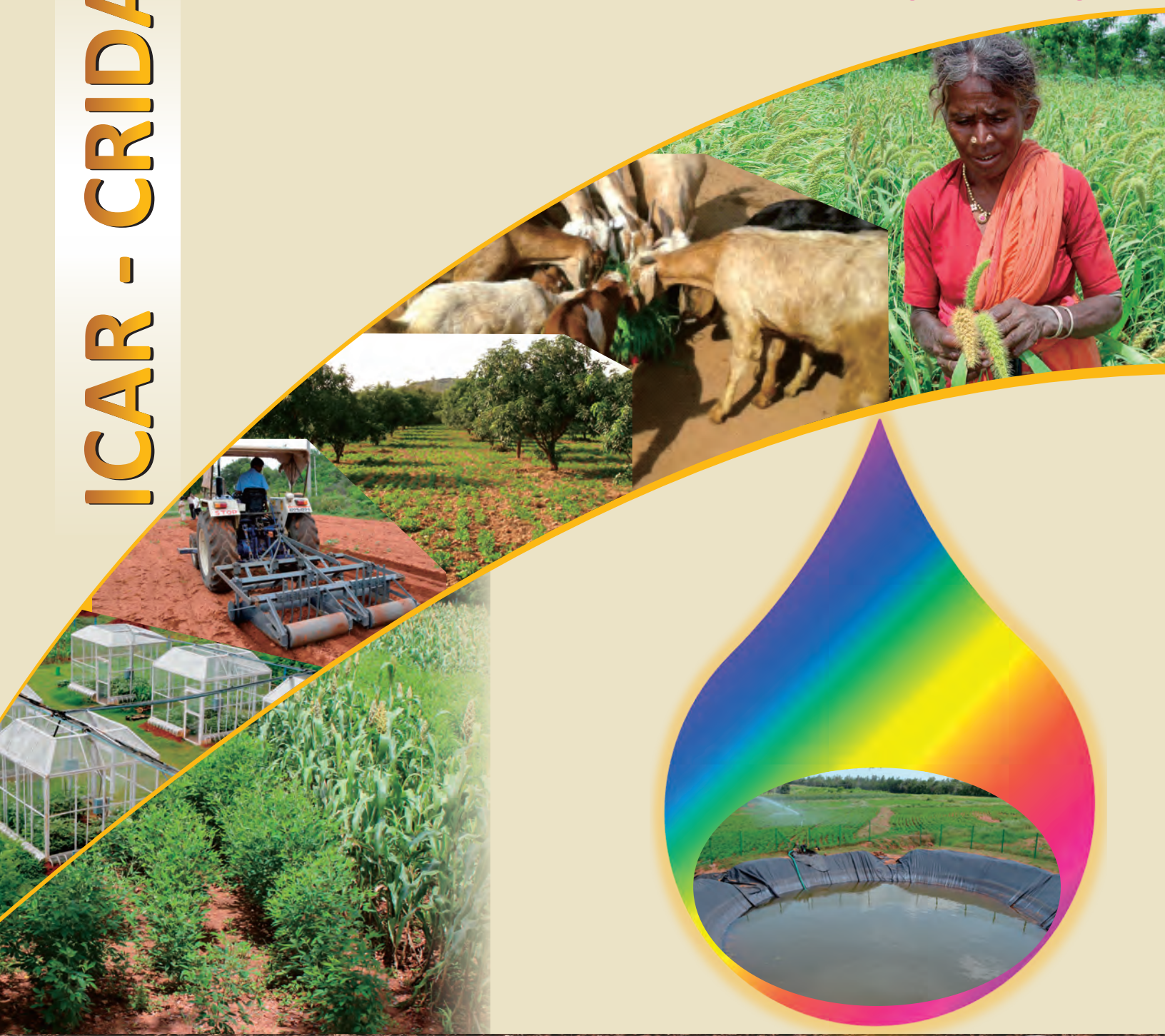
वार्षिक प्रतिवेदन
Annual Report
2017-18

ICAR - CRIDA



भाकृअनुप - केंद्रीय बारानी कृषि अनुसंधान संस्थान
ICAR - Central Research Institute for Dryland Agriculture
Santoshnagar, Hyderabad - 500 059 (Telangana)

ISO 9001 : 2008 Certified Institute

Live telecast of Krishi Unnati Mela, New Delhi in ICAR-CRIDA campus on March 17th, 2018

"Farmers and Scientists are Two Sentinels of New India and they have to Work Together to Transform Agriculture"

Sri Narendra Modi ji

Front Cover Page

The theme of the aggregation of pictures on cover page is CRIDA working towards doubling the farmer's income. The soil picture at base is the mother of all interventions which need to be supplemented with rainwater management as exhibited in the rain drop. The seven colours in water drop suggests water as the base to achieve rainbow revolution in agriculture. Beside the raindrop, cropping system is the primary biomass producer followed by technologies to make the agriculture climate resilient. Thereafter from left to right upwards the picture follows is agriculture mechanization to match the efficient harvesting. This is followed by integrated farming system by using horticulture and small ruminants. Ultimately through the use of CRIDA technologies, a farmer in dryland is able to harvest good yield and improved income.

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Preface

I am extremely happy and privileged to present the annual report of ICAR-CRIDA for the year 2017-18. During the reporting year, ICAR-CRIDA has made eloquent progress in technology development and dissemination associated with climate change in rainfed agriculture and dealing contingencies in agriculture and allied sector.

The institute has received copyright for "Unreaped yield potentials in major rainfed crops and scope for bridging yield gaps - A decision support system". ICAR-CRIDA along with SAUs and KVKs prepared contingency plans at district level for all the 126 agro-climatic zones of the country (623 districts) to deal with weather related aberrations. An IFS module with cotton, vegetables, fodder and small ruminants with farm pond using portable raingun at Chenchu tribal farmer field implemented in Petrallachenu village of Nagarkurnool district showed positive impact on socio economic condition of the farmer with total net income of Rs. 96,605/- over the traditional system of growing only rainfed cotton, which gave negative returns of Rs. (-) 3600. A small scale solar powered micro-irrigation system was designed and installed for small farmers having one acre or less land under farm pond system for growing vegetables. The assessment based on daily rainfall dataset, annual average effective rainfall and runoff percentages helped in developing the expected runoff in various rainfall zones, which could be used to estimate the runoff in meso-scale watersheds. Seven inbreds of maize (DTL2, SNJ2011-03, SNJ2011-37, SNJ2011-26, Z101-15, Z32-12 and HKI7660) were found to be promising for use in crop improvement programme under rainfed conditions. 4:4 strip intercropping system of sorghum and pigeonpea with relay horse gram performed better compared to traditional 2:1 intercropping system. In a study on resource conserving technologies, conventional tillage recorded 15% lower maize yields as compared to conservation agriculture practices. Intensive system of rearing livestock not only improved the profitability but also significantly reduced methane emissions as compared to semi-intensive and extensive systems. Heat

Load Index (HLI) and Temperature Humidity Index (THI) was found to be better choice for comparing heat stress in extensively and intensively reared sheep, respectively. A rotary implement for weeding operation was developed to effectively utilize low horse power tractor for field applications. A raised bed planter cum herbicide applicator was developed and the design was transferred to Avanthi Bufa Industries Ltd., Jahirabad. Farmers' first project, envisaged to transfer rainfed technologies with objective of doubling farmers income is being implemented in 4 villages of Pudur mandal of Vikarabad district.

Among 12 pigeonpea genotypes AKT-8811, PUSA-33, GRG-276-1 and RVK-274 were the high yielders in both unstressed and rainfed conditions. An econometric analysis of impact of climate change on crop yields showed that the impacts would be more severe and widespread towards the end of the century. Under changing climatic scenarios, runoff is not expected to vary much in Vijayapura district under low or medium emission scenarios, but the high runoff potential available under the present scenario itself shows substantial scope for rainwater harvesting and its utilization for supplemental irrigation. Decreased grub duration with increased predation capacity of *M. sexmaculatus* on *A. craccivora* with elevated CO_2 indicated increased predation in future climate change scenarios. For assessing the real time climate change impacts on crop water requirements, SCADA

based rainfall simulator and precision lysimeter was designed and developed by using state of art process automation instrumentation in climate change research complex at Hayathnagar. Rotavator, cultivator and disc plough + harrow recorded higher GHG emissions and global warming potential, whereas animal drawn implements recorded lower emissions. Evaluation of the performance of different crops under organic, inorganic and integrated production systems showed that yield of sunflower was 14 and 7% higher under integrated management (1374 kg/ha) than that of under inorganic and organic management, respectively. Supplementation of chromium propionate @ 200 ppb can help in mitigation of heat stress in grazing lambs. An experiment to evaluate 36 elite clones of short rotation and high biomass yielding multipurpose tree species (*M. dhubia*, Casuarina, *B. balcoa*, *D. sisoo* and Eucalyptus) was established at Hayathnagar Research Farm.

The KVK under technology assessment and refinement has assessed 17 technologies through 115 trials on crop varieties, integrated crop management, horticulture and livestock management. 269 Frontline demonstrations on 19 technologies were conducted in different disciplines. It also organized 115 need based and skill oriented training programmes on various aspects of improved technologies to 3005 clientele farmers and filed level extension workers. Two special skill development programmes allotted by Department of Horticulture, Government of Telangana in the disciplines of " farm pond construction and lining" were organized for 520 rural youths.

Exemplary performance of its scientists were visible as two scientists attended trainings/exposure visit outside the country and 52 graduate and post graduate students carried out research work at ICAR-CRIDA. Sustained performance of its scientists were exhibited in terms of 20 scientists of Institute receiving several awards, fellowships, copyright and recognition from national academies, professional societies and other institutions. The scientists of the institute published a total of 116 research articles in international and national journals, 29 books/bulletins including 2 in Hindi and 112 book chapters. The contributions of scientists also appeared in the form of a number of policy papers, bulletins, popular articles, presentations in conferences, e-publications and radio and television programmes.

The collaborations with several Ministries and Departments, SAUs, NGOs and Private Industries reflect its commitment to work hand-to-hand with grow together and finding the technological solutions to the problems of farmers in rainfed regions of India. I would like to place on record my sincere gratitude to Indian Council of Agricultural Research for its continued guidance and support. I appreciate all the committee members of annual report for their timely compilation and shaping this report in time.

Hyderabad
May, 2018

(*K Sammi Reddy*)
Director (Acting)

Contents

कार्यकारी सारांश

संसाधन लक्षण

- वर्ष 2017 के दौरान, हैदराबाद में मानसून का आगमन 12 जून को हुआ। खरीफ मौसम में कुल वर्षा 740 मि.मी. हुई। यह लंबी अवधियों की औसत वर्षा (532 मि.मी.) से 39 प्रतिशत अधिक थी।
- जिला स्तरीय कृषि सांख्यिकीय आंकड़ों को भाकृअनुप-केंबाकृअनुसं (क्रीडा) की वेबसाइट http://www.crida.in:82/DDAS/ पर उपलब्ध कराया गया है। हाल ही में उपलब्ध राज्य स्तरीय एवं अखिल भारतीय स्तरीय कृषि सांख्यिकीय आंकड़ों को एकत्रित कर संकलित किया गया है एवं राज्य स्तरीय कृषि सांख्यिकीय आंकड़ों का अद्यतनीकरण (अपडेट) किया गया है।
- वर्षा आधारित प्रमुख फसलों में अप्राप्त उत्पादन क्षमताओं एवं वर्तमान में प्राप्त उत्पादन अंतरालों के बीच की दूरी को कम करने की संभावनाओं के संबंध में एक निर्णय सहायक प्रणाली (डीएसएस) को भाकृअनुप-केंबाकृअनुसं (क्रीडा) की वेबसाइट http://www.crida.in:8129/ पर उपलब्ध कराया गया है। डीएसएस में फसल पोषक उपयोग आंकडों की पुष्टि करनोपरांत उनकी जांचों को विकसित एवं कार्यान्वित किया गया। इसी दौरान 20 फसलों को ध्यान में रखते हुए जिला स्तरीय समग्र वर्षा आधारित फसल उत्पादन क्षमताओं का सूचकांक तैयार किया गया।
- डीएसएसएटी, इनफोक्रॉप एवं एपीएसआईएम फसल अनुकरण मॉडलों का उपयोग करते हुए ज्वार पर जलवायु परिवर्तन के अनुमानित प्रभावों की जांच, पुष्टि एवं मूल्यांकन करने के लिए परियोजना के एक भाग के रूप में तीन अलग-अलग अवधियों में ज्वार की तीन किस्मों की बुआई की गई। उत्पन्न जननिक गुणाकों का उपयोग कर डीएसएसएटी मॉडल की जांच ने दर्शाया कि विभिन्न प्राचलों में देखे गए परिणामों एवं मॉडल द्वारा अनुकरित किए गए परिणामों के बीच अच्छा अनुबंध था।
- भाकृअनुप-केंबाकृअनुसं (क्रीडा) एवं कृषि तथा सहकारिता विभाग (डीएसी), कृषि एवं किसान कल्याण मंत्रालय सहित राज्य कृषि विश्वविद्यालयों और कृषि विज्ञान केंद्रों ने मौसम संबंधी प्रतिकूलताओं से जूझने के लिए देश के सभी 126 कृषि-जलवायुवीय क्षेत्रों के लिए जिला स्तर पर आकस्मिक योजनाओं की तैयारी की जिम्मेदारी ली है। देश के 623 जिलों के लिए आकस्मिक योजनओं की तैयारी की गई है एवं इसे भारतीय कृषि अनुसंधान परिषद (भाकृअनुप-आईसीएआर) और कृषि एवं सहकारिता विभाग (डीएसी) की वेबसाइटों (http://agricoop.nic.in/acp.html, http://www.crida.in/) पर उपलब्ध कराया गया है। राज्य सरकारों को आकस्मिक योजनाओं के सफल संचालन और संवेदनशील बनाने हेतु खरीफ मौसम 2017 के आगमन से पूर्व ही कई राज्यों में इंटरफेस बैठकों का आयोजन किया गया।

