission of greenhouse gases from soil due to application of organic amendments in India. *Agriculture Research Journal* 58 (2): 169-182, DOI No. 10.5958/2395-146X.2021.00027.2.

Sammi Reddy, K., Pratibha, G., Sharma, K. L., Srinivas, K., Indoria, A. K., Kundu, S., Prasad, J. V. N. S., Gopinath, K. A. and Singh, V. K. 2021. Conservation agriculture in dryland ecosystem: Prospects and opportunities. *Indian Journal of Agronomy.* Special Issue 66: S44-S56.

Sammi Reddy, K., Srinivasarao, C., Girija Veni, V., Prasad, J. V. N. S., Sharma, K. L., Sumanta, K. and Singh, A. K. 2021. Mitigation strategies to enhance carbon sink potential in climate vulnerable districts of Eastern India. *Climate and Development*, *13*(4): 360-373.

Santhoshini Chinta, Satyanarayana, CH, Srinivasa Reddy, M, Raghunandan, T and Ramana, D.B.V. 2021. Dairy farmers' knowledge on climate variability in Southern Telangana Zone. *The Pharma Innovation Journal*, 10(1): 237-239

Seethalam, M., Kiran Gandhi, B., Murari Kumar., Shabistana Nisa., Puran Chandra., Prabhakar, M. and Vennila, S. 2021. Characetization of Helicoverpa armigera spatial distribution in pigeonpea crop using geostatistical methods. *Pest Management Science*. DOI 10.1002/ps.6536.

Shankar, K. R., Nagasree, K., Nirmala, G., Rao, C. A. R., Raju, B. M. K., Beevi, C. N. A., Rohit, J., Pankaj, P. K., Ramana, D. B. V., Srinivas, I., Kumar, S. V., Sindhu, K. and Rao, C. S. 2020. Farmers' perceptions, attitudes and adaptions towards climate change in selected semi-arid districts of India: Implications from an adaptation view. *Current Journal of Applied Science and Technology,* 39(48): 379-395.

Sharma, K. L., Indoria, A. K., Sammi Reddy, K. and Singh, V. K. 2021. Role of conservation agriculture in improving soil health and crop productivity amidst the threats of climate change in rainfed areas. *Indian Journal of Fertilizers* 17(6): 524-539.

Sharma, K. L., Sammi Reddy, K., Ravindra Chary, G., Singh, V. K., Lal, M., Chandrashekar, Ch., Indoria, A. K., Asewar, B. V., Gore, A. K., Gaikwad, G. K. and Gayatri, D. L. A. 2021.Effect of integrated nutrient management (INM) practices on soil quality indicators and indices under sorghum (Sorghum bicolor L (Moench) + pigeon pea (*Cajanus cajan* L. Millsp.) (4:2) and soybean (Glycine max L. Merr) + pigeaon pea (*Cajanus cajan* (L.) Millsp.) in rainfed Vertisols of western India. *Annals of Plant and Soil Research.* 23(4): 379-389.

Sharma, K.L., Munna Lal., Sammi Reddy, K., Indoria, A.K., Chandra Sekhar, Ch., Srinivas, K., Prabhakar, M., Singh, V.K., Brajendra Parmar. and Gayatri, DLA. 2021. Effect of different levels of surface application of sorghum residue under minimum tillage on crop yields and sustainable yield index of Sorghum (*Sorghum bicolor* (L.) Modench) and cowpea (*Vigna unguiculata* (L.) Walp) and nutrient status in rainfed alfisol soils. *Communications in Soil Science and Plant Analysis*. https://doi.org/10.1080/00103624.2021.1993883.

Shruthi Reddy L., Gopala Krishna Reddy A., Vanaja M., Maruthi V. and Vanaja Latha K. 2021. Elevated carbon dioxide and temperature effects on rooting behaviour of grape cuttings. *Journal of Agrometeorology* 23 (3): 257-264.

Singh, N.P., Anand, B., Singh, S.K. Srivastava, Ch. Srinivasa Rao, K.V. Rao, S.K. Bal. 2021. Synergies and trade-offs for climate-resilient agriculture in India: an agro-climatic zone assessment. *Climatic Change.* 164: 11. https://doi.org/10.1007/s10584-021-02969-6

Singh, V.K., Kiran, B.V.S., Pradeep, C.M. and Prasad, J.V.N.S. 2021. Agronomic innovations for climate change adaptation and mitigation. *Indian Journal of Agronomy* 66: 16-31.

Singh, H., Kaur, P., Choudhury, B.U. and S.K. Bal 2021. Effect of elevated temperature on Mung bean [*Vigna radiata* (I). Wilczek] under temperature gradient tunnel environment in Indian Punjab. *Journal of Agrometeorology,* 23(1): 3-13. https://doi.org/10.54386/jam.v23i1.82

Sinha, N.K., Mohanty, M., Somasundaram, J., Chaudhary, R.S., Patra, H., Hati, K.M., Singh, R.P., Thakur, J.K., Kumar, J., Kumar, D. and Rani, A., 2021.

Maize productivity analysis in response to climate change under different nitrogen management strategies. *Journal of Agrometeorology*, 23(3): 279-285.

Sravan Kumar D.V., P. V. Krishnayya, M. Srinivasa Rao, P. Anil Kumar and V. Srinivasa Rao 2021. Impact of elevated CO_2 and temperature on growth and development of *Helicoverpa armigera* Hubner. *Journal of Experimental Agriculture International.* 43(3): 42-54.

Srinivasa Rao M, Rama Rao CA, Sreelakshmi P, Islam Adlul ,SubbaRao AVM, Ravindra Chary G and Bhaskar S.2020.Pest scenario of Spodopteralitura (Fab.) on groundnut under Representative Concentration Pathways (RCPs) based climate change scenarios. *Journal of Thermal Biology*. 94 (2020) 102749. https://doi.org/10.1016/j.jtherbio.2020.102749

Srinivasa Rao M., Sreelakshmi P., Deekshita K., Vanaja M., Srinivas I., Maheswari M., Srinivas K., Sammi Reddy K., Bhaskar S. and Ravindra Chary G. 2021. Interactive effects of temperature and CO_2 on efficacy of insecticides against *Spodoptera litura* Fab. in a global warming context. *Phytoparasitica* 49(3): 417-431. https://doi.org/10.1007/s12600-020-00854-z

Srinivasarao, Ch., Rakesh, S., Ranjith Kumar, G., Manasa, R., Somashekar, G., Subha Lakshmi, C. and Kundu, S. 2021. Soil degradation challenges for sustainable agriculture in Tropical India. *Current Science*, 120: (3): 492-500.

Srinivasarao, Ch., Singh, S. P., Kundu, S., Abrol, V., Lal, R., Abhilash, P. C., Chary, G. R., Thakur, P.B., Prasad, J. V. N. S., Venkateswarlu, B. 2021. Integrated nutrient management improves soil organic matter and agronomic sustainability of semiarid rainfed Inceptisols of the Indo-Gangetic Plains. *Journal of Plant Nutrition and Soil Science*. 2021; 1–11.

Srinivasarao, Ch., Subha Lakshmi, C., Kundu, S., Ranjith Kumar, G., Somashekar, G., Manasa, R., Prasad, J.V.N.S., Narayanaswamy, G., Krishnan, P., Sivaramane, N., Mrunalini, K., Pratibha, G. 2021. Indigenous technical knowledge for enhanced agronomic productivity and soil health of small holder farmers in Tropical India. *Climate Change and Environmental Sustainability*, 9(1):1-13.

Sumalatha, J., Uma Maheswar, T., Ramana, D. B. V., Sheshu Madha, M and Padmavathi, Ch. 2021. Characterization of resistance to leaf folder, *Cnaphalocrocis medinalis* (Lepidoptera:Crambidae) in mutant sources of rice. *Entomologia Experimentalis et Applicata*, 169 (9):859-875.

Venkataravanappa, V., Kodandaram M.H., Manjunath, M., Chauhan N.S., Nagendran, K., Tiwari, S.K., Sarkar, B. and Rao, G.P. 2021. Molecular characterization of phytoplasma strains associated with brinjal little leaf and screening of cultivated and wild relatives of eggplant cultivars for disease resistance. *European Journal of Plant Pathology*. https://doi.org/10.1007/s10658-021-02414-5

Vennila, S., Nisar, S., Islam, A., Bhat, M.N., Sharma S., Sarao P.S., Anandhi, P., Rao, M.S., and Prabhakar, M. 2021. Future scenarios of rice brown plant hopper *Nilaparvata lugens (Stal.)* under changing climate. *Journal of Agrometeorology*, 23 (1): 74-81.

Vijaya Kumar, P., Bal, S.K., Dhakar, R., Sarath Chandran, M.A., Subba Rao, A.V.M., Sandeep, V.M., Pramod, V.P., Malleswari, S.N., Sudhakar, G., Solanki, N.S. and Shivaramu, H.S., 2021. Algorithms for weather-based management decisions in major rainfed crops of India: Validation using data from multi-location field experiments. *Agronomy Journal*, *113*(2): 1816-1830.

Visha Kumari, V., Nath, R., Sengupta, K., Nalia, A., Banerjee, S., Sarath Chandran, M.A., İbrahimova, U., Dessoky, E.S., Attia, A.O., Hassan, M. and Hossain, A. 2021. The response of Lentil (*Lens culinaris* Medik.) to soil moisture and heat stress under different dates of sowing and foliar application of micronutrients. *Frontiers in Plant Science.* 10: 679469.

Visha Kumari, V., Rajib Nath., Kajal Sengupta., Saon Banerjee., Debjani Dutta and Snehashis Karmakar. 2021. Effect of date of sowing and foliar spray of micronutrients on growth, phenology, yield and seed quality of Lentil (Lens culinaris) in New Alluvial Zone of West Bengal. *The Indian Journal of Agricultural Sciences.* 91(4): 573-6.

Visha Kumari, V., Roy, A., Vijayan, R., Banerjee, P., Verma, V.C., Nalia, A., Pramanik, M., Mukherjee, B., Ghosh, A., Reja, M. and Chandran, M.A.S. 2021.

Drought and heat stress in cool-season food legumes in sub-tropical regions: Consequences, adaptation, and mitigation strategies. *Plants.* 10(6):1038.

Yella Swami, C; Senthil Kumaran, G; Naik R.K; Reddy B.S; and Rathina Kumari, A.C. 2021 Physio-morphological and mechanical properties of chillies for mechanical harvesting. *Journal of Horticultural Sciences,* 16(2): 277-285.

10.2. Books / reports

Nirmala, G., Renuka., Pankaj., P.K., Ravi Sankar, K., Nagarjuna Kumar,R., Jagruthi Rohit, Anshida Beevi, CN. 2021. E-book of tools on monitoring, evaluation and impact assessment of rainfed agricultural programs an immediate outcome of training program which is jointly organized ICAR- Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad and MANAGE Hyderabad during 14-16,December 2021.

Prabhat Kumar Pankaj, R. Pourouchottamane and B. Rai. 2021. Scientific pig production and management: A Bio-Treasure for rural society. Satish Serial Publishing House, New Delhi, Pp-387. (ISBN-10:β 9390425077; ISBN-13: 978-9390425075).

Prabhat Kumar Pankaj, Shahaji Phand, G. Nirmala, R. Nagarjuna Kumar, Pushpanjali. 2021. Climate resilient animal husbandry. ICAR-Central Research Institute for Dryland Agriculture, Hyderabad & National Institute of Agricultural Extension Management (MANAGE), Hyderabad, India. Pp-137. (ISBN: 978-93-91668-18-1).

Raju, B.M.K., Josily Samuel, Jagriti Rohit, Anshida Beevi, C.N., Rama Rao, C.A., Prasad, J.V.N.S., Prabhakar, M., Ravindra Chary, G., Singh, V.K., Bhaskar, S. and Chaudhari, S.K. 2021. Mainstreaming climate resilient agriculture technologies into national schemes and development programmes: Scope and Opportunities. NICRA, ICAR-CRIDA, Hyderabad, P.110, ISBN: 978-93-80883-68-8

Rama Rao, C.A., Raju, B.M.K., Islam, A., Subba Rao, A.V.M., Rao, K.V., Ravindra Chary, G., Nagarjuna Kumar, R., Prahakar, M., Sammi Reddy, K., Singh, V.K., Bhaskar, S. and Chaudhari, S.K. 2021. District level risk and vulnerability of Indian agriculture future climate change. Policy Brief. NICRA, ICAR-Central Research Institute for Dryland Agriculture, Hyderabad, 6 p.

Ravindra Chary, G., Gopinath, K.A., Bhaskar, S., Prabhakar, M., Chaudhari, S.K. and Narsimlu, B. (Eds.). 2020. Resilient crops and cropping systems to cope with weather aberrations in rainfed agriculture. All India Coordinated Research Project for Dryland Agriculture (AICRPDA), ICAR-Central Research Institute for Dryland Agriculture, Hyderabad-500 059. 56p

Sattar, M. Kumar, N.K. Singh, R.K. Jha, Gulab Singh and S.K. Bal 2021. Agroclimatic Atlas of Bar, RPCAU Pusa, Bihar, pp.194 .

10.3. Book chapters

Koushik Banerjee S.K. Bal, Debasish Chakraborty, S. Malleswari, Arghya Banerjee and Rahul Sadhukhan 2021. Crop Calendars and Advances in Agriculture Insurance Products in India. In: Ch. Srinivasarao et al., (Eds). Agricultural Research, Technology and Policy: Innovations and Advances, ICAR-National Academy of Agricultural Research Management (NAARM), Hyderabad, Telangana, India, pp79-100.

Reddy K.S., Vanaja M., Maruthi V., Saikrishna T. 2021. SCADA based rainfall simulation and precision lysimeters with open top climate chambers for assessing climate change impacts on resource losses in Semi-arid Regions. In: Pandey A., Mishra S., Kansal M., Singh R., Singh V.P. (eds) *Hydrological Extremes*. Water Science and Technology Library, vol 97. Springer, Cham. https://doi.org/10.1007/978-3-030-59148-9_30. Pp 435-446.

Kumar, S., Natta, S and Yadav, SK. 2021. Advances in plant biochemistry for food quality and nutrition. In: Ch. Srinivasarao et al., (Eds). Agricultural Research, Technology and Policy: Innovations and Advances, ICAR-National Academy of Agricultural Research Management (NAARM), Hyderabad, Telangana, India, pp79-100. ISBN no: 978-93-5526-149-6

Maruthi,V. Reddy, K.S. and Pushpanjali. 2021. Fodder production models for improved livestock management In Ed. Pankaj et al., “Climate Resilient Animal husbandry” Printed E-book by ICAR-CRIDA and MANAGE. ISBN: 978-93-91668-18-1.

Prabhakar, M., 2021. *Livestock specific achievements* under NICRA. In: Climate Resilient Animal Husbandry. An overview of national innovations in climate resilient agriculture (Ed: Pankaj P.K., Shahaji Phand., Nirmala, G., Nagarjuna Kumar, R., and Pushpanjali, ICAR, CRIDA, Hyd, pp 6- ISBN: 978-93-91668-18-1.

Reddy, K. Sreenivas, Maruthi, V.,and and Pankaj Prabhat Kumar 2021. 'Bio-Industrial Watershed Model: A Climate Resilient Unit for Sustainable Production and Profitability in Semi-Arid Tropical Regions of India', in Goyal R.K. & Gaur, Mahesh, K. (Eds.) *Perspectives in Natural Resources Management-Watershed-based Approach.* Central West Publications, New South Wales, 2800 Australia, pp. 93-114.

Pankaj, Prabhat Kumar, Reddy, K. Sreenivas, Maruthi, V., & Nirmala, G. 2021. 'Livestock-based Diversification in Watershed for Sustainability in Drylands', in Goyal R.K. & Gaur, Mahesh, K. (Eds.) *Perspectives in Natural Resources Management-Watershed-based Approach.* Central West Publications, New South Wales, 2800 Australia, pp. 157-186.

Srinivasarao, Ch., Kundu, S., Rakesh, S., Subha Lakshmi, C., Ranjith, G., Narayan Swamy, G., Mrunalini, K., Somasundaram, J. and Mohanty, M., Venkatesh, G., Pratibha, G. and Prasad, J.V.N.S. 2021. Managing Soil Organic Matter under Dryland Farming Systems for Climate Change Adaptation and Sustaining Agriculture Productivity. In: Soil Organic Carbon and Feeding the Future: Basic Soil Processes. Advances in Soil Science (Ed. Rattan Lal). CRC Press, Taylor and Francis Group, Boca Raton, FL. pp. 219-251. DOI: 10.1201/9781003243090-10.

Das Abinash, Mishra, R., Khushboo Rani, Kundu, S., Somasundaram, J. and Srinivasarao, Ch. 2021. Improving nutrient use efficiency: Research, technology and policy, In: Ch. Srinivasarao *et al.*, (Eds). Agricultural Research, Technology and Policy: Innovations and Advances, ICAR-National Academy of Agricultural Research Management, Hyderabad, Telangana, India. pp.

Sharma, K. L., Sammi Reddy, K., Srinivas, K., Maheshwari, M., Indoria, A. K., Prabhakar, M., Osman, M., Munna Lal and Gayatri, D. L. A. 2021. Conservation agriculture and soil health management – Long-term Experiences in Rainfed Agriculture. ICAR-Central Research Institute for Dryland Agriculture, Hyderabad, India. Pp. 1-214.

Sammi Reddy, K., Srinivasamurthy, C. A. and Subba Rao, A. 2019. Determination of phosphorus in soil. In: Soil Analysis (Singh, S. K., Biswas, D. R., Srinivasamurthy, C. A., Datta, S. P., Jayasree, G., Jha, P., Sharma, S. K., Katkar, R. N., Raverkar, K. P. and Ghosh, A. K. Eds). Indian Society of Soil Science, New Delhi. Pp. 151-173.

Rao, D. L. N., Dey, P. and Sammi Reddy, K. 2021. Plant demand adapted fertilization in organic and precision farming. In: Soil and Recycling Management in the Anthropocene Era (Gero Benckiser, Eds). Springer Nature, Switzerland AG. Pp. 137-166

Abhishek Patel, Kethavath Ajay Kumar, Manoranjan Kumar, K V Rao and Ch. Srinivasa Rao 2021. "Sustainable land and water management for reducing soil erosion in tropical India" In book: Agricultural Research, Technology and Policy: Innovations and Advances (pp.333-347). Publisher: National Academy of Agricultural Research Management

Rama Rao, C.A. 2021. Vulnerability and risk assessment of climate change for animal husbandry. Climate Resilient Animal Husbandry (Eds. Drs. Prabhat Kumar Pankaj, ShahajiPhand, G. Nirmala, R. Nagarjuna Kumar, Ms. Pushpanjali), Edition 2021, ICAR-CRIDA and MANAGE, Hyderabad, pp.17-22

Prabhat Kumar Pankaj, D.B.V.Ramana. R. Nagarjuna Kumar. 2021. Contingency plan for livestock and poultry in India in E-book of Climate Resilient Animal Husbandry an immediate outcome of training program which is jointly organized ICAR- Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad and MANAGE, Hyderabad during 18-21 August,2021, ISBN: 978-93-91668-18-1, pp 82-94.

Nagarjuna Kumar.,R, Rama Rao, C.A., Raju., B.M.K., Nirmala, G and Sailaja.,B. 2021. Impact Assessment of Use of Digital Tools in Extension : Case Studies -Review in Compendium of Lectures of Online Training Programme of ICAR-CRIDA & MANAGE, Hyderabad on "Tools on Monitoring, Evaluation and impact assessment of Rainfed Agricultural Programs"

during 14-16,December 2021.12p.

Raju.,B.M.K,, Rama Rao, C.A, Nagarjuna Kumar., R. 2021. Statistical tools for impact assessment and evaluation in Compendium of Lectures of Online Training Programme of ICAR-CRIDA & MANAGE, Hyderabad on "Tools on Monitoring, Evaluation and impact assessment of Rainfed Agricultural Programs" during 14-16,December 2021.7p.

Pankaj, Prabhat Kumar, Reddy, K. Sreenivas, Maruthi, V., & Nirmala, G. 2021. 'Livestock-based Diversification in Watershed for Sustainability in Drylands', in Goyal R.K. & Gaur, Mahesh, K. (Eds.) Perspectives in Natural Resources Management-Watershed-based Approach. Central West Publications, New South Wales, 2800 Australia, pp. 157-186. (ISBN-13: 978-1925823943)

Reddy, K. Sreenivas, Maruthi, V., and Pankaj Prabhat Kumar 2021. 'Bio-Industrial Watershed Model: A Climate Resilient Unit for Sustainable Production and Profitability in Semi-Arid Tropical Regions of India', in Goyal R.K. & Gaur, Mahesh, K. (Eds.) Perspectives in Natural Resources Management-Watershed-based Approach. Central West Publications, New South Wales, 2800 Australia, pp. 93-114. (ISBN-13: 978-1925823943)

Shahaji Phand and Prabhat Kumar Pankaj. 2021. Climate-Resilient Livestock Farming to Ensure Food and Nutritional Security. In Climate Change and Resilient Food Systems, Issues, Challenges, and Way Forward. Springer Nature Singapore, Pp-381-398. DOI: https://doi.org/10.1007/978-981-33-4538-6_15. (ISBN 978-981-33-4537-9).

Baswa Reddy, P. P.K. Pankaj and D.B.V. Ramana. 2021. Climate smart feeding of small ruminants. (*In Eds* Kandeepan *et al*) Climate Smart Technologies for Food Animal Production and Products. Pp-72-80. (ISBN: 978-93-5473-922-4).

Maruthi, V., Reddy, K.S., Pankaj, P.K., Srinivas, K., Vidyasekhar, S.M. and Srikrishna, G. 2021. Indeterminate pigeonpea: An ideal leguminous crop for rainfed cropping systems. *Sustainable production of pulses in diverse agro-ecosystems*. Pp-101-110.

Nirmala. G, Prabhat K Pankaj, Sanjeev Reddy. B, Ravi Shanker K, Jagriti Rohit and Anshida Beevi. 2021. Technological empowerment of women in agriculture and livestock management by mitigation of drudgery. Eds Anitha Kumari P,Letha Devi G, Ashaletha S, Adhiguru P. Gender and Agriculture: An Indian Perspective. International Books and Periodical Supply Service pp 61-80. ISBN 978-93-90425-53-2

Rohit, J., Nirmala, G., Girijaveni, V., Saurabh, K., Beevi, Anshida., Nagasree, K & Ravishankar, K. 2021. Gender Gap in agricultural resources and extension services, *In*: Gender and Agriculture: An Indian Perspective (*eds.* Anithakumari.,P *et al.*) ISBN: 978-93-90425-53-2

10.4. Technical bulletins

Jadhav, V.T., Londhe, V.M., Amrutsagar, V.M., Pawar, P.B., Jadhav, J.D., Birajdar, S.G., Manikandan, N. and Bal, S.K. 2021. Agrometeorology of Chickpea. Technical Bulletin no.2380, Zonal Agricultural Research Station, Mahatma Phule Krishi Vidyapeeth, Solapur, 38p.

Singh, V.K., Prasad J.V.N.S., Manoranjan Kumar., Prabhat Kumar Pankaj., Sumanta Kundu., Prasad, T.V., Prabhakar, M., Tripathi, A.K., Bhaskar, S., Chaudhari, S.K. and Singh, A.K. 2021. Promising Climate Resilient Technologies for Assam. ICAR-Central Research Institute for Dryland Agriculture, Hyderabad. 92p

Singh, V.K., Prasad, J.V.N.S., Osman, M., Ramana, D.B.V., Nagasree, K., Rejani, R., Subbarao, A.V.M., Srinivas, I., Prabhakar, M., Lakhan Singh, Bhaskar, S., Chaudhari, S.K. and Singh, A.K. 2021. Promising Climate Resilient Technologies for Maharashtra. ICAR-Central Research Institute for Dryland Agriculture, Hyderabad. 113p.

Singh, V.K., Prasad, J.V.N.S., Osman, M., Ramarao C.A., Ramana, D.B.V., Nagasree, K., Rejani, R., Subbarao, A.V.M., Srinivas, I., Prabhakar, M., Bhaskar, S., Chaudhari, S.K. and Singh, A.K. 2021. Success Stories from Climate Resilient Villages. ICAR-Central Research Institute for Dryland Agriculture, Hyderabad. 116p.

Singh, V.K., Prasad, J.V.N.S., Ramana, D.B.V., Nagasree, K., Rejani, R., Venkatesh, G., Reddy, D.V.S., Venkatasubramanian, V., Prabhakar, M., Bhaskar, S., Chaudhari, S.K. and Singh, A.K. 2021. Promising Climate Resilient Technologies for Karnataka. ICAR-Central Research Institute for Dryland Agriculture, Hyderabad. 100p

10.5. Popular Articles

Sanjeeva Reddy, B. and Reddy Mallikharjuna, V. 2021. Dukkulu Cheche, Vithanalu Veche Yantraparikaralu. *Annadata,* 53 (5), 34 -36.

Sri Krishna, G., Sekhar, S.M.V. and Gopala Krishna Reddy, A. 2021. Adavi kakaratho aadhayam (in Telugu). *Annadata* magazine, December 2021.pp 10-11.Sri Krishna, G, X Gopala Krishna Reddy, A.and Sekhar, S.M.V. 2021. Haritha gruhallo aakukoorala saagu (in Telugu). *Annadata* magazine, October 2021.pp 10-11. Gopala Krishna Reddy, A. 2021. Crop regulation in Guava. *Agrobios Newsletter*, September 2021.pp. 26 - 28.

Gopala Krishna Reddy, A. 2021. Vesavi kooragayala saagulo melekuvalu (in Telugu). *Annadata* magazine, July 2021.pp 64-65. Gopala Krishna Reddy, A, T.V.Prasad, G.Sri Krishna, Jagati Yadagiri.2021. Mealy bug infestations and their management in Custard apple in Dryland areas. Agriculture & Food E-Newsletter, 3 (9): (153-155).

Nagarjuna Kumar, R., Rama Rao, C.A., Raju, B.M.K., Srinivasa Rao, M., Sailaja, B. 2021. AI and IOT in Smart Farming. *Agro Science Today* 2: 0185-0188.

Nirmala G, Sammi Reddy K, Sanjeev Reddy, Rama Rao C A, Pankaj P K, Narsimhlu B, Reddy A G K, Ravi Shankar K, Nagasree K, Samuel J, Rohit J, Anshida Beevi C N and Singh, V. K. 2021. Famer centric natural resource development for socio- economic empowerment in rainfed areas of Southern Telangana region. *Indian Farming* 71(10): 138–141; October 2021

Prabhat Kumar Pankaj. 2021. Status and Prospects of Dairy Farming in India. Published online at *Pranimitran*, https://pranimitran.com/status-and-prospects-of-dairy-farming-in-india/ Pp. 4-7.

Ramanjaneyulu, A.V, D. Sravanthi , D. Swetha, N. Sainath , M. Madhu , C. V. Sameer Kumar and B. Sanjeeva Reddy. 2021(September). Mechanization in Pigeon pea – Scope and Opportunities in India. *Chronicle of Bioresource Management*, 5(3):099-105.

Reddy, A A. 2021. Offer incentives for climate-resilient farming, *The Tribune*, 8th Nov 2021 https://www.tribuneindia.com/news/features/offer-incentives-for-climate-resilient-farming-335509

Reddy, A A. 2021. Stable, long-term policies can turn the tide, *The Tribune*, 18th Oct 2021. https://www.tribuneindia.com/news/features/stable-long-term-policies-can-turn-the-tide-326153

Reddy, A.A. 2001. Technology or Ideology?, *Economic and Political Weekly*, 3rd April 2021. 56(14): pp. 5.