वर्षाजल प्रबंधन

- संसाधनों के समुचित उपयोग पर आधारित ज्ञान द्वारा जलवायु समुत्थान जल कुंड (वाटरशेड) का निर्माण आवश्यक है। इस दिशा में रंगा रेड्डी जिले के याचारम मंडल में स्थित गड्डा मल्लैय्या गुडा गांव में प्राकृतिक संसाधनों के समुचित प्रबंधन, विभिन्न कृषि प्रणालियों एवं संबंधित उद्यमों की खाद्यान्न, पोषण एवं जीविकोपार्जन सुरक्षा को सुनिश्चित करने के लिए वर्ष 2015 में जल कुंड (वाटरशेड) का निर्माण किया गया। वर्षाजल को संरक्षित करने के लिए अनेक वर्षाजल संग्रहण संरचनाएं, ढ़ीले पत्थरों की दीवार (लूज बोलडर) एवं पीपा संरचनाएं (गैबियन संरचनाएं) तथा पुरानी जल संग्रहण संरचनाओं (अंतस्रवण तालाब/पोखर) का निर्माण करके किसानों के खेतों पर विद्यमान खुले एवं गहरे कुओं में जल पुन:भरण का प्रयास किया गया। गहरे कुंओं (बोरवेल) में जल स्तर को बढ़ाने के लिए कृत्रिम बोरवेल पुन:भरण तकनीकियों का विकास कर प्रदर्शित किया गया।
- नागरकर्नूल जिले के पेट्रल्लाचेनु गांव में एक जनजाति किसान द्वारा 3 एकड भूमि में कपास, सब्जियां, चारा और छोटे पशुओं का पालन एवं कृषि तालाब के माध्यम से समेकित कृषि प्रणाली मॉडल को अपनाने से कुल 96,605/-रुपए की आय प्राप्त हुई एवं किसानों की सामाजिक-आर्थिक परिस्थिति पर भी सकारात्मक प्रभाव पडा। जबकि, केवल वर्षा आधारित कपास को पारंपरिक प्रणाली में उगाने से 3600/-रुपए का नकारात्मक प्रतिफल प्राप्त हुआ। वर्षा आधारित कपास में पोर्टबल रेनगन प्रणाली का उपयोग कर कृषि तालाब से पूरक (30 मि.मी. कम) सिंचाई देने से कपास के उत्पादन में तिगुनी वृद्धि हुई।
- कृषि तालाब प्रणाली के अंतर्गत सब्जियों को उगाने के लिए एक एकड या उससे कम भूमि वाले छोटे किसानों के उपयोग के लिए छोटे आकार की सौर ऊर्जा युक्त सूक्ष्म सिंचाई प्रणाली की डिजाइन तैयार कर इसे स्थापित किया गया। परिणाम दर्शाते हैं कि तरबूज की उत्थित क्यारी प्रणाली में बुआई करके इसमें जैविक पलवार (4.8 किलोग्राम प्रति घन मीटर) एवं पलवार रहित (2 किलोग्राम प्रति घन मीटर) की तुलना में प्लास्टिक पलवार से (5.6 किलोग्राम प्रति घन मीटर) अधिक जल उत्पादकता देखी गई।
- आंध्र प्रदेश में लघु स्तर पर वर्तमान में चालू जलकुंड (वाटरशेड) विकास का पर्यावरणीय मूल्यांकन, आर्थिक एवं सामाजिक प्रभावों को समृद्ध एवं अद्यतन करने के समेकित दृष्टिकोण के लक्ष्य से

अनुसंधान परियोजना कार्यरत है। देश में स्थित हरेक केंद्र के लिए एफ्रोडाइट के 0.25 डिग्री विस्तार (रेसोलुशन) पर आधारित दैनिक वर्षा आंकडे, वार्षिक औसत प्रभावी वर्षा एवं वार्षिक औसत अपवाह प्रतिशत की गणना की गई। यह आंकलन विभिन्न वर्षा क्षेत्रों में अपेक्षित अपवाह की जानकारी प्रदान करता है, जिसका उपयोग समेकित जलकुंड (वाटशेड) प्रबंधन कार्यक्रम परियोजना के लिए जलकुंड (वाटशेड) में अपवाह का अनुमान लगाने के लिए किया जा सकता है।

फसल एवं फसल प्रणालियां

- मक्का में जननिक वृद्धि एवं सूखा सहिष्णुता के लिए क्युटीएल मानचित्रण एवं संबंधित अध्ययनों में उपयोग के लिए मानचित्रण जनसंख्या का विकास किया गया ताकि जनक के रूप में इसका उपयोग किया जा सके। इसके लिए सूखा सहिष्णु वाले अंत:प्रजातक विकास करने एवं चित्रण के लिए 2014 में एक परियोजना का आरंभ किया गया। वर्षा आधारित परिस्थितियों के अंतर्गत मूल्यांकन पर आधारित फसल सुधार कार्यक्रम में उपयोग के लिए सात अंत:प्रजात (डीटीएल 2, एसएनजे 2011-03, एसएनजे 2011-37, एसएनजे 2011-26, जेड 101-15, जेड 32-12 एवं एचके 17660) आशाजनक पाए गए। वर्षा आधारित परिस्थितियों के अंतर्गत तीन संकर किस्में (एचके 17660/ एसएनजे 2011-26, आरजेआर 385 / एसएनजे 2011-26, जेड 10115 / एसएनजे 2011-26) अधिक उत्पादन देने वाली एवं सूखा सहिष्णु पाई गई एवं ये व्यवसायिक संकरों के समान थी। सूखा संबंधी जांचों के लिए पुन:संयोजक अंत:प्रजात वंशावलियों के विकास के लिए एफ 7.8 से एचके 1161 / एसएनजे 2011-26 की मानचित्रण जनसंख्या की एकल पौधा संततियों को उन्नत बनाया गया।
- खरीफ 2017 के दौरान, खेत की परिस्थितियों के अंतर्गत अठाइस कुल्थी जीनरूपों के मूल्यांकन ने दर्शाया कि सीआरएचजी 1, सीआरएचजी 3, सीआरएचजी 9 एवं सीआरएचजी 10, अन्य जारी किस्मों से बेहतर निष्पादन वाले थे। जननद्रव्य में भी सूक्ष्म पोषकों की मात्राओं के लिए काफी विविधता देखी गई, विशेषकर लोहे की मात्रा, जिसकी सीमा 27 से 104 मि.ग्रा. प्रति किलोग्राम थी। एक मौसम के दौरान प्राप्त आंकडों के आधार पर यह पाया गया कि परिवेशी कार्बन-डाइ-आक्साइड की तुलना में उत्थित कार्बन-डाइ-आक्साइड के अंतर्गत कुल्थी की किस्मों ने बेहतर निष्पादन दिया। इस पुष्टि के लिए इस जांच को दोहराने की आवश्यकता है।
- ग्वार की प्रविष्टियां, आरजीआर 16-7, आरजीसी-1033, सीएजेडजी 17-4, एचजी-2-20 एवं आरजीसी 1066 प्रारंभिक किस्म जांच में अधिक उत्पादक पाए गए। कुल्थी प्रविष्टियों की प्रारंभिक किस्म जांच में, सीआरएचजी-19, सीआरएचजी-22, एटीपीएचजी-11, सीआरएचजी-26 एवं बीएसपी 17-3 ने अधिक बीज उत्पादन दर्ज किया एवं सीआरएचजी-26, वीएचजी-15, सीआरएचजी-22, वीएचजी 935 एवं एटीपीएचजी-11 ने अधिक चारा उत्पादन दर्ज किया।
- पारंपरिक 2:1 अंतर सस्ययन प्रणाली की तुलना में रिले रूप में बोई गई कुल्थी में उन्नत सूक्ष्म जलवायु एवं अच्छी वर्षा की मात्रा ग्रहण के लिए पर्याप्त जगह की उपलब्धता के कारण रिले कुल्थी सहित ज्वार एवं अरहर की 4:4 पट्टीदार अंतर सस्ययन प्रणाली (प्रति स्थापना श्रंखला) में अरहर में अधिक संख्या में शाखाओं सहित उन्नत उत्पादन हुआ।
- वर्षा आधारित परिस्थितियों के अंतर्गत पारंपरिक सस्ययन प्रणालियों एवं चारा समेकित सस्ययन प्रणालियों के तुलनात्मक मूल्यांकन ने स्पष्ट किया कि वार्षिक चारा –गीनी घास एवं हेज ल्युसर्न ने क्रमश: 51.6 टन प्रति हेक्टेयर एवं 31.2 टन प्रति हेक्टेयर हरा चारा का उत्पादन दिया। 0.5 हेक्टेयर में ज्वार+अरहर (2:1) एवं 0.5 हेक्टेयर में गीनी घास की चारा आधारित सस्ययन प्रणाली से 1,18,054/-रुपए प्रति हेक्टेयर के सकल प्रतिफल सहित अधिक लाभदायक पाई गई। पशुओं की चारा आवश्यकताओं को पूरा करने की दृष्टि से 0.5 हेक्टेयर में ज्वार+अरहर (2:1) एवं 0.5 हेक्टेयर में हेज ल्युसर्न सहित चारा आधारित प्रणाली ने अधिकतम अपरिष्कृत प्रोटीन एवं उपापचेय ऊर्जा उत्पादनों सहित श्रेष्ठ प्रणाली पाई गई।
- अरहर के दानों में जैव मजबूती (बायोफोरटिफिकेशन) की संभावनाओं के अध्ययन के लिए सिफारिश की गई नाइट्रोजन एवं फासफोरस की मात्रा के साथ फासफेट घुलनशील बैक्टेरिया सहित एवं रहित क्यारियों में आयरन सल्फेट एवं जिंक सल्फेट के विभिन्न संयोगों का मृदा प्रयोग एवं पर्णीय छिड़काव का प्रयोग किया गया। आयरन सल्फेट + जिंक सल्फेट एवं पीएसबी के मृदा प्रयोग से अरहर के बीजों में उन्नत प्रोटीन की मात्रा देखी गई, जबकि, राख की मात्रा बिना लोहा, जिंक या पीएसबी (नियंत्रित क्यारी) में अधिक थी। केवल पीएसबी के प्रयोग से बीज में फासफोरस की मात्रा अधिक देखी गई।

मृदा स्वास्थ्य एवं पोषक प्रबंधन

- दो कर्षण एवं तीन अवशेष धारण उपचारों से लंबी अवधि के अध्ययन के पांचवें वर्ष में, पारंपरिक कर्षण की तुलना में न्यूनतम कर्षण में ज्वार का अनाज उत्पादन 18 प्रतिशत अधिक था एवं बिना अवशेष की तुलना में पिछले वर्ष की उड़द फसल के 100 प्रतिशत अवशेष खेत में ही रखने से 27 प्रतिशत अधिक उत्पादन हुआ। न्यूनतम कर्षण में मृदा में जैविक कार्बन एवं खनिज नाइट्रोजन (अमोनियम + नाइट्रेट) अधिक थे एवं 100 प्रतिशत फसल अवशेष खेत में ही रखने से मृदा को 1438 किलोग्राम प्रति हेक्टेयर कार्बन की मात्रा प्राप्त हुई।