Reddy, A.A. 2021 Food subsidy: Crop-specific mechanism is the way forward, *The Tribune*, 21st June 2021 https://www.tribuneindia.com/news/features/food-subsidy-crop-specific-mechanism-is-the-way-forward-271679

Reddy, A.A. 2021. Boost price stabilisation fund for pulses, oilseeds, *The Tribune,* 20th July 2021 https://www.tribuneindia.com/news/features/boost-price-stabilisation-fund-for-pulses-oilseeds-285149

Reddy, A.A. 2021. Prioritise high-value produce to turn the tide, *The Tribune,* 23rd August 2021 https://www.tribuneindia.com/news/features/prioritise-high-value-produce-to-turn-the-tide-300917

Reddy, A.A. 2021. Recognising pluriactivity of farm families, *The Tribune*, 20th Sept 2021 https://www.tribuneindia.com/news/features/recognising-pluriactivity-of-farm-families-313696

Reddy, A.A. 2021. Resilient grain needs a fillip to gain ground, *The Tribune*, 5th April 2021 https://www.tribuneindia.com/news/features/resilient-grain-needs-a-fillip-to-gain-ground-234860

Reddy, A.A. 2021. Sustainable Palm Oil Production, *Economic and Political Weekly*, 4th Sept 2021. 56(36). pp.5.

Reddy, A.A. 2021. Why a price insurance policy makes sense, *The Tribune*, 20th December 2021. https://www.tribuneindia.com/news/features/why-a-price-insurance-policy-makes-sense-352426

Reddy, A.A., 2021. Income Policy over Price Policy, *Economic and Political Weekly,* 23rd January 2001.56(4) pp.5.

Rohit. J., Saurabh, K., Girijaveni, V., Reddy, S. G. and Vijaykumar, S. 2021. Covid 19 and its severity on farming society, *Agri Journal World*, 1(4):10-13

Saurabh, K., Rohit. J.,Pawan, J., Sundaram, P.K., Kumar, M., Singh, A.K. & Upadhayaya, A. 2021. Agricultural challenges and solutions during corona period, *Krishi Manjusha*, 4(!):36-39

Srinivas, K. 2021. *Varshadhaara aamudam saagu* (article in Telugu), Vyavasaaya Paadipantalu, October 2021: 29-30.

Srnivas, I; P.Rajaiah; M.Govardhan; D.Srilata; C.Ramana ; G.Pratibha and B.Sanjeeva Reddy. 2021. Yantra Sedyam -- Labhala Saadhyam. International Agronomy Congress Special Issue –- Annadata, November, 42 -44.

Visha Kumari, V. Rajib Nath, Kajal Sengupta and Chandran, M. A. S. 2021. Foliar spray of B+Fe to mitigate the heat and moisture stress. *Indian Farming*, 71(12): 25-26.

आर. के. महापात्र, पी. के. पंकज, एस. पी. यादव, एस. के. भंज, एन आनंद लक्ष्मी एवं एम. शन्मुगम (2021) पोल्ट्री हैचरी एवं फार्म अपशिष्ट प्रबंधन। पोल्ट्री मंच, जनवरी अंक 1. Pp 42-43.

10.6. Consultancy reports

MoEF&CC 2021. India: Third Biennial Update Report to the United Nations Framework Convention on Climate Change. Ministry of Environment, Forest and Climate Change, Government of India.

10.7. Software, DSS, databases, websites developed and maintained

Nagarjuna Kumar R , Ravindra Chary, G, and Raju, N.S. AICRPDA website (www.aicrpda.in).

Nagarjuna Kumar, R., Rama Rao, C.A., Raju, B M K., 2021. Developed query-based system: Climate Change Risk Information System (CRIS) – An application for data retrieval from risk and vulnerability database, which is available on local intranet system.

Nagarjuna Kumar, R., Rama Rao, C.A., Raju, B M K., Josily Samuel, Subba Rao, A.V.M., Srinivas Rao, M., Nirmala, G and Raju, N.S.2021.Developed A Mobile App- Risk and Vulnerability Assessment of Indian Agriculture to Climate Change. ICAR-Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad. app.https://play.google.com/store/apps/details?id=com.icar.crida.viacc

Raju N S, R Nagarjuna Kumar . 2021-22. KRISHI portal Management for CRIDA.

Raju N S, R Nagarjuna Kumar. 2021-22. ARMS Database Management for CRIDA.

Raju N S, R Nagarjuna Kumar. 2021-22. PIMS Database Management for CRIDA.

Raju N S.2021-22. KVK Website Management(http://icar-crida.res.in:82/kvk).

Raju, B. M. K., Nagarjuna Kumar, R.., Rama Rao, C. A., Josily Samuel, Rao, K. V., Subba Rao, A. V. M., Osman, Md and Srinivasa Rao and Swapna,N. 2021. Unreaped yield potentials in major rainfed crops and scope for bridging yield gaps, Decision support system is available at http://www.icar-crida.res.in:8129/.

Ravi Kumar N, and Chandra P. CRIDA website (http://www.icar-crida.res.in)

Ravi Kumar N, and Rao KV. Database on District wise Contingency plans (http://www.icar-crida.res.in:82/contingencyplanning)

Ravi Kumar N, Chandra P and Prabhakar M. NICRA website (www.nicra-icar.in)

Ravi Kumar N, Prasanth, Gowtham Reddy K, and Srimannarayana A, "Salary cum Income Tax Report Generation software package, ICAR-CRIDA"

Ravi Kumar N, Raju BMK and Rama Rao CA. District Database Agricultural Statistics - A Database Management System (web enabled) (http://www.icar-crida.res.in:82/DDAS)

10.8. e-publications

Raju B.M.K., Nagarjuna Kumar R., Rama Rao C.A., Josily Samuel, Rao K.V., Subba Rao A.V.M., Osman Md. and Swapna N. (2021) Unreaped Yield Potentials in Major Rainfed Crops and Scope for Bridging Yield Gaps - A Decision Support System (Version-2), ICAR-Central Research Institute for Dryland Agriculture, Santoshnagar, Hyderabad-500059. http://www.icar-crida.res.in:8129/

Reddy, A. A. 2021. How MGNREGA is promoting climate-smart villages, *Downtoearth*, 22nd March

2021 https://www.downtoearth.org.in/blog/climate-change/how-mgnrega-is-promoting-climate-smart-villages-76070

Reddy, A. A. 2021. Inequalities in India after COVID Pandemic, *Academia Letters* Article no. 1138.https://doi.org/10.20935/AL1138

Reddy, A. A. 2021. Policy implications of Minimum Support Price for Agriculture in India,*Academia Letters*, Article No. 2406. https://doi.org/10.20935/AL2406

Reddy, A.A. 2021. How MGNREGA is promoting climate-smart villages, *Down to Earth*, 22nd March 2021 https://www.downtoearth.org.in/blog/climate-change/how-mgnrega-is-promoting-climate-smart-villages-76070

Reddy, A.A. 2021. Why India Needs a Climate-Resilient Action Plan For Its Drylands, *Thewire*, 7th October 2021. https://science.thewire.in/environment/why-india-needs-a-climate-resilient-action-plan-for-its-drylands/

Reddy, A.A. 2021.Urban MGNREGA for urban life. *The Policy Circle*, 19 April 2021 https://thepolicytimes.com/urban-mgnrega-for-urban-life/

Reddy, A.A., 2021. Scaling up of Farmer Producer Organizations in India, *Academia Letters*, Article No. 2607. Pp.1-4. https://doi.org/10.20935/AL2607

10.9. Extended summaries

Ashly Abraham, Madhavi Lata, A., Prasad, J.V.N.S. and Madhavi, A. 2021. Silvi-Medicinal System – A Tool for Climate Smart Agriculture. Agri- Innovations to Combat Food and Nutrition Challenges In: Extended Summaries of 5th International Agronomy Congress. The Indian Society of Agronomy, IARI, New Delhi 110012.

Boini Narsimlu, A.K.Kothari, J.K.Balyan,G.Ravindra Chary, K.A.Gopinath and K.B.Sridhar. 2021. Performance of lined farm ponds for enhancing water productivity in southern zone of Rajasthan. Agri-Innovations to Combat Food and Nutrition Challenges In: Extended Summaries of 5th International Agronomy Congress. Edn: Drs Shiva Dhar, Babu, Subhash Raj R., Upadhyay, P.K., Singh, T., Yadav, S.K., Meena, R.P., Kumar, A., Yadav, D.D., Sarangi, S.K., Singh, D.N., Gupta, G., Jinger, D., Ramalu, B., Kumar, D., Prajapat, K., Rajpoot, S., Bamboria, S., Ravishankar, N., Kumar, V., Ramanjaneyulu, A.V. and Choudhary, S.K. The Indian Society of Agronomy, IARI, New Delhi 110012, Vol. 1 pp 1-526.

Dhimate A S, I Srinivas, Adake R V, Reddy B S, Reddy K S and Mallikarjuna (2021) "Mechanization of Green gram in India-Status and Scope cultivation" Extended summery, Vol I, Fifth International Agronomy Congress held at PJTSAU, Hyderabad during 23-27 November 2021.

Ravindra Chary, K.A.Gopinath, S.Bhaskar, B.Narsimlu et.al. 2021. Real time contingency planning to cope with cilmate variablility in rainfed areas of India. Agri-Innovations to Combat Food and Nutrition Challenges In: Extended Summaries of 5th International Agronomy Congress. Edn: Drs Shiva Dhar, Babu, Subhash Raj R., Upadhyay, P.K., Singh, T., Yadav, S.K., Meena, R.P., Kumar, A., Yadav, D.D., Sarangi, S.K., Singh, D.N., Gupta, G., Jinger, D., Ramalu, B., Kumar, D., Prajapat, K., Rajpoot, S., Bamboria, S., Ravishankar, N., Kumar, V., Ramanjaneyulu, A.V. and Choudhary, S.K. The Indian Society of Agronomy, IARI, New Delhi 110012, Vol. 1 pp 1-526.

Gopinath, K.A., Venkatesh, G., Yadav, S.K., Prasad, J.V.N.S., Jayalakshmi, M., Prabhamani, P.S., Narsimlu, B., Pushpanjali, Ravindra Chary, G., Sridhar, K.B., Abdul Rasul, Rajkumar B. and Deepika, S. 2021. Potential of organic crop production as an adaptation strategy to climate variability in rainfed regions of Southern India. Agri- Innovations to Combat Food and Nutrition Challenges In: Extended Summaries of 5th International Agronomy Congress. The Indian Society of Agronomy, IARI, New Delhi 110012.

Josily Samuel, Shalander Kumar, Rama Rao, C.A., Pankaj, P.K., Pushpanjali and Samba Siva. 2021. Farming systems approach to enhance famers income in the smallholder crop livestock system in drylands. Extended Summaries: 5th International Agronomy Congress, November 23-27, 2021, pp.285-286

Gopinath K. A, Venkatesh, G..Ravindra Chary, G,.Narsimlu, B, Sridhar, K.B. et.al.,2021. Potential of organic crop production as an adaptation strategy to

climate variability in rainfed regions of Southern India. Agri-Innovations to Combat Food and Nutrition Challenges In: Extended Summaries of 5th International Agronomy Congress. Eds: Drs Shiva Dhar, Babu, Subhash Raj R., Upadhyay, P.K., Singh, T., Yadav, S.K., Meena, R.P., Kumar, A., Yadav, D.D., Sarangi, S.K., Singh, D.N., Gupta, G., Jinger, D., Ramalu, B., Kumar, D., Prajapat, K., Rajpoot, S., Bamboria, S., Ravishankar, N., Kumar, V., Ramanjaneyulu, A.V. and Choudhary, S.K. The Indian Society of Agronomy, IARI, New Delhi 110012, Vol. 1 pp 1-526.

Nagarjuna Kumar, Rama Rao, C.A., Raju, B.M.K., Josily Samuel, Subba Rao, A.V.M., Srinivasa Rao, M., Nirmala, G., Raju, N.S. and Singh, V.K. 2021. A Mobile app for Risk and Vulnerability Assessment of Indian Agriculture to Climate Change. Extended Summaries : 5th International Agronomy Congress, November 23-27, 2021, pp.26-28

Nagasree K, Prasad JVNS, Osman M, Srinivas I Ramana DBV, Prabhaka R.M, Singh V. K and Subbarao AVM. 2021. Equipping rural stakeholders with coping abilities to manage climate variability through Institutional Interventions. Agri- Innovations to Combat Food and Nutrition Challenges In: Extended Summaries of 5th International Agronomy Congress. The Indian Society of Agronomy, IARI, New Delhi 110012.

Prasad, J.V.N.S., Pradeep, C. M., Osman, M., Ramana, D.B.V., Nagasree, K., Rejani, R., Srinivas, I., Subba Rao, A.V.M., Kiran, B.V.S., Singh, V.K., Prabhakar, M. and Sammi Reddy, K. 2021. Impact of *in-situ* moisture conservation measures in frequently drought affected areas of Karnataka. Agri- Innovations to Combat Food and Nutrition Challenges In: Extended Summaries of 5th International Agronomy Congress. The Indian Society of Agronomy, IARI, New Delhi 110012.

Prasad, J.V.N.S., Osman, M., Ramana, D.B.V., Nagasree, K., Rejani, R., Srinivas, I., Subba Rao, A.V.M., Kiran, B.V.S., Pradeep, C. M., and Singh, V.K. 2021. Climate resilient technologies and opportunities for their scaling in India. Agri- Innovations to Combat Food and Nutrition Challenges In: Extended Summaries of 5th International Agronomy Congress. The Indian Society of Agronomy, IARI, New Delhi 110012.

Raju, B.M.K., Rama Rao, C.A., Nagarjuna Kumar, R., Rao, K.V., Subba Rao, A.V.M., Josily Samuel, Osman, M., Singh, V.K. and Swapna, N. 2021. Towards achieving self-sufficiency in oilseeds production in India: Identifying districts with untapped yield potential. Extended Summaries: 5th International Agronomy Congress, November 23-27, 2021, pp.951-953

Raju, B.M.K., Swapna, N., Rama Rao, C.A. and Samba Siva, G. 2021. Effect of Area and Yield Changes on Change in Production of Rainfed Crops in India during the past decade. Extended Summaries: 5th International Agronomy Congress, November 23-27, 2021, pp.1570-1571

Rama Rao, C.A., Raju, B.M.K., Prasad, J.V. N. S., Tomar, R.S., Josily Samuel, Nagarjuna Kumar, R. and Singh, V.K. 2021. Enhancing yield and income resilience to drought through adaptation interventions in Central India. Agri- Innovations to Combat Food and Nutrition Challenges In: Extended Summaries of 5th International Agronomy Congress. The Indian Society of Agronomy, IARI, New Delhi 110012.