- वर्षा आधारित एल्फीसोल्स में अरहर-अरंड सस्ययन प्रणाली में वर्ष 2009 से विभिन्न कर्षण एवं अवशेष प्रबंधन प्रक्रियाओं सहित संरक्षण कृषि प्रक्रियाओं की संभावित भूमिका का मूल्यांकन किया जा रहा है। वर्ष 2017 में, पारंपरिक कर्षण एवं कम कर्षण की तुलना में शून्य कर्षण से अरहर का बीज उत्पादन क्रमश: 30 एवं 20 प्रतिशत अधिक था। बिना अवशेष (आधार से कटाई) की तुलना में 10 सेंटीमीटर एवं 30 सेंटीमीटर की ऊंचाई पर कटाई द्वारा पिछले अरंड फसल के अवशेषों की धारणा से 25 एवं 30 प्रतिशत अधिक उत्पादन प्राप्त हुआ। खरपतवारों में पारंपरिक एवं कम कर्षण की तुलना में शून्य कर्षण में उच्च प्रजाति समृद्धि एवं विविधता सूचकांक एवं कम समानता सूचकांक देखे गए।
- संसाधन संरक्षण प्रौद्योगिकियों पर किए गए अध्ययन में, संरक्षण कृषि प्रक्रियाओं की तुलना में पारंपरिक कर्षण में मक्का में 15 प्रतिशत कम उत्पादन दर्ज किया गया। संरक्षण कृषि प्रक्रियाओं के अंतर्गत, नमी संरक्षण रहित प्रक्रियाओं की तुलना में स्थाई क्यारी या संरक्षण कूंड द्वारा चौथे सिद्धांत के रूप में स्व-स्थाने नमी संरक्षण एवं खरपतवार प्रबंधन प्रक्रियाओं को लागू करने के परिणामस्वरूप मक्का के बीज उत्पादन में क्रमश: 20 एवं 25 प्रतिशत की वृद्धि हुई। फसल अवशेषों के प्रकार के अनुसार, फसल अवशेषों पर दीमक का संदूषण भिन्न-भिन्न पाया गया। गाय के गोबर की स्लरी या क्लोरोपाइरीफॉस के प्रयोग से दीमक के संदूषण को कम किया गया।
- मक्का-अरहर सस्यावर्तन के अंतर्गत टिकाऊ कृषि एवं नाइट्रोजन प्रबंधन प्रक्रियाओं हेतु विकास करने, ताकि कृषि उत्पादकता, लाभ एवं मृदा स्वास्थ्य को सुधारा जा सके, वर्ष 2012 में एक परियोजना का आरंभ किया गया। वर्ष 2017 में, अरहर के कुल बायोमॉस एवं बीज उत्पादन को कर्षण प्रक्रियाओं एवं नाइट्रोजन स्तर, दोनों ने ही महत्वपूर्ण रूप से प्रभावित किया। पारंपरिक कर्षण की तुलना में कर्षण रहित एवं कम कर्षण में क्रमश: औसत बीज उत्पादन 23.4 एवं 15.1 प्रतिशत अधिक था।
- एक अन्य अध्ययन में वर्ष 2016 से, बाजरा-कुल्थी एवं कपास-अरहर सस्यानुवर्तन में विभिन्न कर्षण एवं पोषक प्रबंधन प्रक्रियाओं के अंतर्गत, फसल प्रणालियों की उत्पादकता, लाभ एवं ग्रीन हाउस गैस उत्सर्जनों का मूल्यांकन किया जा रहा है। वर्ष 2017 में, कर्षण प्रक्रियाओं में शून्य कर्षण में एवं पोषक प्रबंधन प्रक्रियाओं में 125 प्रतिशत सिफारिश किए गए उर्वरक के अंतर्गत, बाजरा का अनाज उत्पादन अधिकतम था। अरहर के बीज उत्पादन में कर्षण प्रक्रियाओं में महत्वपूर्ण अंतर दिखाई नहीं दिया, जबकि 125 प्रतिशत सिफारिश की गई उर्वरक प्रक्रिया में महत्वपूर्ण रूप से अधिक उत्पादन प्राप्त हुआ। कर्षण प्रक्रियाओं में पारंपरिक कर्षण एवं पोषक प्रबंधन प्रक्रियाओं में 125 प्रतिशत सिफारिश किए गए उर्वरक प्रयोग के अंतर्गत नाइट्रस ऑक्साइड का उत्सर्जन अधिक था।
- वर्ष 2010-2013 के दौरान 4 वर्षों के लिए बायोचर उपचारों (3 प्रकार के बायोचर–अरहर का डंठल, अरंड का डंठल एवं कपास का डंठल; 2 दरों का प्रयोग – 3 टन प्रति हेक्टेयर एवं 6 टन प्रति हेक्टेयर एवं प्रयोग के 2 अंतराल - हर वर्ष प्रयोग एवं एकांतर वर्ष प्रयोग) के अवशेष प्रभावों का अध्ययन वर्ष 2014 से किया जा रहा है। आठवें वर्ष में (उपचारों की समाप्ति के चार वर्ष बाद) सिफारिश किए गए उर्वरक + एकांतर वर्ष में 6 टन प्रति हेक्टेयर की दर से अरहर की डंठल से तैयार बायोचर के प्रयोग वाले खेतों में अधिक अरहर उत्पादन प्राप्त हुआ।

पशुधन प्रबंधन

अर्ध-गहन एवं विस्तीर्ण प्रणालियों की तुलना में पशु पालन की गहन प्रणाली से न केवल लाभ में सुधार हुआ बल्कि मिथेन उत्सर्जनों में महत्वपूर्ण रूप से कमी आई। विस्तीर्ण रूप से पाली गई भेड़ों में तापमान के दबाव की तुलना के लिए हीट लोड इंडेक्स बेहतर पाया गया, जबकि, शेडों में पाले गए पशुओं में तापमान दबाव की तुलना के लिए टेंपरेचर ह्युमिडिटी इंडेक्स बेहतर सूचक सिद्ध हुआ। मृदा-पौधा-पशु की पारस्परिक क्रिया पर किए गए अध्ययनों ने स्पष्ट किया कि बारानी पशुधन में आम खनिज कमियों को 1.96:0.32:0.008:1 के अनुपात में डाई-कैल्शियम फॉसफेट, जिंक सल्फेट, कॉपर सल्फेट एवं साधारण नमक की कम लागत के खनिज मिश्रण की सहायता से पूरा किया जा सकता है। साइलेज चारा न केवल कमजोर अवधि के दौरान पोषकों की आपूर्ति करता है, बल्कि इसके अतिरिक्त इसके प्रयोग से 45.56 ग्राम प्रति दिन के नियंत्रण की तुलना में भेड़ 78.89 ग्राम प्रति दिन का औसत दैनिक भार प्राप्त करता है। साधारण बायोमेट्रिक मांपों पर आधारित नेल्लूर भेड़ के भार में अनुमान लगाने के लिए एक समीकरण का विकास किया गया।

ऊर्जा प्रबंधन

- खेत में किए जाने वाले प्रचालनों के लिए कम हार्स पावर वाले ट्रेक्टर का प्रभावी उपयोग करने के लिए, अधिक सफाई करने वाले एवं उन्नत ट्रेक चौडाई प्लेटफार्म एवं निराई-गुड़ाई प्रचालनों के लिए रोटरी उपकरण का विकास किया गया। 90 सेंटीमीटर पंक्ति अंतराल पर उगाई गई अरंड एवं अरहर में निराई-गुडाई प्रचालनों के लिए रोटरी उपकरण की क्षमता क्रमश: 77-80 प्रतिशत एवं 79-84 प्रतिशत थी।
- एक उत्थित क्यारी रोपक व शाकनाशी प्रयोग हेतु उपकरण का विकास किया गया एवं इसे पिछले दो वर्षों में अनुसंधान फार्म एवं किसानों के खेतों पर जांचा गया। इसका डिजाइन अवंती बूफा इंडस्ट्रीस लिमिटेड, तेलंगाना को निर्माण एवं विक्रय के लिए हस्तांतरित किया गया।

सामाजिक आर्थिक अध्ययन एवं प्रौद्योगिकी का हस्तांतरण

- 'फार्मर्स फर्स्ट' परियोजना, जोकि एक कार्रवाई अनुसंधान परियोजना है, विकाराबाद जिले के पुडुर मंडल के 4 गांवों में किसानों की आय को दुगुना करने के लक्ष्य से लागू की गई। इसकी मुख्य अवधारण यह थी कि वर्षा आधारित तकनीकियों को पूरे 'गांव को अपनाकर' गांव के समूह में हस्तांतरित किया जाए। इस परियोजना में प्रमुख अवयव थे: किसान-वैज्ञानिक इंटरफेस, फसल एवं फसल प्रणालियों के अवयवों में प्रौद्योगिकी का समावेश, बागवानी, मृदा एवं जल संरक्षण, छोटे पैमाने पर फार्म यांत्रिकीकरण, सामग्रियों का संग्रह और सामाजिक, आर्थिक संपर्कों का विकास करना। इस परियोजना में मुख्यत: अरहर एवं चना की किस्मों की जांच, येल्लो स्टिकी ट्रेपों से समेकित नाशीजीव प्रबंधन, पलवार एवं कद्दूवर्गीय फसलों की पंडाल खेती, प्लास्टिक फिल्मयुक्त गेबियन संरचनाओं की स्थापना, पशु स्वास्थ्य शिविर एवं दूध देने वाले पशुओं के लिए अतिरिक्त खनिज मिश्रण, बकरियों के लिए खनिज ब्लॉक्स, उन्नत चारा की खेती, प्लांटर, वीडर एवं पावर स्प्रेयर जैसे कृषि उपकरणों के लिए पारंपरिक किराए केंद्र, प्रशिक्षण एवं बागवानी में प्राथमिक प्रसंस्करण केंद्रों एवं श्रेष्ठता के केंद्रों का दौरा आदि हस्तक्षेपों का कार्यान्वयन किया गया। इनसे किसानों को अच्छा लाभ प्राप्त हुआ।
- क्रीडा के वैज्ञानिकों ने नियमित रूप से मेरा गांव मेरा गौरव कार्यक्रम में भाग लिया, जिसमें वैज्ञानिक जागरूकता निर्माण की विभिन्न गतिविधियों को पूरा करने, प्रदर्शन करने, प्रशिक्षण प्रदान करने के साथ-साथ कृषि समुदाय को नियमित एसएमएस सलाह प्रदान किया गया।
- जनजातीय उप-योजना(टीएसपी) के तहत, लघु संयंत्रों जैसे पॉवर स्प्रेयर, वीडर, आदि उपकरणो को छोटे किसानो के मध्य कृषि मशीनीकरण को बढ़ावा देने के ध्येय से बॉटा गया और तत्संबंधित प्रशिक्षण भी प्रदान किया गया।

निक्रा

भाकृअनुप-क्रीडा की निक्रा परियोजना के रूप में प्राप्त परिणामों का संक्षिप्त विवरण इस प्रकार है :-