Saileela, K., Yakadri, M., Rao, K.V. and Prasad, J.V.N.S. 2021. Land configuration and cropping intensification as approaches for enhancing crop yields in alfisols of semi-arid regions. Agri- Innovations to Combat Food and Nutrition Challenges In: Extended Summaries of 5th International Agronomy Congress. The Indian Society of Agronomy, IARI, New Delhi 110012.

Samba Siva., G., Rama Rao, C.A., Raju, B.M.K. and Swapna, N. (2021). Growth of animate and mechanical farm power availability in Indian agriculture. Extended Summaries: 5th International Agronomy Congress, November 23-27, 2021, pp.398-400

Sreenivasulu, S., Divya, V., Sudhakar, P.S., Ramu Kumar, T., Prasad, J.V., Prasad, Y. G. and Prasad, J.V.N.S. 2021 Direct seeding in rice using drum seeder – A resource conservation technology. Agri- Innovations to Combat Food and Nutrition Challenges In: Extended Summaries of 5th International Agronomy Congress. The Indian Society of Agronomy, IARI, New Delhi 110012.

Sridhar K.B, G.Ravindra Chary, K.A.Gopinath,, B.Narsimlu and Venkatesh G. 2021. O_2 from trees, valuing oxygen production potential of trees from dryland agroforestry systems. Agri-Innovations to Combat Food and Nutrition Challenges In: Extended Summaries of 5th International Agronomy Congress. Edn: Drs Shiva Dhar, Babu, Subhash Raj R., Upadhyay, P.K., Singh, T., Yadav, S.K., Meena, R.P., Kumar, A., Yadav, D.D., Sarangi, S.K., Singh, D.N., Gupta, G., Jinger, D., Ramalu, B., Kumar, D., Prajapat, K., Rajpoot, S., Bamboria, S., Ravishankar, N., Kumar, V., Ramanjaneyulu, A.V. and Choudhary, S.K. The Indian Society of Agronomy, IARI, New Delhi 110012, Vol. 1 pp 1-526.

Srinivas, I., Prasad, J.V.N.S., Kiran, B.V.S., Osman, M., Ramana, D.B.V., Nagasree, K., Rejani, R., Subba Rao, A.V.M., Pradeep, C. M., Prabhakar, M., Sammi Reddy, K and Singh, V.K. 2021. Flood tolerant rice varieties in minimising the impact of floods in India. Agri-Innovations to Combat Food and Nutrition Challenges In: Extended Summaries of 5th International Agronomy Congress. The Indian Society of Agronomy, IARI, New Delhi 110012.

Sumanta Kundu, Sammi Reddy, K., Pratibha, G., Prasad, J.V.N.S., Indoria, A.K., Srinivas, I., Girija Veni, V., Arunakumari, H., Sravani, K., Srinivasarao, Ch. and Singh, V.K. 2021. Effect of conservation agriculture on yield and soil properties of rainfed Pearlmillet based cropping system in Alfisols of semi-arid southern India. Agri- Innovations to Combat Food and Nutrition Challenges In: Extended Summaries of 5th International Agronomy Congress. The Indian Society of Agronomy, IARI, New Delhi 110012.

Thirupathi, I., Vidya Sagar, G.E.Ch., Mahender Kumar, R., Surekha, K., Prasad, J.V.N.S and Narender Reddy, S. 2021. Assessing the yield, water productivity and Greenhouse gas emissions of rice with irrigation regimes and N management practices under different establishment methods. Agri- Innovations to Combat Food and Nutrition Challenges In: Extended Summaries of 5th International Agronomy Congress. The Indian Society of Agronomy, IARI, New Delhi 110012.

Ongoing Projects- 2021

S. No.	Title of the Project	Investigators	Year of Start-Close
1.	Impact of conservation agriculture practices on soil physical properties in maize-pigeonpea crop rotation under rainfed alfisols	**Ashok Kumar Indoria** G. Pratibha K. Sammi Reddy	2012-2021
2.	Estimating the carbon sequestration potential of semi-arid soils using carbon saturation concept.	**K. Srinivas** A.K. Indoria S.S. Balloli	2018-2023
3.	Potential role of conservation agriculture on resource conservation and soil carbon sequestration in pigeon pea castor systems in rainfed regions	G. Pratibha I. Srinivas K.V. Rao K. Srinivas B.M.K. Raju	2009-2022
4.	Integrated watershed management for resilient farming system and improved rural livelihood.	**Manoranjan Kumar** M. Prabhakar K.A. Gopinath A.V.M. Subba Rao A.G.K. Reddy R.V. Adake R. Rejani B. Narsimlu G. Venkatesh A.K. Indoria D.B.V. Ramana G. Nirmala Josily Samuel C.N. AnshidaBeevi Jagriti Rohit	2015-2022
5.	Assessment of soil quality and development of indices for predominant rainfed areas of Karnataka falling in AESR-6.2 under different crops and cropping systems	**Ashok Kumar Indoria** K. Srinivas K. L. Sharma K. Sammi Reddy Pushpanjali	2018-2021
6.	Design and development of sub-surface water harvesting and recycling system for augmentation of farm pond in dryland agriculture	**Manoranjan Kumar** K.V. Rao B. Narsimlu Pushpanjali	2019-2024
7.	Development and performance evaluation of self-propelled reaper for harvesting of short and bushy crop	**Dhimate Ashish Satish** I. Srinivas R. V. Adake B. Sanjeeva Reddy G. Pratibha	2018-2021
8.	Development of solar powered mechanization package for small farm holders in rainfed system	**R. V. Adake** I. Srinivas B. Sanjeeva Reddy Dhimate Ashish Satish Manoranjan Kumar K. Sammi Reddy G. Pratibha A. Amarender Reddy V. Maruthi	2019-2024

S. No.	Title of the Project	Investigators	Year of Start-Close
9.	Development and performance evaluation of intra row weeder cum basin lister for tree-based dryland horticultural crops	**B. Sanjeeva Reddy** K.A. Gopinath Dhimate Ashish Satish A.G.K. Reddy	2019-2022
10.	Characterizing preferential flow in soils of semi- arid Telangana	**Pushpanjali** G. Ravindra Chary K. Sammi Reddy K.L. Sharma K.S. Reddy Manoranjan Kumar Dhimate Ashish Satish N. Ravi Kumar	2019-2024
11.	Evaluation of multipurpose tree species based agroforestry systems.	**G. Venkatesh** G. Ravindra Chary K.A. Gopinath J.V.N.S. Prasad K. Sammi Reddy I. Srinivas K.V. Rao Basudeb Sarkar Arun Kumar Shanker D.B.V. Ramana B.M.K. Raju	2019-2025
12.	Development of IOT based water application system for farm ponds in rainfed areas.	**N. S. Raju** K.S. Reddy N. Ravi Kumar B. Sanjeeva Reddy R. Nagarjuna Kumar	2019-2022
13.	Evaluation of bamboo species suitable for Southern Telangana region	**G. Venkatesh** K. Sammi Reddy K.A. Gopinath V.K. Sing	2021-2023
14.	Effect of Ca-bentonite on soil moisture dynamics and availability of nutrients in semi-arid rainfed alfisols	**A.K. Indoria** K. Sammi Reddy K. Srinivas S. Kundu M. Manjunath V. K. Singh	2021-2025
15.	Soil water dynamics in raised bed with modified furrow system and supplemental irrigation in Alfisols	**R. Rejani** KV Rao I. Srinivas G.Pratibha A.K.Indoria, K Srinivasa Reddy K. Srinivas Ashish Dhimate K Sammi Reddy	2021-2025
16.	Enhancing the bio-availability of rock phosphate P through the application of natural zeolite	**V. GirijaVeni** K. Sammi Reddy K. Srinivas Manjunath	2021-2024

S. No.	Title of the Project	Investigators	Year of Start-Close
17.	Potential role of in situ moisture conservation and nutrient management strategies for sustainable production and resource use efficiency in rainfed areas	**G. Pratibha** K. Srinivas K.V.Rao I.Srinivas B.M.K. Raju M.Srinivas Rao Arun.K. Shanker	2021-2024
18.	Development and management of integrated water resources in different agro-ecological regions of India	K. Srinivas Reddy Manoranjan Kumar V. Maruthi Pushpanjali K. Nagasree P. K. Pankaj	2015-2021
19.	Enhancement of input use efficiency in rainfed areas through precision farming and farm mechanization	**I. Srinivas** B. Sanjeeva Reddy R.V. Adake Dhimate Ashish Satish	2015-2021
20.	Updation of District Agriculture contingency plans.	**K.V. Rao** J.V.N.S. Prasad G. Ravindra Chary P. Vijay Kumar D.B.V. Ramana M. Osman S. Desai S.S. Balloli K.A. Gopinath A.V.M. Subba Rao Josily Samuel I. Srinivas B.M.K. Raju N. Ravi Kumar P.K. Pankaj B. Sarkar	2016-2021
21.	Drought Monitoring, Planning and Management: Improving food security and resilience of the drought affected states in India.	**K.V. Rao** J.V.N.S. Prasad S. Desai G. Pratibha A.V.M. Subba Rao S.S. Balloli K. Srinivas K. Sammi Reddy	2016-2021
22.	Effect of Polyhalite application on maize yield, nutrient use efficiency and GHGs emission under rainfed condition	**Sumanta Kundu** K. A. Gopinath G. Pratibha JVNS Prasad A.K. Shanker A.K. Indoria K. Sammi Reddy V.K. Singh	2021-2023

S. No.	Title of the Project	Investigators	Year of Start-Close
23.	Development and validation of conservation agriculture (CA) practices for rainfed production systems of India	**G. Pratibha** K. L. Sharma G. Ravindra Chary J.V.N.S. Prasad A. K. Indoria Sumanta Kundu I. Srinivas K. V. Rao B.M.K Raju B. Sanjeeva Reddy Manjunath M. M. Srinivasa Rao S. Desai K.A. Gopinath AICRPDA-Bengaluru AICRPDA-Akola KVK Kurnool KVK Tumkur KVK Sonitpur	2017-2021
24.	Potential of cropping systems as a climate resilient adaptive strategy for managing drought in rainfed agriculture: Strip cropping	**V. Maruthi** B. Sanjeeva Reddy K.S. Reddy K. Srinivas P.K. Pankaj M. Vanaja B.M.K. Raju M. Maheswari	2016-2021
25.	Development of resilient fodder-based cropping system for resource conservation and profitability in rainfed areas	**V.VishaKumari** S.S. Balloli K. Srinivas V. Maruthi M. Prabhakar D.B.V. Ramana Manoranjan Kumar M. Osman A.K. Indoria G. Ravindra Chary	2015-2022
26.	Physiological characterization of tillering genotypes of maize for rainfed conditions	**N. Jyothi Lakshmi** M. Vanaja K. Salini Basudeb Sarkar V. Maruthi S.K. Yadav S. Desai P.K. Pankaj K. Sreedevi Shankar K. Srinivas M. Maheswari	2018-2023
27.	TmapGen+ - An online interactive thematic map generator	**N. Ravi Kumar** B. M. K. Raju A. V. M. Subba Rao M. Prabhakar	2018-2021
28.	Predicting climate change impact on insect pests of dryland crops using phenology modeling	**T. V. Prasad** M. Srinivasa Rao S.K. Bal K.V. Rao	2018-2021

S. No.	Title of the Project	Investigators	Year of Start-Close
29.	Development of microbial consortia for drought tolerance in rainfed crops	**M. Manjunath** S. Desai, S.K. Yadav N. Jyothi Lakshmi K. Srinivas G. Ravindra Chary K.A. Gopinath B.V. Asewar A. Kokhar S.B. Patil	2018-2021
30.	Collection and evaluation of tamarind (*Tamarindus indica* L.) germplasm from rainfed areas of Deccan and Bastar Plateau.	**A.G.K. Reddy** M. Osman S.K Yadav N. Jyothi Laxmi S.K. Bal T.V. Prasad Pushpanjali K. Salini K. SreedeviShanker	2018-2023
31.	Nutritional profiling of major rainfed crops from diverse agro ecologies	**K. Sreedevi Shankar** G Ravindra Chary S K Yadav V GirijaVeni	2021-2024
32.	Rhizo-microbiome of rainfed crops under semi-arid region of India	**M. Manjunath** S. K. Yadav N. Jyotilakshmi Arun Kumar Shanker G. Pratibha K A Gopinath A.K. Indoria	2021-2024
33.	Genetic enhancement for nutritionally rich high yielding horse gram varieties suitable for rainfed conditions	**K. Salini** Basudeb Sarkar S.K. Yadav M. Vanaja V. Maruthi N. Jyothilakshmi K. Sreedevi Shankar	2021-2024
34.	Evaluation of low-cost approaches for management of FAW, *Spodoptera frugiperda* in maize	**M. Srinivasa Rao** TV Prasad K Srinivas G Pratibha	2021-2023
35.	Genetic enhancement for abiotic stress tolerance in maize	**Basudeb Sarkar** M. Vanaja, K Salini, SK Yadav, N. Jyothi Lakshmi, Arun Shanker	2021- 2023
36.	Mitigation of water stress in pearl millet (*Pennisetum glaucum*) by Zn nano particle action on photosystem II, electron transport and pigment complex	**A. K. Shanker** M. Jyothilakshmi	2022 - 2024
37.	Bioclimatic Thresholds and Thermal Constants for aphid, *Melanaphis sacchari* (Homoptera: Aphidida) on Sorghum bicolor	**M. Prabhakar** N. Ravi Kumar	2021-2023
38.	Individual and interactive effects of moisture deficit and elevated temperature on physiological efficiency of C3 and C4 rainfed crops	**M. Vanaja** S.K. Yadav B. Sarkar N. Jyothi Lakshmi Arun Shanker V. Maruthi	2021-2023

S. No.	Title of the Project	Investigators	Year of Start-Close
39.	Crop Pest Surveillance and Advisory project (CROPSAP) in Maharashtra	**M. Prabhakar** A.V.M. Subba Rao N. Ravi Kumar	2011-2021
40.	Enabling decision makers in technology transfer in rainfed agriculture through mobile based applications	**R. Nagarjuna Kumar** C.A. Rama Rao B.M.K. Raju Josily Samuel P. Vijay Kumar A.V.M. Subba Rao G. Nirmala M. Srinivas Rao	2018-2021
41.	Building longitudinal panel data on development pathways in dryland villages.	**A. Amarender Reddy** C.A. Rama Rao G. Nirmala B.M.K. Raju K.S. Reddy R. Nagarjuna Kumar Josily Samuel R.V. Adake	2019-2024
42.	Prioritization of interventions in farming systems through systems modeling tools in selected semi-arid regions.	**Josily Samuel** G. Ravindra Chary C.A. Rama Rao K.A. Gopinath P.K. Pankaj A.V.M. Subba Rao Pushpanjali	2019-2024
43.	Harnessing statistical tools for informed decision making towards sustainable rainfed agriculture	**B.M.K. Raju** C.A. Rama Rao G. Ravindra Chary	2021-2025
44.	Using the economic surplus method to assess economy wide impacts of CRIDA technologies/policies	**A. Amarender Reddy** I. Srinivas Basudeb Sarkar K.V. Rao Boini Narsimlu	2021-2024
45.	Economic impact of livestock as means of livelihood security to resource poor dryland farmers	**Josily Samuel** C A Rama Rao B M K Raju P K Pankaj Pushpanjali Jagriti Rohit	2021-2024
46.	Agrarian Distress and PMFBY: An analysis of rainfed agriculture	**A. Amarender Reddy**	2021-2022
47.	Evaluation of communication networks for the adoption of rainfed technologies: An experimental study	**C.N. AnshidaBeevi** G. Nirmala Jagriti Rohit K. Nagasree K. Ravi Shankar B.M.K. Raju Ashish Dhimate Satish	2018-2021
48.	Sustainable nutrient management in indigenous sheep using crop residue based fortified Total Mixed Ration (TMR).	**P. K. Pankaj** D.B.V. Ramana G. Nirmala M. Osman N. Ravi Kumar Josily Samuel Pushpanjali	2019-2024

S. No.	Title of the Project	Investigators	Year of Start-Close
49.	Assessment of effectiveness of Extension Approaches in adoption of rainfed technologies.	**K. Ravi Shankar** G. Nirmala K. Nagasree C.N.Anshida Beevi Jagriti Rohit C.A. Rama Rao B.M.K. Raju B. Sanjeeva Reddy G. Pratibha V. Girija Veni	2019-2023
50.	Development of strategic framework for upscaling of proven technologies in rainfed areas	**K. Nagasree** JVNS Prasad Jagriti Rohit Anshida Beevi	2021- 2023
51.	Assessment of adoption potential and constraints for popularizing/upscaling raised bed planter (RBP) and broad bed & furrow planter (BBF) in unreached areas	**K. Ravi Shankar** I. Srinivas G. Nirmala K. Nagasree B.M.K. Raju Ashish Dhimate Jagriti Rohit C.N. AnshidaBeevi	2021-2024
52.	Multi-dimensional study on wellbeing outcomes in relation to agricultural interventions: Evidences from semi-arid regions of India	**Jagriti Rohit** K. Nagasree K. Ravi Shankar Anshida Beevi C.N Josily Samuel B.M.K Raju	2021-2024
53.	Dry fortified Total Mixed Ration (TMR) for indigenous sheep	**P. K. Pankaj** D.B.V. Ramana, V. Maruthi, Sreedevi Shankar, G. Nirmala and R. Nagarjuna Kumar	2021-2024
54.	Livelihood diversification strategies in rainfed areas of Telangana State	**G. Nirmala** P. K. Pankaj K. Ravi Shanker A. Amarender Reddy	2021-2024
55.	Farmers' centric natural resource development for socio-economic empowerment in rainfed areas of Southern Telangana region	G. Nirmala K Sammi Reddy B. Narsimlu B. Sanjeeva Reddy P. K. Pankaj K. Ravi Shankar A. Gopal Krishna Reddy K.A. Gopinath C.A. Rama Rao K. Nagasree Josily Samuel C. N. AnshidaBeevi Jagriti Rohit	2016-2021
56.	Behavioural surveillance of farmers in the wake of COVID 19: A Psychosocial Study	Jagriti Rohit G.Nirmala K.Nagasree	2021

S. No.	Title of the Project	Investigators	Year of Start-Close
57.	Study on performance and economics of lined farm ponds for sustainable rainfed ecosystems	**Boini Narsimlu** K.S. Reddy G. Ravindra Chary Manoranjan Kumar M. Osman K.A. Gopinath A. Amarender Reddy	2018-2023
58.	Water resources development and livelihood improvements of farmers in rainfed areas- an on-farm research	**Boini Narsimlu** G. Ravindra Chary K.S. Reddy A.G.K. Reddy S.S. Balloli K.B Sridhar P.K. Pankaj T.V. Prasad M. Osman	2021-2023
59.	Quantification and valuation of ecosystem services from agroforestry systems in rainfed agro ecological regions	**K. B. Sridhar** G. Ravindra Chary C.A. Rama Rao G. Venkatesh K.A Gopinath B. Narsimlu M.S. Shirahatti Mudlagiriappa M R Umesh	2020-2022
60.	Effect of Polyhalite on yield and quality of rainfed groundnut and on soil properties in Telangana and Andhra Pradesh	**K.A. Gopinath** V.K. Singh V. Visha Kumari	2021-2023
61.	Effect of foliar application of different Nano fertilizers on nutrient use efficiency, drought stress tolerance, productivity and economics of rainfed crops	**K. A. Gopinath** K. Sammi Reddy V.K. Singh G. Ravindra Chary A.K. Shanker S. Kundu V. VishaKumari	2021-2023
62.	Reducing uncertainty in modeling heat units for improving phenology prediction: An input for automated AAS	**S. K. Bal** A.V.M. Subba Rao M. Vanaja	2018-2021
63.	Innovative & contextual Agromet advisor services for climatic smart agriculture.	**A.V.M. Subba Rao** S.K. Bal Anthony Whitbread R. K. Mishra	2018-2021
64.	Evaluation of universal soil extractants for rapid soil testing	**S.S. Balloli** K Sammi Reddy K Srinivas B M K Raju	2021-2023

Thematic Programmes under NICRA

Following projects were proposed under 5 major themes for next phase of NICRA (2021-2026)

Theme No.	Major Themes	Theme leader/ PI/Co-PI
1	Impact of elevated carbon di oxide and temperature on crops, pests, diseases, weeds, soil, microbes and livestock in rainfed ecosystem.	S.K. Yadav, Theme Leader M Vanaja K. Srinivas G. Pratibha K. Sreedevi Shankar Arun Kumar Shanker A.G.K. Reddy M. Srinivasa Rao Manjunath M. V. Maruthi D.B.V. Ramana
2	Impact of Variable Rainfall on Soil, Crops etc.	K Srinivas Reddy, Theme Leader and PI
3	Adaptation and mitigation technologies for minimizing impact of climate change in rainfed farming systems.	. K. Sammi Reddy, Theme Leader M. Manjunath A.K. Indoria K. Srinivas V. GirijaVeni Sumanta Kundu A.V.M. Subba Rao M.A. Sarath Chandran V. K. Singh G. Pratibha K. V. Rao K. A. Gopinath J.V.N.S. Prasad B. Sarkar D.B.V. Ramana
4	Bio-physical and socio-economic aspects of climate resilient technologies.	C.A. Rama Rao, Theme Leader B.M.K. Raju A.V.M. Subba Rao K.V. Rao R. Nagarjuna Kumar A. Amarender Reddy K. Nagasree G. Ravindra Chary Dr. G. Pratibha Josily Samuel K. Nagasree Jagriti Rohit K. Ravi Shankar C.N. AnshidaBeevi JVNS Prasad
5	Development of IT based tools for climate change research.	Santanu Kumar Bal, Theme Leader K.V. Rao A.V.M. Subba Rao G. Venkatesh P.K. Pankaj N. Ravi Kumar

IRC and IMC Meetings 12

12.1. Institute Management Committee (IMC) meeting

The 50th Institute Management Committee (IMC) meeting of ICAR-CRIDA was held on March 05th, 2021 in virtual mode at ICAR-CRIDA.

The following is the composition of the present IMC team: 1. Dr. V.K Singh, Director, ICAR CRIDA, Hyderabad - Chairman 2. Agriculture Commissioner, Telangana state, Hyderabad, 3. Director of Agriculture, Government of Andhra Pradesh, 3. Dr. Jagadeeshwar, Director of Research, PJTSAU, Hyderabad, 4. Shri Z.H Khilji Chief Finance and Accounts Officer, ICAR-NAARM, Hyderabad, 5. Dr. (Smt) M. Vanaja, Principal Scientist, ICAR-CRIDA, Hyderabad, 6. Dr. M. Prabhakar, Principal Scientist, ICAR-CRIDA, Hyderabad, 7. Dr (Smt) B Sridevi, Principal Scientist, ICAR-IIRR, Hyderabad, 8. Dr. A. K Tripathi, Principal Scientist, ICAR-IISS, Bhopal, 9. Shri Edla Ashok Reddy, Warangal District, Telangana. 10. Shri Seeram Jagga Rao, Hyderabad, Telangana. The research activities, institute budget utilization and other important activities of the institute were discussed during the meeting.

12.2. Institute Research Council Meeting

The IRC meeting chaired by Dr. Vinod Kumar Singh, Director, ICAR-CRIDA was held during May and June, 2021 (17th, 18th, 30th May and 13th, 18th, 20th, 29th June 2021) in virtual mode using Zoom facility. The meeting was attended by project coordinators, heads of the divisions/ sections/units and scientists. In his opening remarks, the Chairman, IRC suggested for the building of proposals for four to five themes matching with division/ section mandate and also to set the goal proposed for SFC five-year plan period (2021-26). The objective is to have quality outcome addressing the changing climatic and socio-economic scenario not only in the country but across the globe. He emphasized on research with a greater focus in a comprehensive mode by building on complementarity among various disciplines for mandated dryland crops. The research carried out by Central Research Institute for Dryland Agriculture, Hyderabad, should have direct relevance to 52% of net cultivated area, which is totally rainfed and should be addressed by carrying out basic as well as applied research together. The priority should be given to Institute research followed by support to the external programmes. The budgetary constraints and availability of resources have to be kept in mind while planning experiments and these experiments should be focused and will be reviewed after every two to three years for their continuity or to draw conclusions. All the scientists were advised to bring novelty in the research programme and should involve partners from AICRPs and KVKs of NICRA-TDC for addressing various agro-ecologies.

12.3. Field Institute Research Council (IRC) meeting

Field Institute Research Committee meeting for 2021 at Gunegal Research Farm (GRF) and Hayath Nagar Research Farm (HRF) was held on September 23rd and 24th, 2021 respectively, under the Chairmanship of Dr. Vinod Kumar Singh, Director. Project coordinators, Heads of Divisions/Sections and scientists visited various experiments and discussed thoroughly on various aspects of the experiments in detail.

Participation of Staff in Conferences, Meetings, Workshops, Seminars and Symposia

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Scientist	Programme Name	Duration	Venue
Dr. V.K..Singh	**Key note address at PJTSAU in Global Conference on Innovative Approaches for Enhancing Water Productivity in Agriculture including Horticulture and CO-CHAIR AT PJTSAU**	17.09.2021	Hyderabad
Dr. V.K..Singh	Participation and deliver the Lead lecture on the topic of "Redesigning agronomic research for changing climatic scenario" at DrRajendra Prasad Central Agricultural University (RPCAU)	20.09.2021	RPCAU
Dr. V.K..Singh	Chief Guest for the Plenary session in the National Conference on Integrated Farming Systems" A tool for enhancing income land nutritional security for the stakeholders and scientists involved in agricultural research and development held at ICAR-Research Complex for Eastern Region, Patna	07.10.2021	Patna
Dr. V.K..Singh	Panelist at Virtual Workshop on IWMI-ITC Knowledge Partnership" Drought proofing Agri- catchments and Water Security Assessment of Factory Catchments	08.10.2021	Virtual
Dr. V.K..Singh	Organized a one-day pre-conference symposium on New Farm Laws - Prof. Ramesh Chand, Member, NITI Aayog (equivalent to Union Minister of State) has delivered the inaugural address	22.10.2021	Delhi
Dr. V.K..Singh	Delivered Keynote address in the Academy of Natural Resource Conservation and Management, Lucknow (UP), INDIA during a two-day International Web-Conference on 'Smart Agriculture for Resource Conservation and Ecological Stability'	31.10.2021	Lucknow
M. Prabhakar	16th meeting of NICRA Expert Committee	January 15-17, 2021	Virtual
DBV Ramana	Workshop sponsored by NABARD on Climate Resilient Agriculture in Rainfed Areas	January 21, 2021	KVK, Kurnool
B.M.K. Raju	Live session on 'Policy demand for NCA in India and emerging opportunities for NCA to support national priorities in India' under Natural Capital Accounting and Valuation of Ecosystem Services (NCAVES) India Forum	January 21, 2021	MoS & PI, GOI, New Delhi, Virtual
M. Prabhakar	National workshop on Management Strategies for overcoming the effects of Flood and Drought in Bihar	January 28, 2021	Virtual
Salini K	National Web Conference on Sustaining Pulse Production for Self Sufficiency and Nutritional Security	February 9-11, 2021	Virtual
DBV Ramana, K Nagasree,	Online NICRA review cum action plan workshop of ATARI, Patna	February 13, 2021	ICAR-CRIDA
C.A. Rama Rao	Virtual Consultation on 'A Roadmap for upscaling Eco-system-based Adaptation in the rainfed regions of Maharashtra'	February 16, 2021	W-cres and TMG Research, Virtual
M. Prabhakar	Institute management committee meeting, ICAR-NIASM, Baramati	February 17, 2021	Virtual
Sreedevi Shanker	6th National youth convention on "Innovation and Agricultural Reforms towards Farmers' prosperity"	February 20-21, 2021	PJTSAU, Hyderabad
Josily Samuel, Pushpanjali	Webinar on "Agriculture Research through knowledge Discovery"	February 23, 2021	EBSCO information services.
DBV Ramana, C.A. Rama Rao	SAC meeting	February 25, 2021	DDS KVK, Sanga Reddy
Prabhat Kumar Pankaj	International Conference on "New Paradigms for Agriculture, Food and Sustainability Concerns"	February 26-28, 2021	Agriculture Letters, Raichur, Karnataka