- अरहर के 12 जीनरूपों में एकेटी-8811, पूसा-33, जीआरजी-276-1 एवं आरवीके-274 – दोनों तनाव एवं वर्षा आधारित परिस्थिति में भी उच्च उत्पादन देने में सक्षम पाए गए। दबाव रहित एवं वर्षा आधारित दोनों परिस्थितियों में पीआरजी-158 ने उन्नत जल उपयोग क्षमता का प्रदर्शन किया।
- फसल उत्पादनों पर जलवायु परिवर्तन के प्रभाव के अर्थमितीय विश्लेष्ण द्वारा यह स्पष्ट हुआ कि बिना जलवायु परिवर्तन की परिस्थितियों की तुलना में शताब्दी के अंत तक इसके प्रभाव अधिक तीव्र एवं व्यापक हो सकते हैं।
- मालवा क्षेत्र में लंबी अवधि एवं टिकाऊ भूमिजल उपयोगिता को सुनिश्चित करने, फसल के लिए जल की आवश्यकता एवं इसके प्रयोग का उचित अनुमान लगाने की आवश्यकता है। बदलती जलवायु परिस्थितियों के अंतर्गत इंदौर में रबी फसलों की सिंचाई आवश्यकताओं में यथोचित वृद्धि का अनुमान लगाया गया है, जबकि खरीफ फसलों के लिए सिंचाई की आवश्यकता में नाम मात्र की वृद्धि का अनुमान लगाया गया। मालवा क्षेत्र में वर्षा एवं अपवाह में वृद्धि का अनुमान लगाया गया है। बदलती जलवायु परिस्थितियों के अंतर्गत इस क्षेत्र में गहन वर्षाजल संचयन गतिविधियों की आवश्यकता है। कम या मध्यम उत्सर्जन परिस्थितियों के अंतर्गत, विजयपुरा केंद्र के मुख्य जिलों में अपवाह काफी भिन्न होने की उम्मीद नहीं है। लेकिन वर्तमान परिस्थितियों के अंतर्गत, अधिक अपवाह क्षमता की उपलब्धता स्वयं यह स्पष्ट करती है कि वर्षाजल संचयन एवं अतिरिक्त सिंचाई या भूमिजल रीचार्ज के लिए काफी संभावनाएं व्याप्त हैं।
- मक्का के पौधों में तापमान के वितरण का अध्ययन करने के लिए ऊष्मीय विकिरण पर आधारित फारवर्ड लुकिंग इनफ्रारेड कैमरा का इस्तेमाल सफलतापूर्वक किया जा सकता है।
- परिवेश कार्बन-डाइ-आक्साइड की तुलना में उत्थित कार्बन-डाइ-आक्साइड से लोबिया- ए. क्रेक्विवेरा- कोक्विनेल्लिड्स में ट्राइट्रोफिक के अंत:क्रियाओं के अध्ययन में लोबिया पर्ण समूह के पत्तों के नाइट्रोजन, एमिनो अम्ल एवं प्रोटीन में कमी एवं कार्बन : नाइट्रोजन अनुपात में वृद्धि देखा गया। इससे यह ज्ञात होता है कि प्रथम ट्रोफिक स्तर पर जैव रसायन अवयवों का विलयन होता है। परिवेश कार्बन-डाइ-आक्साइड की तुलना में उत्थित कार्बन-डाइ-आक्साइड में 20 से 35 डिग्री सेंटीग्रेड तापमान में वृद्धि से विकास के समय में कमी एवं प्रजनन दर में महत्वपूर्ण वृद्धि देखी गई।
- परिवेश की तुलना में उत्थित कार्बन-डाइ-आक्साइड ए. क्रेक्विवेरा पर एम. सेक्समाकुलेटस की शिकार क्षमता में वृद्धि सहित गर्भ अवधि में कमी लाता है, जो भविष्य की जलवायु परिवर्तन परिदृश्यों में इन कीटों के शिकार में वृद्धि की संभावना इंगित करते हैं।
- अर्ध-शुष्क क्षेत्रों में संसाधन हानि एवं फसल जल आवश्यकताओं पर समयानुरूप जलवायु परिवर्तन प्रभावों के मूल्यांकन के लिए ओपेन टाइप क्लाइमेट चांबर्स में स्काडा आधारित वर्षा अनुरूपक एवं प्रेसिशन लाइसीमीटर, जो कि अत्याधुनिक स्वचालन यंत्र है, की अभिकल्पना एवं विकास हयातनगर के सीसीआरसी प्रांगण में किया गया। इस प्रणाली में वर्षा की तीव्रता के नियंत्रण के लिए एमएमआई, वर्षा अनुरूपक की गति, वर्षा की तीव्रता (30-150 मि.मी. प्रति घंटा), कार्बन-डाइ-आक्साइड (550±50 पीपीएम) एवं तापमान (1-5 डिग्री तापमान) इत्यादि को संचालन करने की क्षमता शामिल है। 4 प्रतिशत ढलान सहित मक्का की फसल में

टस्सलिंग एवं सिलकिंग के नाजुक समय के दौरान, अति वर्षा की तीव्रता से फसल की उत्पादन क्षमता में नियंत्रित फसल की तुलना में 94 प्रतिशत तक की कमी आई। अत्यधिक वर्षा के कारण मक्का गुल्लियों के आकार में भी कमी आई।

- जीएचजी उत्सर्जन एवं वैश्विक गर्मी की संभाव्यता, जुताई उपकरण तथा जोत की गहराई द्वारा प्रभावित होती है। रोटावेटर, कल्टीवेटर एवं डिस्क हल + हैरो के प्रयोग से ग्रीनहाउस गैस उत्सर्जनों एवं वैश्विक गर्मी की संभाव्यता में वृद्धि दर्ज की गई, जबकि पशु द्वारा चालित उपकरणों से कम उत्सर्जन एवं ऊर्जा खपत में कमी दर्ज की गई।
- जैविक, अजैविक एवं समेकित उत्पादन प्रणालियों के अंतर्गत विभिन्न फसलों के प्रदर्शनों के मूल्यांकन द्वारा यह स्पष्ट हुआ कि अजैविक एवं जैविक प्रबंधन की तुलना में समेकित प्रबंधन (1374 किलोग्राम प्रति हेक्टेयर) के अंतर्गत आने वाले भू-खंडों में सूरजमुखी का बीज उत्पादन, क्रमश: 14 एवं 7 प्रतिशत अधिक था।
- मैदानों में विचरण करने वाली भेड़ों में 200 पीपीबी की दर से क्रोमियम प्रोपिओनेट को अतिरिक्त रूप से देने से कार्बोहाइड्रेट एवं लिपिड मेटाबोलिज्म में बदलाव आया। इसके फलस्वरूप पशुओं को गर्मी के तनाव से राहत मिली।
- जुलाई, 2017 के दौरान, हयातनगर अनुसंधान फार्म पर लघु चक्रानुक्रम एवं अधिक बायोमास उत्पादन करने वाली बहुप्रयोजनीय वृक्षों की प्रजातियों (एम.धुबिया, केसुआरिना, बी.बलकोआ, डी.सीसो एवं यूकेलिप्टस) के 36 सर्वोत्कृष्ट क्लोनों को मूल्यांकन करने के लिए स्थापित किया गया।
- आंध्र प्रदेश के अनंतपुरम जिले एवं तेलंगाना के नलगोंडा जिले के निक्रा पोषित कृषि विज्ञान केंद्रों में जलवायु समुत्थान प्रौद्योगिकियों को किसानों द्वारा बड़े स्तर पर अपनाया गया है। सूखा प्रबंधन पर ई लर्निंग मॉड्युल के लिए पाठ्यक्रम की समीक्षा एवं सामग्री का एकत्रीकरण पूरा कर लिया गया है एवं फ्रीवेयर का उपयोग कर ड्राफ्ट मॉडल बनाई जा रही है । आशाजनक प्रौद्योगिकियों एवं घटनाओं की जानकारी के लिए परियोजना में सामाजिक माध्यम मंच https://www.facebook.com/nicracrida/ का उपयोग किया जा रहा है।

कृषि विज्ञान केंद्र

- कृषि विज्ञान केंद्र ने प्रौद्योगिकी मूल्यांकन एवं परिष्करण के अंतर्गत वर्ष 2017-18 खरीफ एवं रबी के दौरान 17 प्रौद्योगिकियों (115 परीक्षण फसल किस्मों, समेकित फसल प्रबंधन, बागवानी एवं पशुधन प्रबंधन) का मूल्यांकन किया गया। वर्ष 2017-18 में खरीफ एवं रबी के दौरान फसलों, सब्जियों, फल फसलों, पशुधन, फार्म यांत्रिकीकरण, मृदा जल संरक्षण एवं श्रम में कमी जैसे विभिन्न विषय क्षेत्रों की 19 प्रौद्योगिकियों पर (269 प्रदर्शन) अग्रगामी प्रदर्शन का आयोजन किया गया। कृषि विज्ञान केंद्र ने 3005 अनुयायी किसानों, कृषि महिलाओं, ग्रामीण युवा एवं क्षेत्र स्तरीय प्रसार कार्यकर्ताओं के लिए उन्नत प्रौद्योगिकियों के विभिन्न पहलुओ पर 115 आवश्यकता आधारित एवं कौशलोन्मुख प्रशिक्षण कार्यक्रमों का आयोजन किया। कृषि विज्ञान केंद्र ने विश्व मृदा दिवस, आम उगाने वालों के लिए समूह बैठक, उद्यमियों के लिए बागवानी, पशुधन में टिकाऊ सघनता, विविधिकरण पर एक दिवसीय कार्यशाला एवं आपसी जानकारी आदान-प्रदान करने हेतु चित्तूर, कर्नूल एवं कड़पा जिलों के दौरों का आयोजन किया। बागवानी विभाग, तेलंगाना सरकार द्वारा प्रायोजित 520 ग्रामीण युवाओं को कृषि तालाब निर्माण एवं लाइनिंग के विषयों में जून 2 से 16, 2017 एवं 20 फरवरी से 27 मार्च 2018 के दौरान दो विशेष कौशल विकास कार्यक्रमों के माध्यम से प्रशिक्षित किया गया।
- 2017-18 के दौरान, सीड हब परियोजना के तहत, हयातनगर रिसर्च फार्म (एचआरएफ) में 19.5 क्विंटल अरहर बीज (पीआरजी 176 किस्म) और 5 क्विंटल कुल्थी (सीआरएचजी-04 किस्म) का तेलंगाना राज्य बीज प्रमाणन एजेंसी (टीएसएससीए) से प्रमाण पत्र प्राप्त किया गया।

मानव संसाधन विकास

- इस वर्ष संस्थान के दो वैज्ञानिक प्रशिक्षण/प्रदर्शन कार्यक्रम में भाग लेने के लिए विदेश गए। दो वैज्ञानिकों ने अपनी पी.एचडी. उपाधि अर्जित की। बावन स्नातक/स्नातकोत्तर छात्रों ने अपना परियोजना/अनुसंधान कार्य भाकृअनुप-क्रीडा में पूरा किया।
- भाकृअनुप-क्रीडा के बाइस वैज्ञानिकों ने विभिन्न पुरस्कार, अध्येतावृत्ति तथा राष्ट्रीय अकादमियों, व्यवसायिक सोसाइटियों एवं अन्य संस्थाओं से मान्यताएं प्राप्त की।

संपर्क एवं सहयोग

संस्थान नए/पुराने पणधारियों एवं संगठनों (राष्ट्रीय एवं अंतर्राष्ट्रीय) से निरंतर संपर्क बनाए हुए है। इसके साथ ही साथ संस्थान ने अपने तकनीकी कार्यक्रमों को ओर अधिक प्रभावी रूप से कार्यान्वित किया है तथा आपसी जानकारियों का आदान-प्रदान करते हुए अपने पुराने संपर्कों का नवीकरण किया है तथा उन्हें मजबूती प्रदान की है।

प्रकाशन

संस्थान के वैज्ञानिकों के अंतरराष्ट्रीय और राष्ट्रीय अभिजात की समीक्षा पत्रिकाओं में कुल 116 शोध लेख प्रकाशित हुए हैं। हिंदी में दो पुस्तकें, अंग्रेजी की संकलित सत्ताइस पुस्तकें और 112 पुस्तकों के अध्याय प्रकाशित हुए। संस्थान के वैज्ञानिकों ने अनेक नीतिगत लेख, बुलेटिन, लोकप्रिय लेख, सम्मेलनों में प्रस्तुती, ई-प्रकाशन तथा रेडियो और टेलिविजन कार्यक्रमों के माध्यम से भी अपना योगदान दिया है।

Executive Summary

Resource Characterization

- The onset of monsoon over Hyderabad took place on June 12, 2017. Total rainfall received during the *kharif* season was 740 mm, which was 39% higher than long period average of 532 mm.
- The District Database of Agricultural Statistics is being maintained on ICAR-CRIDA website at http://www.crida.in:82/DDAS/. State level and all India level agricultural statistics recently made available were gathered and compiled, and the State Database of Agricultural Statistics was updated.
- Unreaped yield potentials in major rainfed crops and scope for bridging yield gaps - A decision support system (DSS) was hosted on ICAR-CRIDA website at http://www.crida.in:8129/. Validation checks for nutrient use data in the DSS were developed and implemented. District overall rainfed yield efficiency index was computed considering 20 crops.
- A field experiment with three cultivars of sorghum sown on three different dates was taken up as part of a project to calibrate, validate and assess the projected impact of climate change on sorghum using DSSAT, Infocrop and APSIM crop simulation models. Genetic coefficients for DSSAT model were generated for three cultivars. Calibration of the DSSAT model using the generated genetic coefficients showed good agreement between observed and simulated values of different parameters.
- ICAR-CRIDA and Department of Agriculture and Cooperation, Ministry of Agriculture & Farmers' Welfare, along with state agricultural universities and KVKs undertook the responsibility of preparing contingency plans at district level for all the 126 agro-climatic zones of the country to deal with weather related aberrations. Contingency plans have been prepared for 623 districts in the country and are hosted on ICAR/ DAC websites (http://agricoop.nic.in/acp.html; http://www.crida.in/). Interface meetings were held in several states before *kharif* 2017 to sensitize the State Governments for operationalization of the contingency plans.