Scientist	Programme Name	Duration	Venue
B.M.K. Raju	Second virtual meeting of the committee of experts constituted to study the operational issues in implementation of PMFBY,	March 3, 2021	NRAA, DA&FW, New Delhi,
DBV Ramana	NICRA-TDC Sensitization meeting	March 3, 2021	Virtual
G Nirmala, PK Pankaj, Jagriti Rohit	Farmers-entrepreneur-scientist meet with a theme to improve the entrepreneurship on the occasion of International Women's day under Farmers FIRST project (FFP)	March 8, 2021	Gangupally village, Pudur Mandal
M. Prabhakar	Review meeting of CGC and Sponsored Research Institutes of NICRA	March 10-22, 2021	Virtual
C.A. Rama Rao	National Workshop on 'Policy perspectives on farm subsidies in India vis a vis other country: Issues and way forward'	March 11, 2021	ICAR-NAARM, Hyderabad, Virtual
Sridhar K.B, Venkatesh G.	National Conference on climate smart forestry through adaptive forestry management	March 16th, 17th, 2021.	FCRI, Mulugu, Telangana
Dhimate Ashish Satish	Artificial Intelligence and Machine Learning concepts- Deep Learning- Application of AI & ML tools in Agriculture– Cloud computing organized by ICAR-NAARM, Hyderabad.	March 15-20, 2021	Virtual
M. Prabhakar, Pushpanjali	International Symposium on Coastal Agriculture: Transforming Coastal Zone for Sustainable Food and Income Security	March 16-19, 2021	Virtual
AGK Reddy	Impacts of Cyclones on Perennial Horticulture Crops and Sustainable Management Strategies for Livelihood Security.	March 16-19, 2021	ISCA Webinar-West Bengal.
R.Rejani	Virtual National Conference on "Strategic Reorientation for Climate Smart Agriculture"	March 17-19, 2021	Association of Agrometeorologists and PAU, Ludhiana, Virtual
M. Prabhakar	Technical Program Finalization Workshop of NICRA Strategic Partner Institutes of Crop Sciences	March 19, 2021	Virtual
AGK Reddy	Mango Decline: Case study in Rangareddy district of Telangana.	March 22-24, 2021	JNTU Hyderabad Telangana.
Josily Samuel	Fourth Indian National Ground Water Conference on Groundwater Management in Arid and Semi-Arid Regions of Hard Rock Terrains at on "Minimizing drought Impacts on farm incomes in drylands"	March 22-24, 2021	Virtual
Boini Narsimlu	Virtual meeting for finalizing AICRPDA-NICRA programme - 2021.	March 24, 2021	ICAR-CRIDA, Hyderabad
C.A. Rama Rao	'Marketing initiatives to achieve sustainable agricultural growth during National Web Conference on 'Strategies for strengthening ecosystems for their sustainable services in the era of intensive agriculture and climate change',	March 25-26, 2021	ANGRAU, Agricultural College, Rajamahendravaram,
M. Prabhakar	Scientific Advisory Committee Meeting at CTRI- Krishi Vigyan Kendra, Kandukur	April 5, 2021	Virtual
M. Prabhakar	Business and investment meet in smart agriculture with Lam Dong province, Vietnam, organized by consulate general of India at Vietnam	April 22, 2021	Virtual
DBV Ramana, K Nagasree	Annual Review Workshop of ATARI- Jabalpur, Kanpur, Barapani, Guwahati, Jodhpur, Pune and Bengaluru	May 15-29, 2021	Virtual
B.Sanjeeva Reddy	State Level Technical Programme of Agricultural Engineering	May 19-June 3, 2021	ANGRAU, Guntur, Virtual
K.V Rao	Interface meeting for enhancing the preparedness for Agricultural Contingencies- Maharashtra, Karnataka, Odisha, Telangana, Gujarat	June 8-17 2021	Virtual Consultation
M. Prabhakar	Campaign workshop for COP26-Adaptation and Resilience, organized by Science and Innovation Network in India	June 15, 2021	Virtual
B.M.K. Raju	Meeting to 'Review & deliberate on the study regarding challenges in the ongoing crop insurance schemes and suggestive recommendations'	June 18, 2021	NRAA, DA&FW, New Delhi, Virtual

Scientist	Programme Name	Duration	Venue
Jagriti Rohit	41st International Symposium on Forecasting	June 27-30, 2021.	International Institute of forecasting, USA, Virtual
K. Ravi Shanker	Collaborative Online Training Program on Enhancing Agricultural Resilience through Index-based Flood Insurance and Post-flood Management Interventions in India.	June 29-30, 2021	ICAR-Indian Institute of Water Management & International Water Management Institute.
DBV Ramana, K Nagasree	Annual Review Workshop of ATARI- Bengaluru, Kolkata, Patna, Ludhiana, Hyderabad	June 7-26, 2021	Virtual
K. Sammi Reddy	Delivered lecture on "Conservation agriculture techniques for soil health and crop management" at 3-week training programme on "Soil Management for Climate Smart Agricuture".	June 17, 2021	MPKV, Rahuri
K Nagasree	Annual Review Workshop of NICRA-TDC, ICAR- ATARI, Zone-I, Ludhiana	June 19, 2021	ICAR-CRIDA
G Nirmala K Nagsree P K Pankaj B Sanjeev Reddy B Narsimulu	Site committee meeting cum Farmer-Scientist Interaction Farmers FIRST Project	June 30,2021	Gangupally village, Pudur Mandal, Hyderabad
AVM Subba Rao	**Meeting of ICAR-CRIDA, NBSS&LUP and NIAP on NRAA-PMFBY study**	**June 30-July 01, 2021**	ICAR-CRIDA Hyderabad, Virtual
DBV Ramana	Workshop on "Fodder resource development plan for Telangana"	July 4, 2021	Virtual
K.V Rao	Webinar on "Drought Monitoring and Management using Earth Observation and Weather Forecast Data" by SAARC Disaster Management Centre (IU)	July 7, 2021	Virtual Consultation
V. Maruthi	Webinar on "Global hunger Index"	July10, 2021	IARSI, New Delhi virtual
K.V Rao, AVM Subba Rao	Interface meeting for enhancing the preparedness for Agricultural Contingencies- Madhya Pradesh	July 15, 2021	Virtual
V. Maruthi, K. S Reddy	ICID webinar on "Rainwater harvesting vs traditional catchment storage"	July 15, 2021	Virtual
G Nirmala K Nagsree P K Pankaj B Sanjeev Reddy B Narsimulu	Farmer FIRST Project - Zonal Project Monitoring Committee meeting	July 27 2021	Virtual
K. Nagasree	Webinar on "Ecosystem for Sustainable FPO'	July 30, 2021	ICAR-RCER, Patna, Virtual
AVM Subba Rao	**Interface Meeting on Agricultural Contingencies for the state of Madhya Pradesh**	**July 15, 2021**	ICAR-CRIDA Hyderabad
K.V Rao	Interface meeting for enhancing the preparedness for Agricultural Contingencies- Rajasthan	August 2, 2021	Virtual
G Nirmala, Salini K, K A Gopinath, C.A. Rama Rao, K Ravi Shanker, B.M.K. Raju, M. Manjunath	National Webinar on Food and Nutritional Security: Challenges and Opportunities in rainfed areas	August 16 2021	ISDA, ICAR-CRIDA Hyderabad
M. Prabhakar	First Quad Climate Working Group Workshop on Adaptation, Resilience and Preparedness	August 17,2021	Virtual

Scientist	Programme Name	Duration	Venue
V. Maruthi	Online training on "An introduction to climate change: Science, Politics and impacts"	August 16-27, 2021.	CSE, New Delhi Virtual
Sreedevi Shanker	Consultative Workshop, on "strengthening capacities for Nutritive sensitive Agriculture and Food systems- Integration of nutrition into the Trainings by Agricultural EAS Providers in India	August 24, 2021	MANAGE, Hyderabad.
B. Sanjeeva Reddy	International Webinar on "Emerging Technologies in Agricultural Engineering for Food Safety and Security"	August 25- 27, 2021	Dr. NTR College of Agricultural Engineering, Bapatla ANGRAU
M. Prabhakar	13th NICRA High Level Monitoring Committee (HLMC) meeting	September 3, 2021	Virtual
S K Yadav	National Conference on Oil Palm: A right choice towards self-sufficiency in edible oil production	September 6, 2021	Virtual
M. Prabhakar	Second Quad Climate Working Group on Adaptation, Resilience and Preparedness	September 9, 2021	Virtual
K. Nagasree	Webinar on "Evolution of agricultural extension policies in India: implications for Future"	September15- **2021**	ICAR-CRIDA, Hyderabad.
B.M.K. Raju, R. Rejani, K.A. Gopinath	Global conference on Innovative Approcahes for Enhancing water productivity in Agriculture including Horticulture	Sepetember 16 -19 2021	PJTSAU Rajendranagar, Hyderabad, Telangana
K. Sammi Reddy	Nutri-Cereals Multi-stakeholders' Mega Convention 3.0 organized by the ICAR-IIMR, Hyderabad	September 17, 2021	Novatel, Hyderabad
K.V Rao	Roadmaps for Scaling up Ecosystem based Adaptation: Insights from Guatemala and India	September 22, 2021	Virtual
Pushpanjali, Josily Samuel	International webinar on Disaster Risk Reduction, resilience and sustainability' by on	September 24, 2021	IPE, Hyderabad
AVM Subba Rao, S.K Bal, Manikandan	4th Online Workshop on Next-Gen Climate Services Dashboard	September 28, 2021	ICRISAT, Hyderabad
K. Nagasree, Josily Samuel, Pushpanjali	Online event- 3 days International Webinar Conference "Alternate Cropping Systems for Climate Change and Resource Conservation"	September 29-October 1, 2021	ICAR- Indian Institute of Farming Systems Research
Salini K	International conference on "Future challenges and prospects in Plant Breeding"	October 6-7, 2021	Virtual
K Ravi Shanker	Conference on New Farm Laws: Issues and Concerns for Agriculture Development, Livelihood and Food Security.	October 22, 2021	Telangana Economic Association & ICAR-CRIDA, Hyderabad.
V. Maruthi	Participated in the Webinar on "Crop diversification: a way towards nutritional Security reduction policies" by ICAR-Research complex for Eastern region, Patna Bihar	October 26, 2021	Virtual
AVM Subba Rao, Salini K	International Webinar on "Fighting the Hunger using Smart Technology"	October 26, 2021	ICAR-IIOPR Pedavegi, AP
M. Prabhakar	United Nations Framework Convention on Climate Change (UNFCCC) world climate change conference (COP-26/CMP16/CMA3)	October 28- November 12, 2021	Glasgow, United Kingdom
K. Sammi Reddy	National Workshop on "Nutrient management in dryland/rainfed cropping systems" delivered invited lecture on on "Nutrient Management in Dominant Cropping Systems under different Agro-climatic Zones of India"	November 11, 2021.	ICAR-IISS, Bhopal

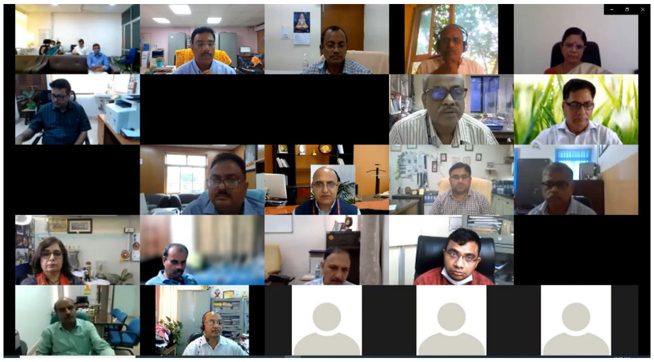
Scientist	Programme Name	Duration	Venue
Anshida Beevi CN	Gender Sensitization Workshop	November 23-25, 2021	(virtual)ICRISAT, Hyderabad
K. Sammi Reddy, M. Prabhakar Prabhat Kumar Pankaj, G Nirmala C.A. Rama Rao, S K Yadav, M. Srinivasa Rao, K. Salini, K. S Reddy K. Srinivas, M. Vanaja, J.V.N.S. Prasad, K.V Rao, I Srinivas, V. Visha Kumari. T.V. Prasad, Ravi Kumar N, B. Sanjeeva Reddy, K Nagasree, Jagriti Rohit, A.G.K Reddy, Pushpanjali, G. Pratibha, Josily Samuel, Anshida Beevi, G. Girija Veni, M. Manjunath, Salini K, Ashish Dhimate, Sreedevi Shanker, V. Maruthi, R. Nagarjuna Kumar, B.M.K Raju, N S Raju, R. Rejani, R V Adake, N. Manikandan, M.A. Sarath Chandran, S K Bal, Boini Narsimlu, K Ravi Shankar, Sridhar K.B	Fifth International Agronomy Congress on "Agri-innovations to combat food and nutrition challenges"	November, 23-27, 2021.	PJTSAU, Hyderabad
K.V Rao	Workshop on India's National Water Policy – Issues and Suggestions Workshop on India's National Water Policy – Issues and Suggestions by NAARM, Hyd	November 25-26, 2021	Virtual
C.A Rama Rao	Workshop on 'Agricultural household income and research impact assessment' organized by National Institute of Agricultural Economics and Policy Research,	November 29, 2021	Virtual
K.V Rao	NAAS Brainstorming Session on "Road Map to Rehabilitate 26 million ha Degraded Lands in India by 2030".	December 9, 2021	Virtual
C.A Rama Rao	Brainstorming Session on 'Mapping of Science and Technology Interventions in achieving sdgs in Telangana State'	December 12, 2021,	CESS, Begumpet
M. Vanaja	National Conference on Plant Physiology-2021 on 'Frontiers of Plant Physiology for Climate Smart Agriculture'	December 9-11, 2021	Virtual

Scientist	Programme Name	Duration	Venue
R. Nagarjuna Kumar	Hybrid mode International conference on Promoting Environmental Technologies for Waste Management and Sustainable Development (WMSD-2021)	December 12-13, 2021	Kalinga Institute of Industrial Technology, Bhubaneswar,
M. Manjunath	International Web Conference on Global Research Initiatives for Sustainable Agriculture & Allied Sciences (GRISAAS-2021)	December 13–15, 2021	Astha Foundation, Meerut in Collaboration with CSAUAT, Kanpur; BAU, Ranchi; IGKV, Raipur; SKRAU, Bikaner and UAHS, Shivamogga.
K.V Rao	2nd meeting of Working Group on Odisha Rainfed Agriculture Mission (ORAM)	December 14, 2021	Virtual Consultation
N. Manikandan, M.A. Sarath Chandran, S K Bal	National Web Conference on "Soil and Water management technologies for climate resilience, agricultural and environmental sustainability"	Dec 14-16, 2021	ICAR-IIWM, Bhubaneswar.
C.A Rama Rao	Stakeholder's consultation on 'Climate change and its effect on food security and nutrition'	December 14-15, 2021	World Food Programme and ICRISAT in virtual mode
M. Manjunath, Boini Narsimlu, Sridhar K.B	Brainstorming Session on Rainwater Harvesting Models	December 21 2021	CRIDA-AICRPDA
M. Manjunath	Online Hindi Workshop for CRIDA Scientists	December 31, 2021	ICAR-CRIDA, Hyderabad

14 Workshops, Seminars and other Activities Organized by the Institute

14.1. Technical Program Finalization Workshop of NICRA Strategic Partner Institutes under Crop Science organized

Technical Program Finalization Workshop of Crop Science institutes under Strategic Research component of National Innovations in Climate Resilient Agriculture (NICRA) was held on March 19th, 2021 through video conferencing under the chairmanship of Dr. TR Sharma, DDG (Crop Science), ICAR. Dr. S Bhaskar, ADG (Agronomy, Agroforestry and Climate Change), ICAR, Dr. Vinod Kumar Singh, Director, ICAR-CRIDA, Hyderabad, Dr. HE Shashidhar, CEO, Cultiva Agri Tech (An agricultural startup in Bangalore), NICRA Expert Committee member, Dr. M Prabhakar, PI, NICRA, ICAR-CRIDA, Hyderabad, Principal Investigators, Scientists, Research Associates and Senior Research Fellows from 6 Crop Science institutes participated in the video conferencing.



14.2. Annual Review and Concluding Workshop of Technology Demonstration Component of NICRA of ICAR-ATARI, Bengaluru.

The annual review and concluding workshop of Technology Demonstration Component of NICRA of ICAR-ATARI, Bengaluru was held on June 26th, 2021 through virtual mode under the Chairmanship of Dr. S. Bhaskar, ADG (Agronomy, Agroforestry and Climate Change), ICAR, New Delhi. The meeting was attended by Dr. V.K. Singh, Director, ICAR-CRIDA, Hyderabad, Dr. V. Venkatasubramanian, Director ICAR-ATARI, Bengaluru, Dr.S. Sudhakar Former Director-ATARI Hyderabad and Chairman ZMC, Dr. K.C. Shashidhar, DEE, UAHS, Shivamogga, Dr. D.M.Chandargi, DEE, UAS, Raichur, Dr. D.V.Srinivasa Reddy, Principal Scientist and Nodal officer, ATARI, Bengaluru, Dr.J.V.N.S. Prasad, Principal Scientist & Co-PI, NICRA-TDC, along with Project Coordinators at ICAR-CRIDA, Heads of Divisions of ICAR-CRIDA, Co-PIs of TDC and other scientists from ICAR-CRIDA, Hyderabad. Heads of NICRA KVKs of the participating districts and also the new districts and KVK staff involved in NICRA project.

Meeting at Macchapur

Scientist- farmer interaction at Pedda Malkapur

Scientist-farmer interaction in Naddam Guda

Field visit with farmers at naddam guda

14.3. Concluding Review Meeting of Technology Demonstration Component of NICRA of ATARI Hyderabad.

The concluding review workshop of Technology Demonstration Component of NICRA of ICAR-ATARI, Hyderabad was held on June 7th, 2021 through video conferencing. The Chief Guest of the meeting was Dr. V.K. Singh, Director, ICAR-CRIDA. Dr. J.V. Prasad, Director, ICAR-ATARI, Hyderabad, Dr. N. Sudhakar, Chairman ZMC, Directors of Extension

Education of ANGRAU-Lam, PJTSAU-Hyderabad, TANUVAS-Chennai, TNAU-Coimbatore, Heads of NICRA KVKs of the concluded districts and also the new districts and KVK staff involved in NICRA project, Project Coordinators at ICAR-CRIDA, Heads of Divisions of ICAR-CRIDA, PI of NICRA participated in the meeting.

14.4. National Webinar on Food and Nutritional Security: Challenges and Opportunities in Rainfed areas

Commemorating the Azadi ka Amrut Mahotsav and 50 Years of All India Coordinated Research Project for Dryland Agriculture celebrations, ICAR-CRIDA in collaboration with Indian Society of Dryland Agriculture (ISDA) organized one day National Webinar on Food and Nutritional Security: Challenges and Opportunities in Rainfed areas on August 16th, 2021. Dr. Ashok Dalwai, I.A.S., CEO, National Rainfed Area Authority, Dr. S.K. Chaudhari, DDG, NRM, Dr. V. Praveen Rao, VC, PJTSAU, Dr. S. Bhaskar, ADG (AAFCC), Dr. V.K. Singh, Director, CRIDA, Dr. A. Vishnuvardhan Reddy, VC, ANGRAU, Dr. V. Tonapi, Director, IIMR, Dr. G. Ravindra Chary, President, ISDA, Er. B. Rath, Technical Expert, NRAA, Mr. Crispino Lobo, WoTR, Pune, Sri, Y.K. Rao, CGM and Sri.Santhanam, DGM, NABARD, Telangana, Dr. A. Ravindra, CEO, WASSAN, Dr. K. Kareemulla, PS, NAARM, Directors of Research, Project Coordinators, Heads of Divisions, chief scientists and scientist from AICRPDA and AICRPAM, scientists from ICAR institutes and SAUs, officials from Departments, research scholars, RAs, SRFs and students, all together 268 participated in the webinar.

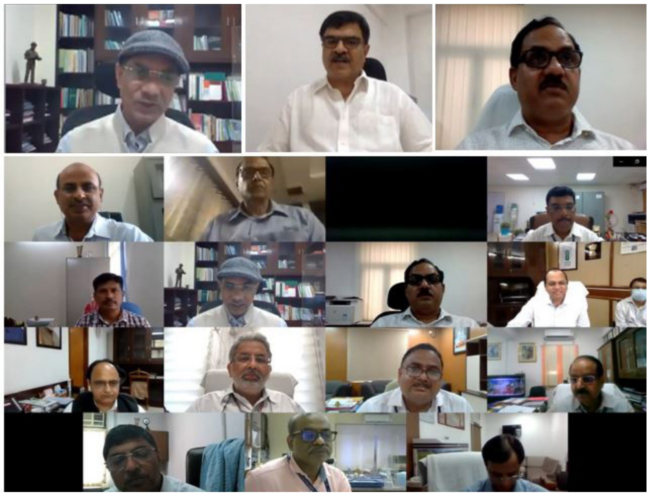
14.5. National Level Campaign on "Food and Nutrition for Farmers"

In commemoration of 75 years of India's independence, ICAR-CRIDA organized *Kisan Gosthis* as part of Azadi Ka Amrit Mahotsav in Adilabad district of Telangana State on August 24th, 2021 on the theme of agriculture and nutrition - the way of tribal agriculture. The scientists and farmer's interactions were held in three-gram panchayats namely Macchapur and Pedda Malkapur in Gudihatnoor mandal and Nadam Guda in Utnoor mandal of Adilabad district. The Kisan Gosthis were held in collaboration with ARS, PJTSAU, Adilabad and line department officials. About 100 farmers participated in these *gosthis*. Farmer were advised to grow nutri-cereals mainly sorghum and oilseed crop like safflower during *rabi*. Farmers were also advised to give up the last picking of cotton by providing irrigation during December/January which doesn't give much yield. The saved water to be diverted for growing sesame and summer green gram. Interested farmers were ensured supply of seeds of improved varieties of above crops under tribal sub-plan (TSP). The idea of diversification and intensification of crops and cropping systems was appreciated by all the farmers and readily agreed to take up these interventions.

14.6. High Level Monitoring Committee Meeting of NICRA Project organized

The 13th High-Level Monitoring Committee (HLMC) meeting of the National Innovations in Climate Resilient Agriculture (NICRA) project was held through virtual mode on September 3rd, 2021. Dr T Mohapatra, Secretary, DARE and Director General, ICAR chaired the meeting. Dr SK Chaudhari, DDG (NRM and AE) welcomed the participants. Shri Sanjiv Kumar, Financial Advisor (DARE); Shri Sanjay Garg, Additional Secretary (DARE) & Secretary (ICAR); Shri Charanjit Singh, Joint Secretary, Rural Livelihoods, MoRD; Shri Govind Sharma, Director (Finance), ICAR; Dr TR Sharma, DDG (Crop Science); Dr JK Jena, DDG (Fisheries); Dr BN Tripathi, DDG (Animal Science); Dr RC Agrawal, DDG (Agricultural Extension); Shri Praveen Malik, Animal Husbandry Commissioner (DAHD), Dr Saurabh Upadhyay, MoEF&CC; Dr Debapriya Dutta, DST; Dr KK Singh, IMD; Dr B Venkateswarlu, Member, NICRA Expert Committee and other officials from various ministries and departments, Dr S Bhaskar, ADG (Agronomy, Agroforestry and Climate change); Dr Adlul Islam, ADG (Soil and Water Management); Dr Vikramaditya Pandey, ADG (Horticultural Sciences); Dr KK Singh, ADG (Agricultural Engineering); Dr Vishesh Saxena, ADG (Animal Scince); Dr V. P Chahal, ADG (Agricultural Extension); Shri Manda Verma, Assistant Commissioner (NRM); Dr VK Singh, Director

(CRIDA), and Scientists from CRIDA, representatives from various Ministries and Departments also participated and provided inputs. Hon'ble DG, ICAR stressed up on the documentation of state-specific climate resilient technologies for their inclusion in NMSA and state action plans. He emphasized to assess the impact of technology demonstration component on socio-economic status of the farmers in the adopted villages.



14.7. A talk on "Evolution of Agricultural Extension Policies in India: implications for Future".

A talk on Evolution of Agricultural Extension Policies in India: implications for Future was organized as part of "Azadi ka Amrit Mahotsav" by ICAR-Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad on September 15th, 2021 through video conferencing mode. Dr Vinod Kumar Singh, Director, ICAR-CRIDA, Hyderabad chaired the meeting. Dr. Suresh Chandra Babu FNAAS Head, Capacity Strengthening, IFPRI, Washington DC, USA was the guest speaker. Dr V.P Chahal ADG, Agricultural Extension, Directors of ICAR institutes, Scientists from CRIDA and other ICAR institutes research scholars and students participated in the programme.

14.8. World Food Day

A virtual program has been organized by the ICAR-Central Research Institute for Dryland Agriculture and KVK-Ranga Reddy on the occasion of the World Food Day on October 16th, 2021 as part of *Azad Ka Amrut Mahostav* under the Chairmanship of the Director, ICAR-CRIDA. Various technologies and programmes helping to overcome this endemic problem have been discussed in depth.

14.9. Seminar on New Farm Laws: Issues and Concerns for Agriculture Development, Livelihood and Food Security in Telangana

A one-day seminar on New Farm Laws: Issues and Concerns for Agriculture Development, Livelihood and Food Security in Telangana State was organized by ICAR-Central Research Institute for Dryland Agriculture, Hyderabad in association with Telangana Economic Association on October 22nd, 2021. Dr.V.K. Singh, Director ICAR-CRIDA in his opening remarks mentioned that the three farm laws are beneficial to the farmers in enhancing farmers' incomes through creating new markets in addition to the existing APMC markets. He mentioned that among three laws, the Farmers' Produce Trade and Commerce (Promotion and Facilitation) Act is more important and will help in increasing and attracting private investment in agricultural market infrastructure. He also mentioned that the second law the Farmers (Empowerment and Protection) Agreement of Price Assurance and Farm Services Act will safeguard farmers' interests and ensure grievance redressal. The Essential Commodities (Amendment) Act will enhance investments in postharvest and storage infrastructure. Prof. Linga Murthy, President, Telangana Economic Association dealt with the pros and cons of the laws and stressed the need for wider discussion.

Prof. Ramesh Chand, Member, NITI Aayog, Government of India, in his key note address explained that the actual process of stakeholders' constitution, discussion with the farmers began long back and took inputs from all sections of the society and political parties while framing the laws.

14.10. National Agriculture Education Day

ICAR-CRIDA celebrated National Agriculture Education Day on December 3rd, 2021 to mark the birth anniversary of first President of Independent India and Union Minister of Agriculture, Bharat Ratna (Late) Dr. Rajendra Prasad. The objective of this day is to expose the students in schools to various facts of agriculture and its relevance to country›s development, inspire them and attract them towards agriculture, so that they develop interest in agriculture and allied subjects, choose professional career in some of these courses, engage themselves in agriculture and related activities or become agri-entrepreneurs in future.

14.11. World Soil Day

1. Chincholi, Kalaburgi District, Karnataka

ICAR-CRIDA organised World Soil Day on December 5th, 2021 at Chincholi, Kalaburgi district Karnataka in association with Department of Agriculture, Karnataka. The event was organised at the farm of one of the progressive farmer Shri Basawraj. About 75 farmers from Kalabhavi and Bhogalindahalli, SCSP villages of ICAR-CRIDA and farmers from other villages attended the programme.