Rainwater Management

- Development of a climate resilient watershed through knowledge based optimal utilization of resources including efficient management of natural resource, diversified farming system and allied enterprises to ensure food, nutrition and livelihood security was begun in 2015 in Gadda Mallaiah Guda watershed located in Yacharam mandal of Ranga Reddy district. Rainwater harvesting structures, loose boulder structures and gabion structures to conserve rainwater and restore old water harvesting structures including percolation tanks/ponds were tried for recharging of open wells as well as deep wells in the farmers' fields in the watershed. Artificial bore well recharge techniques for augmenting borewell water were also developed and demonstrated.
- An integrated farming system module with cotton, vegetables, fodder and small ruminants with farm pond implemented in a 3 acre land owned by a tribal farmer in Petrallachenu village of Nagarkurnool district showed positive impact on socio economic condition of the farmer with total net income of Rs 96,605/- over the traditional system of growing only rainfed cotton, which gave negative returns of Rs. 3600. The yield of cotton with 30 mm deficit supplemental irrigation from the farm pond using portable raingun system tripled over rainfed cotton.
- A small scale solar powered micro irrigation system was designed and installed for the use of small farmers having one acre or less land for growing vegetables under farm pond system. Watermelon was successfully grown on the raised beds with water productivity of 5.6 kg/m^3 with plastic mulching as compared to organic mulching (4.8 kg/m^3) and no mulching (2 kg/m^3).
- A research project is in progress with the objective to enrich and upgrade an integrated approach for the assessment of the environmental, economic and social impacts of current watershed development at a meso-scale in Andhra Pradesh. Based on 0.25 degree resolution daily rainfall dataset of Aphrodite, annual average effective rainfall and annual average

runoff percentages were worked out for each of the stations covered in India. The assessment provides the expected runoff in various rainfall zones, which could be used to estimate the runoff in watersheds for Integrated Watershed Management Programme (IWMP) projects.

Crops and Cropping Systems

- A project was initiated in 2014 to develop and characterize inbreds having drought tolerance to be utilized as parents for genetic enhancement and to develop mapping population for using in QTL mapping and association studies for drought tolerance in maize. Seven inbreds (DTL2, SNJ2011-03, SNJ2011-37, SNJ2011-26, Z101-15, Z32-12 and HKI7660) were found to be promising for use in crop improvement programme based on evaluation under rainfed condition. Three hybrids (HKI7660/SNJ2011-26, RJR385/SNJ2011-26, Z10115/SNJ2011-26) were found to be high yielding and drought tolerant under rainfed conditions and at par with commercial hybrids. Single plant progenies of mapping populations of HKI161/SNJ2011-26 were advanced to $F_{7:8}$ for developing recombinant inbred lines for drought related traits.
- Twenty eight horse gram genotypes evaluated under field conditions during *kharif* 2017, showed CRHG1, CRHG3, CRHG9 and CRHG10 as better performing and comparable to released varieties. Germplasm also showed high variation for micronutrient contents, especially iron content, which ranged from 27 to 104 mg/kg. Based on one season data it was found that horse gram varieties performed better under elevated CO_2 as compared to ambient CO_2. The trial needs to be repeated for confirmation.
- Cluster bean entries RGr 16-17, RGC-1033, CAZG 17-4, HG-2-20 and RGC 1066 were the high yielders in initial varietal trial. Among the horse gram entries of initial varietal trial, CRHG-19, CRHG-22, ATPHG-11, CRHG-26 and BSP 17-3 recorded high grain yield and CRHG-26, VHG 15, CRHG-22, VHG 935 and ATPHG-11 recorded high fodder yield.
- 4:4 strip intercropping system (replacement series) of sorghum and pigeonpea with relay horse gram performed better with more number of branches in pigeonpea contributing to higher yield due to sufficient space availability for improved microclimate and good rainfall quantities for the relay sown horse gram compared to traditional 2:1 intercropping system (additive series).
- Comparative evaluation of conventional cropping systems and fodder integrated cropping systems under rainfed conditions showed that perennial fodders - guinea grass and hedge lucerne, yielded 51.6 t/ha and 31.2 t/ha of green fodder, respectively. The fodder based cropping system with soghum+pigeonpea (2:1) in 0.5 ha and guinea grass in 0.5 ha was the most remunerative, with gross returns of Rs. 1,18,054/ha. With the highest crude protein and metabolizable energy yields, the fodder based system with soghum+pigeonpea (2:1) in 0.5 ha and hedge lucerne in 0.5 ha was the best system from the viewpoint of meeting the fodder requirements of animals.
- An experiment was carried out with different combinations of iron sulphate, zinc sulphate applied through soil and foliar applications with and without phosphate solubilising bacteria (PSB) along with recommended N and P, to study the possibility of biofortifying pigeonpea seeds. Protein content of pigeonpea seed was significantly higher with soil application of iron sulphate + zinc sulphate and PSB, ash content was higher with control (no iron, zinc or PSB), and seed phosphorus was higher with application of PSB alone.

Soil Health and Nutrient Management

- In the fifth year of a long term study with two tillage and three residue retention treatments, grain yield of sorghum was 18% higher with minimum tillage over conventional, and 27% higher with 100% retention of residue of previous year's blackgram crop over no residue. Organic carbon and mineral nitrogen (ammonium + nitrate) in soil were higher with minimum tillage, and 100% residue retention, which added 1438 kg/ha of carbon input to the soil.
- The potential role of conservation agriculture practices including different tillage and residue management practices is being assessed from 2009 in pigeonpea-castor cropping system in rainfed

Alfisols. In 2017, the seed yield of pigeonpea with zero tillage was 30% and 20% higher over conventional tillage and reduced tillage, respectively. Retention of residues of previous castor crop by harvesting at heights of 10 cm and 30 cm recorded 25 and 30% higher yields over no residues (harvesting from base). Higher species richness, diversity index and lower evenness index of weeds were observed in zero tillage as compared to conventional and reduced tillage.

- In a study on resource conserving technologies, conventional tillage recorded 15% lower maize yields as compared to conservation agriculture practices. Among the conservation agriculture practices, integration of *in-situ* moisture conservation and weed management practices as 4th principle through permanent bed or conservation furrow resulted in 20 and 25% higher seed yields of maize respectively, over no moisture conservation practice. Termite infestation on crop residues varied with the type of residue. Application of cow dung slurry or chlorpyriphos reduced the termite infestation.
- A project was initiated in 2012 to develop sustainable tillage and nitrogen management strategies to improve farm productivity and profitability and soil health under maize-pigeonpea crop rotation. In 2017, both, tillage practices and nitrogen levels significantly influenced the total biomass and seed yield of pigeonpea. The mean seed yield was 23.4 and 15.1% higher with no tillage and reduced tillage, respectively over conventional tillage.
- System productivity and profitability, and green house gas (GHG) emissions under different tillage and nutrient management practices are being evaluated in pearl millet-horse gram and cotton-pigeonpea rotation since 2016. In 2017, pearl millet grain yield was highest under zero tillage among tillage practices, and 125% recommended dose of fertilizers (RDF) among nutrient management practices. While pigeonpea seed yields did not differ significantly with tillage treatments, significantly higher yield was obtained with 125% RDF nutrient management practice. Emissions of N_2O were higher under conventional tillage among tillage practices, and 125% RDF among nutrient management practices.
- The residual effects of biochar treatments (3 types of biochar – pigeonpea stalk, castor stalk, cotton stalk; 2 rates of application – 3 t/ha and 6 t/ha); and 2 frequencies of application – every year application and alternate year application) applied for 4 years during 2010-2013 are being studied since 2014. In the eighth year (4 years after cessation of treatments), pigeonpea yields were higher in plots that received RDF + alternate year application of pigeonpea stalk biochar @ 6t/ha.

Livestock Management

- Intensive system of rearing livestock not only improved the profitability but also significantly reduced methane emissions as compared to semi-intensive and extensive systems. Heat Load Index (HLI) was found to be better choice for comparing heat stress in extensively reared sheep, whereas, Temperature Humidity Index (THI) was a better indicator for comparing heat stress in intensively reared animals. Soil-plant-animal continuum studies revealed that general mineral deficiencies in dryland livestock can be overcome with the help of low cost mineral mixture with dicalcium phosphate, zinc sulphate, copper sulphate and common salt in the proportion of 1.96:0.032:0.008:1. Silage feeding was not only able to supply nutrients during lean period, but also, sheep were able to achieve a better average daily gain of 78.89 g/per day as compared to 45.56 g/per day in control. An equation was developed to predict body weight of Nellore sheep based on simple biometric measurements.

Energy Management

- A high clearance and enhanced track width platform and a rotary implement for weeding operation were developed to effectively utilize low horse power tractor for field applications. In castor and pigeonpea crops with 90 cm row spacing, weeding efficiency of rotary implement was 77-80% and 79-84%, respectively.
- A raised bed planter cum herbicide applicator was developed and tested in the research farm and in farmers' fields over the last two years. The design

was transferred to Avanthi Bufa Industries ltd, Jahirabad, Telangana State for manufacturing and sale.

Socio Economic Studies and Transfer of Technology

- Farmers FIRST project, an action research project, envisaged to transfer rainfed technologies to a cluster of villages adopting whole village concept with the objective of doubling farmers income is being implemented in 4 villages of Pudur mandal of Vikarabad district. The project involves four major components, namely, farmer-scientist interface, technology assemblage in components of crops and cropping systems, horticulture, soil and water conservation, small farm mechanization, content mobilization and socio economic and linkage development. Varietal trials with pigeonpea and chickpea crops, integrated pest management with yellow sticky traps, mulching and pandal cultivation of cucurbits, establishment of plastic film embedded gabion structures, animal health camps and supplementation with mineral mixtures for milch animals, mineral blocks for goats, cultivation of improved fodder, custom hiring centres for farm equipment such as planters, weeders and power sprayers, training and exposure visits to primary processing centres and centre of excellence in horticulture, were the interventions implemented under the project and were found to be beneficial to farmers.
- ICAR-CRIDA regularly participated in Mera Gaon Mera Garav program with scientists carrying out different activities of general awareness building, conducting demonstration, imparting training and providing regular SMS advisories to farming community.
- Under Tribal Sub Plan (TSP) project, small farm mechanization was promoted by distribution of a small equipments like power sprayers, weeders, etc. and training.

NICRA

The following salient points emerged out of the NICRA projects running at ICAR-CRIDA.

- Among 12 pigeonpea genotypes AKT-8811, PUSA-33, GRG-276-1 and RVK-274 were the high yielders in both unstressed and rainfed conditions. PRG-158 recorded high water use efficiency in both unstressed and rainfed condition.
- An econometric analysis of impact of climate change on crop yields showed that the impacts would be more severe and widespread towards the end of the century as compared to a no climate change scenario.
- In order to ensure long-term and sustainable groundwater utilization in Malwa region, proper estimation of crop water requirement and its application are needed. Considerable increase in the irrigation requirement of *rabi* crops are predicted at Indore under changing climatic scenarios whereas the irrigation requirement for *kharif* crops showed only a slight increase. Increase in rainfall and runoff expected at Malwa under changing climatic scenarios suggest increased potential for rainwater harvesting in this region. Hence adoption of rainwater harvesting and optimum utilization of water resources is one of the recommended climate coping strategies for Malwa region of Madhya Pradesh. Under changing climatic scenarios, runoff is not expected to vary much in Vijayapura district under low or medium emission scenarios, but the high runoff potential available under the present scenario itself shows substantial scope for rainwater harvesting and its utilization for supplemental irrigation or groundwater recharge.
- Forward Looking Infrared (FLIR) camera can be successfully deployed to study the distribution of temperature in maize plants based on detection of thermal radiation.
- In a study of the tritrophic interactions in Cowpea - *Aphis craccivora* – Coccinellids, reduction in leaf nitrogen, amino acid, and protein, and increase in carbon and C:N ratio of cowpea foliage were observed with elevated CO_2 over ambient CO_2, indicating the dilution of biochemical constituents at first trophic level. Shortening of development time and increment of reproductive rate with elevated CO_2 over ambient CO_2 was significant with increase in temperature from 20 to 35°C. Decreased grub duration with increased predation capacity of *Menochilus sexmaculatus* on *A. craccivora*

with elevated CO_2 over ambient was noted, indicating increased predation in future climate change scenarios.

- Study of interactive effects of elevated CO_2 and temperature on *Spodoptera litura* on groundnut using CTGC facility showed significant temporal variation and severe incidence of *S. litura* under elevated temperature and elevated temperature + elevated CO_2 conditions.
- SCADA based rainfall simulator and precision lysimeter with open type climate chambers for assessing the real time climate change impacts on the resource losses and crop water requirements in semi arid regions, was designed and developed by using state of art process automation instrumentation in climate change research complex at Hayathnagar Research Farm. The systems have Man Machine Interface (MMI) for control of rainfall intensity, rainfall simulator movement, varying rainfall intensities (30-150 mm/hr), CO_2 (550 ± 50 ppm) and Temperature (1-5 ^{0}C). An extreme intensity rainfall on maize during the critical stage of tasselling and silking reduced the yield potential of crop by 94% over the control with 4% slope. The size of the maize cobs was reduced as a result of extreme rainfall.
- Tillage implement and depth influenced the GHG emissions and global warming potential. Rotavator, cultivator and disc plough + harrow recorded higher greenhouse gas emissions and global warming potential, whereas, animal drawn implements recorded lower emissions and energy.
- Evaluation of the performance of different crops under organic, inorganic and integrated production systems showed that the seed yield of sunflower was 14 and 7% higher in the plots under integrated management (1374 kg/ha) than that of under inorganic and organic management, respectively. However, both integrated and organic management recorded similar but higher seed yields of green gram (673-706 kg/ha) and pigeonpea (898-911 kg/ha) as compared to inorganic management.
- Supplementation of chromium propionate @ 200 ppb altered the carbohydrate and lipid metabolism and helped in mitigation of heat stress in grazing lambs.
- An experiment to evaluate 36 elite clones of short rotation and high biomass yielding multipurpose tree species (*M. dhubia*, Casuarina, *B. balcoa*, *D. sisoo* and Eucalyptus) was established at Hayathnagar Research Farm during July 2017.
- A study on adoption of climate resilient technologies in NICRA KVKs of Anantapuramu district of Andhra Pradesh and Nalgonda district of Telangana revealed that there was significant difference between the overall levels of adoption of climate resilient agricultural technologies. Review of literature and content aggregation for an e-learning module on drought management was completed and preparation of draft module using freeware is in progress. https://www.facebook.com/nicracrida/ is being used as a social media platform in the project to share the promising technologies and events happened.

Krishi Vigyan Kendra

- The KVK under technology assessment and refinement has assessed 17 technologies (115 trials on crop varieties, integrated crop management, horticulture and livestock management) during *kharif* and *rabi*, 2017-18. Frontline demonstrations (269 demonstrations) on 19 technologies were conducted in different disciplines covering field crops, vegetables, fruit crops, livestock, farm mechanization, soil water conservation and drudgery reduction during *kharif* and *rabi* 2017-18. The KVK organized 115 need based and skill oriented training programmes on various aspects of improved technologies to 3005 clientele farmers, farm women, rural youth and filed level extension workers. The KVK organized World Soil Day, group meeting for mango growers, one day workshop on sustainable intensification and diversification in horticulture and livestock for entrepreneurs and exposure cum knowledge sharing visit to Chittoor, Kurnool and Kadapa districts. Two special skill development programmes allotted by Department of Horticulture, Government of Telangana in the disciplines of "farm pond construction and

lining" during June 2 to 16, 2017 and February 20 to March 27, 2018 were organized for 520 rural youths.

- Under the seed hubs project, during 2017-18, 19.5 q of red gram seed (Var: PRG176) and 5 q of horse gram (Var: CRHG-04) were produced in the Hayathnagar Research Farm (HRF) and certification was obtained from Telangana State Seed Certification Agency (TSSCA).

HRD

- During the year, 2 scientists attended trainings/ exposure visit outside the country. Fifty two graduate and post graduate students carried out project/research work at ICAR-CRIDA and two scientists completed their Ph.D.

Awards and Recognition

- Twenty scientists of ICAR-CRIDA received awards, fellowships and recognition from national academies, professional societies and other institutions.

Linkages and Collaborations

- The Institute continued to explore new linkages and collaborations with stakeholders and organizations (national and international) while renewing and strengthening old ones for more effective implementation of its technical programme as well as cross-learning.

Publications

- A total of 116 research articles were published in international and national peer reviewed journals. Twenty nine books including 2 in Hindi and 112 book chapters were published. The contributions of scientists also appeared in the form of a number of policy papers, bulletins, popular articles, presentations in conferences, e-publications and radio and television programmes.

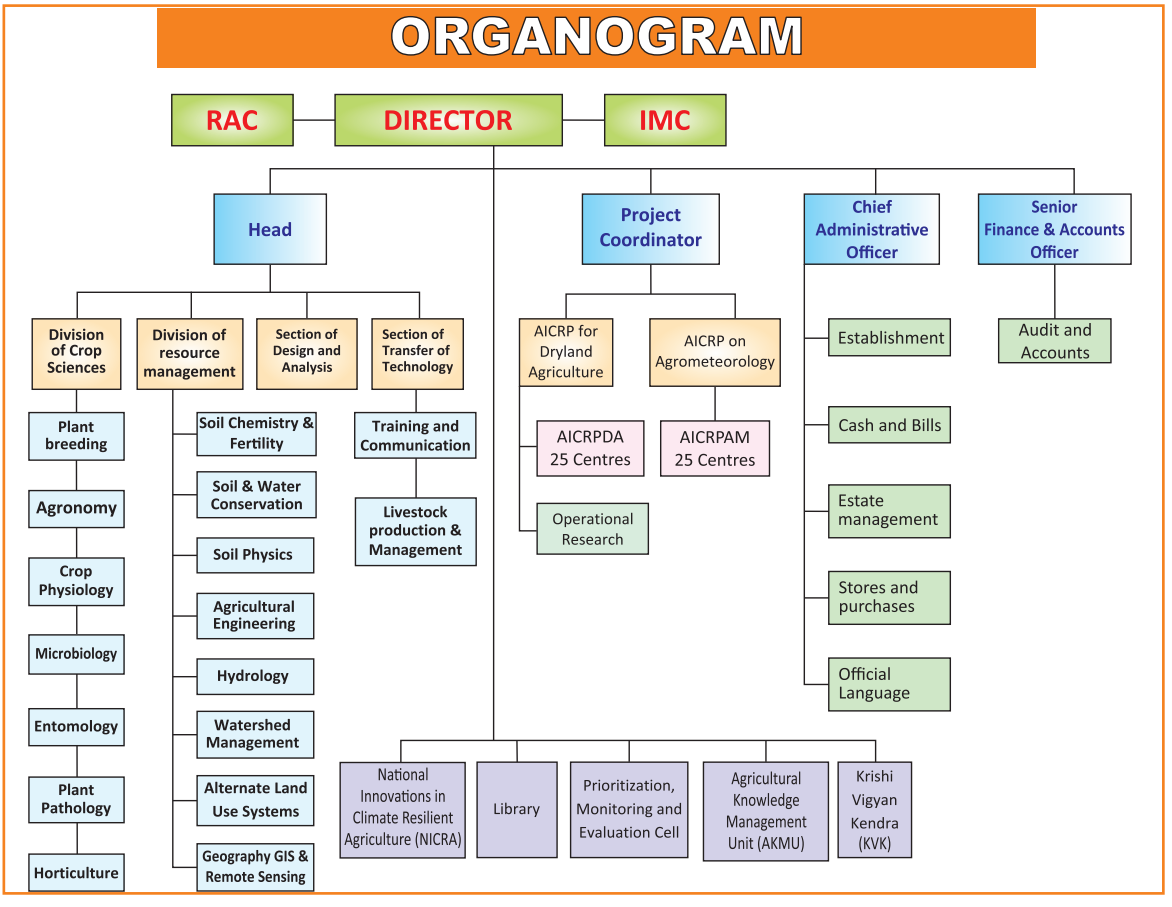
1. About the Institute

Rainfed agriculture is predominant in arid, semi-arid and sub-humid regions of the country. These regions are home to about 81 per cent of rural poor in the country. The geographic and demographic dimensions of rainfed agriculture warrant a continued priority to rainfed agriculture in general and rainfed agriculture research and extension in particular. 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. 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 cooperating centres spread across the country. The All India Coordinated Research Project on Agrometeorology (AICRPAM) was launched in 1983 at Hyderabad with 10 cooperating centres across the country. The ICAR-Central Research Institute for Dryland Agriculture (CRIDA) was established at Hyderabad on April 12, 1985. The present mandate of the institute is as follows:

- 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

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

Programme No.	Programmes	Areas of Research
I	Resource characterization	Rainfall and soil characteristics, length of growing season, land capability-based potential and constraints, climatic analysis, crop weather modeling and geographic information system.
II	Rainwater management	*In-situ* moisture conservation, water harvesting and recycling, groundwater recharge studies, sustained management of surface and groundwater resources and efficient water-use strategies
III	Crops and cropping systems	Efficient crops and cropping systems, crop diversification for sustained water use and productivity, germplasm enhancement/ evaluation and stress physiology
IV	Soil 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
V	Alternate land use 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
VI	Energy management	Development of low-cost seeding and inter-cultural devices, solar and low lift pumps for lifting water from ponds
VII	Socio-economic aspects	Socio-economic and policy research studies, impact of research, constraints and feedback, transfer of technology
VIII	Training	Training of primary and secondary stakeholders and use of modern tools like ICT



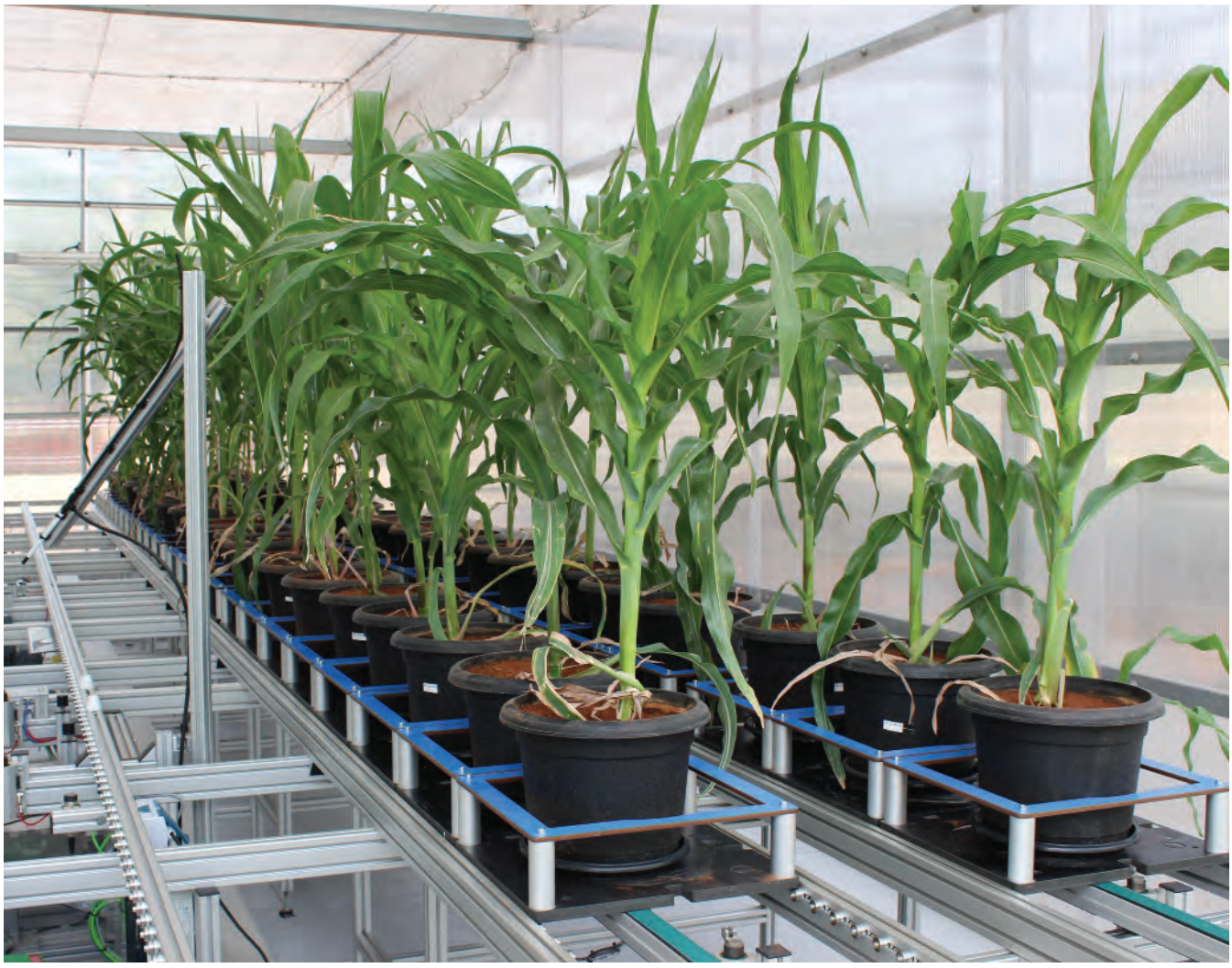
Along with the programme areas mentioned, the institute is also giving due importance to understand the nature of climate change and its impacts on rainfed agriculture and to evolve suitable adaptation and mitigation measures with special emphasis to small and marginal landholders.