2. Pudur Mandal, Vikarabad District, Telangana

World Soil Day was organized on December 5th, 2021 at Gangupally Village, Pudur Mandal, Vikarabad District under Farmer FIRST project. Dr. M. Osman, Head PME and Director I/c, CRIDA, Dr, K. Sammi Reddy Head, DRM, Dr. Sanjeev Reddy, Principal Scientist (FMP), B Narsimulu, Senior Scientist (SWC) and G. Nirmala PI of Project participated in the programme. Informative lectures were delivered by scientists on soil fertility and soil health management practices followed by interaction session on issues of soil and crop management practices. 100 soil health cards had been distributed to farmers on this occasion.

14.12. Regional Campaign on Organic Farming

A regional campaign on organic farming was organized on December 18th, 2021 at Gaddamallaighguda village of Yacharam Mandal, Rangareddy district as a part of Azadi Ka Amrut Mahostav, celebrating 75 years of India's Independence. The campaign was held in the organic farm of Sri Srinivasa Rao, progressive farmer, to provide exposure to the farmers. About 40 farmers of Rangareddy district attended the campaign. Dr K. Srinivas, Principal Scientist, explained to the farmers about the benefits of organic farming in terms of input cost reduction and healthy produce for home consumption, and to society through the avoidance of use of synthetic inputs and consumption of healthy and chemical free agricultural products. Dr S. M. Vidyasekhar, Subject Matter Specialist, Plant Protection, KVK-Rangareddy district explained about pest and disease prevention and control using organic methods and inputs. Dr. D. Sudheer, Subject Matter Specialist, Veterinary Science, KVK-Rangareddy district explained about efficient fodder production and feed management techniques and health care of livestock. Mr Srinivasa Rao and Mr. Suresh Reddy, organic farmers shared their experiences and views on organic farming with the farmers.

Distinguished Visitors 15

Visit of Dr. Suresh Kumar Chaudhari, Deputy Director General (Natural Resource Management), ICAR

Dr. Suresh Kumar Chaudhari, Deputy Director General (Natural Resource Management), ICAR visited ICAR-Central Research Institute for Dryland Agriculture from October 29-31, 2021. During his three days visit to the institute, he inaugurated various facilities, interacted with all staff of CRIDA and reviewed the ongoing research work of the institute. On 29th October, 2021, Dr. Suresh Kumar Chaudhari, Deputy Director-General, inaugurated the First-aid Room and visited the various research facilities and laboratories at the main campus. Later, DDG visited Hayatnagar Research Farm (HRF) and Gungal Research Farm.

Dr. Suresh Kumar Chaudhari, Deputy Director General (Natural Resource Management), ICAR, visited ICAR-CRIDA, Hyderabad

Hon. Governor of Maharashtra, Shri Bhagat Singh Koshiyari visited bamboo demonstration plot/exp managed by Dryland Research centre

Visit of Hon'ble Governor of Maharashtra to AICRP Dryland Agriculture, Parbhani centre

Hon. Governor of Maharashtra, Shri Bhagat Singh Koshiyari visited experiment a bamboo demonstration plot/exp managed by Dryland Research centre along with Dr. A. S. Dhawan, Hon. Vice-Chancellor, Smt. Aanchal Goyal, DM Parbhani on, 7 August, 2021. During the visit, Hon. Governor stated that such type of Bamboo plantation will help to enhance the income of Dryland farmers. This can be an alternate source of income for them. Dr. D. P. Waskar, Director of Research, Dr. W. N. Narkhede Chief Scientist and Dr. M. S. Pendke Agril. Engineer were present and explained the activities of the bamboo program for the rainfed economy.

Personnel 16

Institute staff as on 31st December 2021; Not a gradation list

Director Cell	
Dr. V.K. Singh	Director
Sri M.S.R. Anjaneyulu	Private Secretary
Smt M. Vanitha Raman	Private Secretary
All India Coordinated Research Project for Dryland Agriculture (AICRPDA)	
Dr. G. Ravindra Chary	Project Coordinator (Acting)
Dr. K.A. Gopinath	Principal Scientist (Agronomy)
Dr. B. Narsimlu	Senior Scientist (Soil & Water Conservation Engg.)
Dr. K.B Sridhar	Scientist Senior Scale (Agroforestry)
Sri. S. Shankar Reddy	Skilled Support Staff
All India Coordinated Research Project on Agro meteorology (AICRPAM)	
Dr. Santanu Kumar Bal	Project Coordinator (I/c) Principal Scientist (Agricultural Meteorology)
Dr. A.V.M. Subba Rao	Principal Scientist (Agricultural Meteorology)
Dr. M.A. Sarath Chandran	Scientist (Agricultural Meteorology)
Sri N. Manikandan	Scientist (Agricultural Meteorology)
Sri A. Mallesh Yadav	Skilled Support Staff
Division of Resource Management	
Dr. K. Sammi Reddy	Head (Acting)
Dr. G. Rajeshwar Rao	Principal Scientist (Agroforestry) (on deputation)
Dr. K. Srinivas Reddy	Principal Scientist (Soil & Water Conservation Engg.)
Dr. S.S. Balloli	Principal Scientist (Soil Science)
Dr. D.B.V. Ramana	Principal Scientist (Livestock Production & Management)
Dr. G. Pratibha	Principal Scientist (Agronomy)
Dr. K. Srinivas	Principal Scientist (Soil Science)
Dr. I. Srinivas	Principal Scientist (Farm Machinery Power)
Dr. J.V.N.S. Prasad	Principal Scientist (Agronomy)
Dr. K.V. Rao	Principal Scientist (Soil & Water Conservation Engg.)
Dr. B. Sanjeeva Reddy	Principal Scientist (Farm Machinery Power)
Dr. Ravikanth V. Adake	Principal Scientist (Farm Machinery Power)
Dr. Manoranjan Kumar	Principal Scientist (Soil & Water Conservation Engg.)
Dr. B. Krishna Rao	Principal Scientist (SWCE) (on deputation)
Dr. R. Rejani	Principal Scientist (Soil & Water Conservation Engg.)
Dr. G. Venkatesh	Senior Scientist (Forestry)
Sri. N.S. Raju	Scientist (Computer Applications in Agriculture)
Smt. Pushpanjali	Scientist (Soil Science- Pedology)
Dr. A. K. Indoria	Scientist (Soil Physics)
Dr. Girija Veni	Scientist (Soil Science and Agril. Chemistry)
Dr. Sumanta Kundu	Scientist (Agronomy)

Sri. Ashish S. Dhimate	Scientist (Farm Machinery Power)
Dr. Suvana Sukumaran	Scientist (Soil Science)
Sri. Ram Kumar	Chief Technical Officer
Smt. D.G.M. Saroja	Technical Officer
Sri. Hemanth Sahu	Senior Technical Assistant
Sri. K. Rajeshwar	Senior Technician
Division of Crop Sciences	
Dr. S.K. Yadav	Head (I/c), Principal Scientist (Biochemistry)
Dr. M. Vanaja	Principal Scientist (Plant Physiology)
Dr. V. Maruthi	Principal Scientist (Agronomy)
Dr. M. Srinivasa Rao	Principal Scientist (Entomology)
Dr. Arun Kumar Shanker	Principal Scientist (Plant Physiology)
Dr. M. Prabhakar	Principal Scientist (Entomology)
Dr. N. Jyothi Lakshmi	Principal Scientist (Plant Physiology)
Dr. Basudeb Sarkar	Principal Scientist (Plant Breeding)
Dr. N. Ravi Kumar	Principal Scientist (Computer Applications in Agriculture)
Dr. K. Sreedevi Shankar	Principal Scientist (Food & Nutrition)
Dr. T.V. Prasad	Principal Scientist (Entomology)
Dr. M. Manjunath	Scientist (Agri. Microbiology)
Dr. A.Gopala Krishna Reddy	Scientist (Horticulture)
Dr. K. Salini	Scientist (Plant Breeding)
Dr. V. Visha Kumari	Scientist (Agronomy)
Er. C.V.K. Nageswara Rao	Chief Technical Officer
Sri. S.S. Sishodia	Technical Officer
Sri. P. Sathish	Senior Technical Assistant
Smt. Lakshmi Aruna Gayathri	Technical Assistant
Smt. B. Saraswati	Personal Assistant
Sri. Md. Asif Ahmed	Skilled Support Staff

Section of Transfer of Technology	
Dr. G. Nirmala	Head & Principal Scientist (Agri. Extension)
Dr. K. Ravi Shankar	Principal Scientist (Agri. Extension)
Dr. K. Nagasree	Principal Scientist (Agri. Extension)
Dr. P. K. Pankaj	Senior Scientist (Livestock Production & Management)
Dr. Jagriti Rohit	Scientist (Agri. Extension)
Dr. C.N. Anshida Beevi	Scientist (Agri. Extension)
Sri. S. Yadagiri	Assistant Chief Technical Officer
Section of Design and Analysis	
Dr. C.A. Rama Rao	Head & Principal Scientist (Agri. Economics)
Dr. A. Amarender Reddy	Principal Scientist (Agri. Economics)
Dr. B.M.K. Raju	Principal Scientist (Agri. Statistics)
Dr. R. Nagarjuna Kumar	Scientist (Computer Applications in Agriculture)
Dr. Josily Samuel	Scientist (Agri. Economics)
Smt. C. Kanaka Durga	Personal Assistant

Prioritization, Monitoring and Evaluation Cell (PME Cell)	
Dr. M. Osman	Head & Principal Scientist (Agronomy)
Dr. Arun Kumar Shanker	Principal Scientist (Plant Physiology)
Dr. S.S. Balloli	Principal Scientist (Soil Science)
Sri. N.S. Raju	Scientist (Computer Applications in Agriculture)
Sri P. Ramakrishna	Senior Technical Assistant
Shri Amit Srivastava	Assistant Chief Technical Officer
Library	
Dr. K. Salini	OIC & Scientist (Plant Breeding)
Sri. P. Venkateshwarlu	Technical Assistant
Krishi Vigyan Kendra (KVK)	
Dr. D.B.V. Ramana	Head & Principal Scientist (Livestock Production & Management)
Dr. S.M. Vidyasekhar	Chief Technical Officer (Plant Protection)
Dr. D. Sudheer	Assistant Chief Technical Officer (Veterinary Sciences)
Er. S. Vijaya Kumar	Assistant Chief Technical Officer (Agri. Engineering)
Sri. G. Srikrishna	Assistant Chief Technical Officer (Horticulture)
Sri D. Sridhar	UDC
Hayathnagar Research Farm (HRF)	
Dr. I. Srinivas	OIC, Principal Scientist (Farm Machinery Power)
Dr. K. Venkanna	Assistant Chief Technical Officer
Sri. K. Shankaraiah	Technical Officer
Sri. B. Kurmaiah	Senior Technician
Sri. Mukund Chalkapur	Senior Technical Assistant
Sri. Golla Raju	Senior Technician
Sri. Govinda Lingaiah	Technician
Sri. Chalamcherla Singa Raju	Technician
Sri. Jakkidi Ramana Reddy	Technician
Smt. Avula Lalitha	Skilled Support Staff
Smt. N. Laxmamma	Skilled Support Staff
Sri J. Mallesh	Skilled Support Staff
Gunegal Research Farm (GRF)	
Dr. G. Pratibha	OIC & Principal Scientist (Agronomy)
Sri. Y. Yellappa	Technical Officer
Sri. Bandi Srikanth Goud	Technical Assistant
Sri. B. Krishna	Senior Technical Assistant
Sri. Chakali Buchaiah	Skilled Support Staff
Agriculture Knowledge Management Unit (AKMU)	
Dr. N. Ravi Kumar	OIC & Principal Scientist (Computer Applications in Agriculture)
Sri. P. Chandra Sekhar	Chief Technical Officer (Computer)
Institute Women's Complaints Committee	
Dr. M. Vanaja	Chairperson & Principal Scientist (Plant Physiology)
Dr. C.A. Rama Rao	Member & Principal Scientist (Agri. Economics)
Dr. K. Sreedevi Shankar	Member & Principal Scientist (Food & Nutrition)
Dr. K. Nagasree	Member & Principal Scientist (Agri. Extension)

Smt. D. Kalpana	Member & Assistant Administrative Officer
Vigilance Officer	
Dr. M. Srinivasa Rao	Principal Scientist (Entomology)
Works	
Dr. B. Sanjeeva Reddy	OIC & Principal Scientist (Farm Machinery Power)
Dr. B. Narsimlu	Member & Senior Scientist (Soil & Water Conservation Engg.)
Sri Ram Kumar	Member & Chief Technical Officer
Sri K. Narsimha	Member & Assistant Administrative Officer
Sri. G. Nagesh Kant Rao	Assistant Chief Technical Officer
Vehicle Section	
Dr. Ravikanth V. Adake	OIC & Principal Scientist (Farm Machinery Power)
Sri. K. Ganesh	Technical Officer
Sri. P. Raju	Technical Assistant
Sri. K. Shankar	Technical Assistant
Sri. Ahmed Pasha	Senior Technical Assistant
Landscape	
Dr. Gopala Krishna Reddy	OIC & Scientist (Horticulture)
Sri. Avinash Brahamwanshi	Technician
Administrative Section	
Sri. Charles Ekka	Chief Administrative Officer
Sri. V. Sanu	Assistant Administrative Officer
Sri. K. Narsimha	Assistant Administrative Officer
Smt. D. Kalpana	Assistant Administrative Officer & DDO
Sri. G. Prabhakar	Assist. Chief Technical Officer
Smt. M.A. Rekha	Personal Assistant
Smt. G.M. Shashi Rekha	Personal Assistant
Sri. M. Yadaiah	Assistant
Sri. K. Gowtham Reddy	Assistant
Sri. M. Krishna Reddy	Assistant
Sri. Putta Santosh	Assistant
Ms. Sneha Verghese	Assistant
Smt. S. Swathi Kiran	U.D.C.
Smt. J. Kavitha	U.D.C.
Sri. Bollampalli Prashanth	U.D.C.
Sri. B. Ramakrishna	Skilled Support Staff

Finance and Audit Section	
Sri. N.V.R.N Murthy	Chief Finance & Accounts Officer
Sri. R. Sudharshan	Assistant Finance & Accounts Officer
Sri. G. Udaya Bhaskar	L.D.C.
Sri. G. Anjaiah	Skilled Support Staff
Guest House	
Sri Amit Srivastava	In-charge & Assist. Chief Technical Officer
Sri. P. Venkateshwarlu	Technical Assistant