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 house, trainee hostels, seminar halls, museum, 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 over-view of the facilities is provided below.

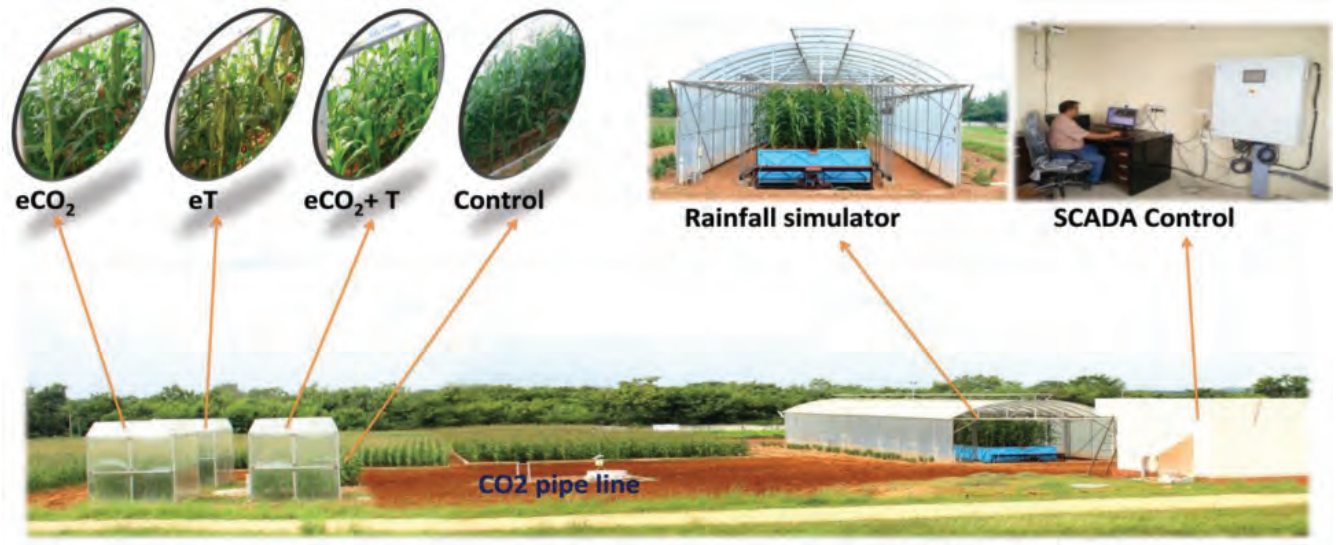
Climate change study facilities: Six Open Top Chambers (OTCs) were set up to assess the impact of elevated CO_2 concentration on crops and soils. State-of-the-art Phenotyping Platform with automated non-destructive imaging based scan analysis of crop growth and development has been developed during XI plan to characterize genetic material with drought and other abiotic stress tolerances. A 7 ha research complex to study crop and soil response to elevated temperature, CO_2 and extreme rainfall events has been developed at Hayathnagar Research Farm, Hayathnagar.

Climate Change Research Complex (CCRC): Free Air Temperature Elevation (FATE) facility a state of art facility to conduct climate change impact studies was established at HRF, CRIDA and inaugurated by DG, ICAR.



Plant phenomics study in progress

FACE and FATE facilities developed at CCRC Complex, Hayathnagar



SCADA based rainfall simulation facility and Precision type lysimeters with open type climate chambers was also established for assessing the climate change impact on resource losses in CCRC, Hayathnagar.

A small scale solar powered micro-irrigation system was designed and installed for the demonstration and use of small farmers having <=1 acre land under IFS module for growing vegetables under farm pond system.

Laboratories: ICAR-CRIDA has 15 well-equipped laboratories to support multi-disciplinary research on natural resource management and crop sciences. Laboratories of various disciplines such as Agronomy, Soil chemistry, Soil physics, Hydrology, Plant physiology, Microbiology, Plant breeding, Molecular biology, Agro-forestry, Horticulture, Plant pathology, Entomology and Animal sciences are well equipped with state-of-the-art facilities. In addition, Central laboratory, Agrometeorology & Data bank, and GIS laboratories cater to the needs of research across the divisions. Dedicated laboratories for root study and estimation of green house gases were added during XI plan.

Soil physics: 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, land degradation and resource mapping.

Soil chemistry: The laboratory is equipped with important 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.

Plant physiology: The laboratory has facilities to conduct research in stress physiology, plant nutrition, crop modelling and climate change. It is equipped with leaf area and transpiration measurement systems, osmometer, cold centrifuges, plant canopy analyzer and sapflow systems and portable photosynthesis analyzer.

Agronomy: The laboratory is equipped with all basic instruments for soil and plant analyses, neutron moisture probes and instrument to study root traits. It supports research activities in soil and water management and crop husbandry.

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

Plant molecular biology and tissue culture laboratory: The laboratory is well equipped with up-to-date facilities for carrying out research activities pertaining to 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. The plant tissue culture laboratory undertakes research on tree micro-propagation.

Entomology: The Entomology laboratory is equipped with modern instruction facilities and equipments 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.

Plant pathology: 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.

Central laboratory: Besides the discipline-wise research facilities highlighted above, the Institute has a central laboratory, which has state-of-the-art instruments, Inductivity Coupled Plasma (ICP) spectrometer, atomic absorption spectrophotometer, auto analyser, CNS analyzer, 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.

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 providing agro-meteorological information, current weather status and contingency crop plans to aid the rainfed farmers across the country.

Hydrology: 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.

Agro-forestry: Agro-forestry laboratory has facilities for soil and plant analysis, including equipment for estimation of aromatic oils and secondary metabolites in medicinal, aromatic and dye yielding plants.

Horticulture: A new 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.

Animal sciences: A new wing has been added in the X-plan for Animal Science towards estimation of proximate principles, fibre fractions, *in-vitro* digestibility of feeds and fodders, *in-vitro* gas production studies, metabolic studies with small ruminants, haematological and metabolic profiling.

GIS: The 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 radio meter and CropScan.

Transgenic glasshouse and green house: 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.

Bio-resource centre: A bio-resource centre for 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.

Agriculture Knowledge Management Unit (AKMU): The unit maintains IT infrastructure of CRIDA and its services such as web services, Internet and network security and its related services. It also renders need based in-house Software and Database development. ICAR-CRIDA successfully runs all Internet based service on National Knowledge Network (NKN) connectivity. ICAR-CRIDA has 4th to 7th generation desktops computers, Fujitsu GPU workstations, Dell servers and Tyan GPU server with 4 teraflops speed. All computes are connected to Centralized uninterrupted power supply (80 + 80 KVA). Websites of ICAR-CRIDA, NICRA, AICRPDA and ISDA hosted at ICAR-CRIDA servers and updated regularly time to time.

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

Conference and training facilities:

The Institute has three air-conditioned conference halls with a seating capacity of 30, 100 and 20, besides a large auditorium for accommodating 250 persons.

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 International Journals. The library extends online access to foreign

journals through subscription of CAB International. Under the National Agricultural Innovation Project (NAIP), ICAR established a Consortium for e-Resources in Agriculture (CeRA) to access peer reviewed e-journals from the most renowned publishers in the disciplines of agricultural and related sciences.

Institute Technology Management Unit (ITMU): It acts as repository to 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, copy rights and conducting awareness programs on IPR issues. It also liaises between Institute and ICAR in fostering Public-Private Partnerships for knowledge generation and dissemination in the field of rainfed farming for the ultimate benefit of stakeholders.

Research farms: The Institute has two research farms at Hayathnagar (Hayathnagar Research Farm, HRF, 280 ha) and Gunegal (Gunegal Research Farm, GRF, 80 ha) about 15 and 45 km from the main campus, respectively. These farms represent the predominant agro-ecological settings of the rainfed regions of the country. The mean annual rainfall received at Hayathnagar is 750 mm and that at Gunegal is 690 mm. The research farms have well equipped infrastructure and facilities for supporting field experiments and demonstrations including weather stations, maintenance workshop, tractors and farm equipments and fabrication facility for farm tools and implements.

Dryland Farm Implements Workshop: This workshop caters the needs of Institute Scientists for developing new prototypes and support to line department officials training. It is a centre of attraction for farmers from different parts of country to train them as well as upscaling farm mechanization in agriculture.

Financial Statement for 2017-18 as on 31st March, 2018 (*Rupees in lakhs*)

CRIDA		AICRPDA		AICRPAM	
Sanctioned	**Utilized**	**Sanctioned**	**Utilized**	**Sanctioned**	**Utilized**
3693.10	3687.41	2630.79	2630.79	722.00	722.0

Staff Position as on 31st March, 2018

Staff	Positions	
	Sanctioned	**Filled**
Scientific	65*	60
Principal Scientists	09	07
Senior Scientists	19	11
Scientists	37	42
Technical	79	45
Administrative	46	28
Supporting	43	18
TOTAL	233	151

**Including Director*

2. Institute and Externally Funded Projects

Research Achievements

2.1. Resource characterization

2.1.1. Weather conditions at Hayathnagar Research Farm

During 2017-18, summer rainfall in the months of April and May was deficient by more than 50% (Table 2.1). However, June received excess rainfall (136%) which was well distributed. Above normal rainfall was received in July (22%), August (12%) and September (16%) months (Fig. 2.1 & 2.2). A dry period of 17 days from July 23 to August 8 created moisture stress condition in the standing crops. Excess rainfall was recorded during October (163%) month towards the end of the *kharif* season. The country as a whole received 841.3 mm rainfall, 5 per cent less than the long period average (LPA) of 887.5 mm. Monsoon onset over Hyderabad took place on June 12, 2017. Total rainfall received during the *kharif* season was 740 mm, which was 39% higher than LPA of 532 mm.

Table 2.1: Weekly meteorological parameters recorded at HRF during April 2017 to March 2018

Year	Week	Max T (⁰C)	Min T (⁰C)	RH 1 (%)	RH 2 (%)	Sunshine (hours)	Rainfall (mm)
2017	14	38.4	20.0	82	36	5.8	6.2
2017	15	38.9	19.1	60	30	9.5	0.0
2017	16	41.0	22.5	54	23	8.2	0.0
2017	17	39.7	25.2	49	25	8.1	0.0
2017	18	38.0	22.9	66	37	8.7	4.8
2017	19	37.5	21.4	80	50	8.5	12.2
2017	20	39.9	28.2	63	44	9.6	0.0
2017	21	41.3	26.1	64	40	5.4	0.0
2017	22	38.4	24.9	61	39	8.7	0.0
2017	23	35.3	22.1	80	48	5.4	86.4
2017	24	30.5	21.2	86	68	2.2	55.8
2017	25	30.5	21.1	84	62	4.2	65.0
2017	26	30.6	19.5	80	53	3.9	34.2
2017	27	31.6	21.1	78	57	2.6	34.4
2017	28	30.6	20.6	82	59	2.2	28.6
2017	29	27.8	18.6	87	71	2.2	98.6
2017	30	29.9	20.4	82	57	6.8	0.4
2017	31	29.0	21.4	73	55	6.7	0.0
2017	32	30.4	20.1	85	66	2.7	38.6
2017	33	29.5	19.7	86	72	2.7	14.2
2017	34	29.1	19.4	87	65	4.7	89.6
2017	35	29.7	20.2	88	67	3.2	35.6
2017	36	30.9	20.3	91	66	5.6	17.2
2017	37	74.1	19.4	93	62	6.8	59.8

2017	38	28.9	19.2	85	68	1.3	3.8
2017	39	30.9	18.6	91	77	0.7	77.6
2017	40	30.6	19.1	96	66	2.1	72.6
2017	41	30.8	18.5	94	75	4.6	87.4
2017	42	31.4	17.4	84	56	3.9	7.2
2017	43	30.8	17.3	94	54	5.2	105.4
2017	44	29.6	11.6	77	48	7.6	0.0
2017	45	30.0	11.9	86	64	8.7	0.0
2017	46	29.5	13.7	84	84	5.8	0.0
2017	47	31.0	16.1	92	92	5.3	0.0
2017	48	29.4	11.6	92	94	7.0	0.0
2017	49	28.6	10.7	84	63	6.6	0.0
2017	50	30.0	10.3	89	43	8.2	0.0
2017	51	26.6	8.0	87	31	8.2	0.0
2017	52	28.1	7.8	86	29	8.1	0.0
2018	1	28.7	9.4	85	31	6.7	0.0
2018	2	28.6	9.3	84	35	7.0	0.0
2018	3	30.0	9.9	88	32	8.0	0.0
2018	4	29.4	8.4	85	31	7.0	0.0
2018	5	30.0	7.6	68	21	8.9	0.0
2018	6	30.3	9.9	81	32	5.9	0.0
2018	7	30.6	11.6	79	33	6.9	0.0
2018	8	32.6	11.9	84	26	9.7	0.0
2018	9	34.4	13.0	58	18	10.1	0.0
2018	10	36.3	13.6	64	20	10.4	0.0
2018	11	34.1	16.4	75	58	9.1	6.0
2018	12	35.9	16.1	72	26	9.7	0.0
2018	13	37.2	17.0	78	32	9.6	0.0

Rainfall is weekly total, other parameters are weekly means

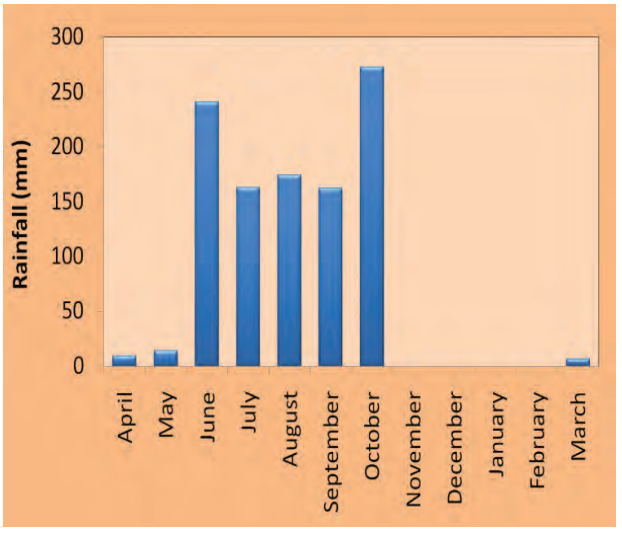


Fig. 2.1: Monthly rainfall distribution during April 2017 to March 2018

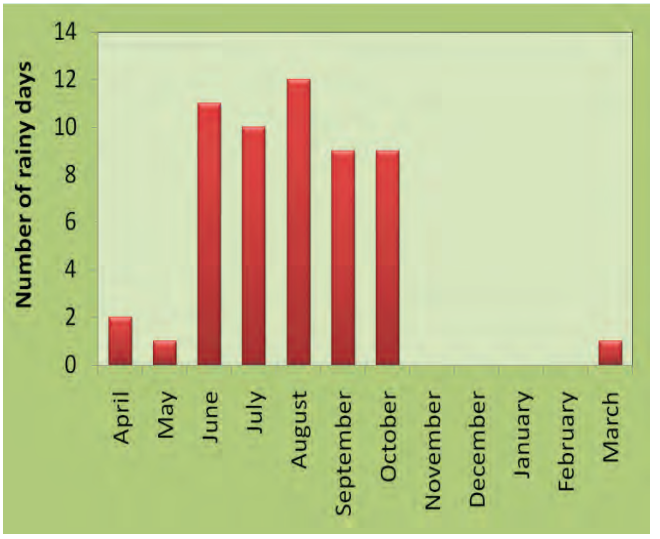


Fig. 2.2: Monthly number of rainy days during April 2017 to March 2018

2.1.2. Development of a database of rainfed districts

District Database of Agricultural Statistics is being maintained on ICAR-CRIDA website at http://www.crida.in:82/DDAS/. State level and all India level agricultural statistics recently made available were gathered, compiled and the State Database of Agricultural Statistics was updated.

2.1.3. Unreaped yield potentials of major rainfed crops (D&A/AS/02)

Unreaped yield potentials in major rainfed crops and scope for bridging yield gaps - A decision support system (DSS) was launched by Dr. Panjab Singh, Chairman, Research Advisory Committee, CRIDA on January 11th, 2018 and is being hosted on ICAR-CRIDA website at http://www.crida.in:8129/. The DSS got a copyright as web enabled software from the concerned office.

Crop-wise nutrient use data gathered from Agricultural Census was found to be unrealistic (unacceptably high) in certain cases. In view of this, certain validation checks were developed for nutrient use data included in the DSS by fixing crop-wise upper limits for use of N, P and K. The checks were implemented and an "*" with a remark 'nutrient use is unacceptably high' is displayed as foot note whenever the reported numbers are greater than upper limits.

Screen shot with remark on nutrient use for blackgram crop in Buldhana district of Maharashtra

Overall rainfed yield efficiency of a district (based on 20 crops) was computed as weighted average of crop-wise efficiencies, with share of area sown under a crop in the district as weight (Fig. 2.3). For each crop, the districts of all those clusters for which cluster mean of area under irrigation as a percent of sown area was less than 25% were considered. The number of districts having rainfed yield efficiency less than 0.5 are more in Madhya Pradesh (10), Rajasthan (8), Jharkhand (8), Tamil Nadu (6) and Orissa (5) states.

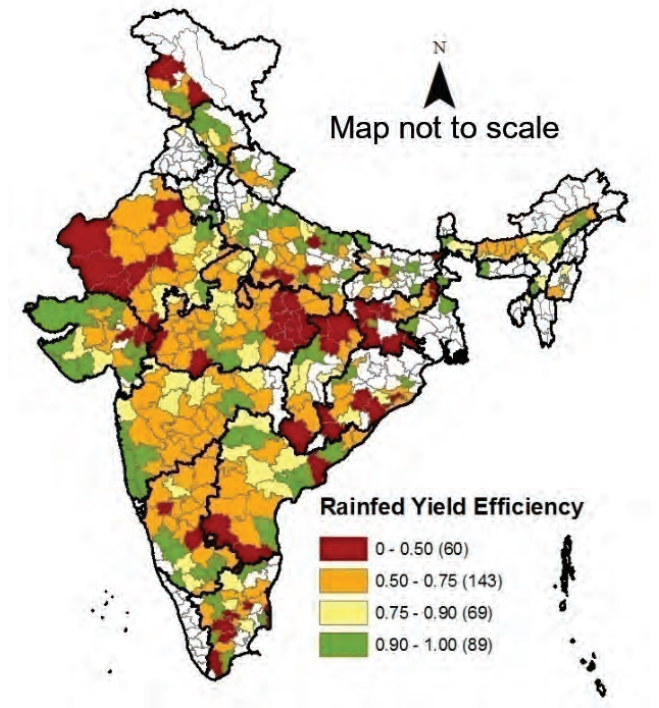


Fig. 2.3: Overall rainfed yield efficiency at district level (with 20 crops)

2.1.4. Inter-comparison of DSSAT, Infocrop and APSIM crop simulation models for climate change impact assessment in sorghum (AGMET/05)

A project was initiated in 2016 to calibrate, validate and assess the projected impact of climate change on sorghum using DSSAT, Infocrop and APSIM crop simulation models. During *kharif* 2017, field experiment was taken up in Gunegal Research Farm (GRF) in split-plot design, with three dates of sowing (June 9th, 16th and 23rd) as main-plots and three cultivars (CSV 20, CSV 23 and CSV 27) as sub-plots with three replications. Field observations were taken based on the minimum data set format developed for running the crop simulation models. Weather data and data on crop phenology, soil moisture, plant biomass, leaf area index, etc., were recorded.

Average yield was highest in the crop sown on 9th June (2597 kg ha^{-1}) and lowest in crop sown on 23rd June (900 kg/ha) due to shoot fly infestation (Fig. 2.4). Among the three cultivars, the highest average grain yields were observed with CSV 27 (2285 kg/ha) and the lowest with CSV 23 (1674 kg/ha).

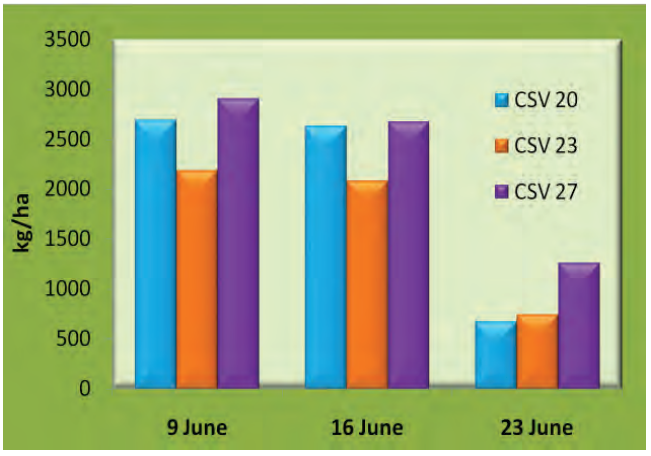


Fig. 2.4: Grain yield of sorghum with three dates of sowing and three cultivars

The calibration of DSSAT was performed using field observations of crop sown on 9th June and genetic coefficients for CSV 20, CSV 23 and CSV 27 were developed (Table 2.2).

Calibration of DSSAT sorghum model using the generated genetic coefficients showed good agreement between observed and simulated values of different parameters (Table 2.3).

2.1.5. Updation of district agricultural contingency plans

Based on the suggestion of the Parliamentary Consultative Committee on Agriculture, Food, Civil Supplies and Consumer Affairs, Government of India (GOI), ICAR (through NRM division) and CRIDA, Department of Agriculture and Cooperation, Ministry of Agriculture & Farmers' Welfare and State Agricultural Universities and KVKs took the responsibility of preparing contingency plans at district level for all the 126 agro-climatic zones of the country to deal with weather related aberrations. The district based contingency plans are prepared for 623 districts in the country (Fig.2.5) and hosted on ICAR/ DAC websites - http://agricoop.nic.in/acp.html; http://www.crida.in/ and circulated to all state agriculture departments.

Table 2.2: Genetic coefficients generated for sorghum cultivars using field experimental data of *kharif* 2017

Cultivar	DSSAT- Genetic Coefficients										
	P1	P2	P2O	P2R	PANTH	P3	P4	P5	PHINT	G1	G2
CSV 20	353	102	13.6	140.5	617.5	279.9	115.5	573	49	17.3	3.8
CSV 23	455	102	13.6	45.1	617.5	152.5	131.2	573	49	18	2.9
CSV 27	455	102	13.4	160.1	617.5	222.5	90.2	563	49	17.1	4.3

P1-Thermal time from seedling emergence to the end of the juvenile phase (expressed in degree days above TBASE during which the plant is not responsive to changes in photoperiod); P2 - Thermal time from the end of the juvenile stage to tassel initiation under short days (degree days above TBASE); P2O - Critical photoperiod or the longest day length (in hours) at which development occurs at a maximum rate. At values higher than P2O, the rate of development is reduced; P2R - Extent to which phasic development leading to panicle initiation (expressed in degree days) is delayed for each hour increase in photoperiod above P2O; PANTH - Thermal time from the end of tassel initiation to anthesis (degree days above TBASE); P3 - Thermal time from to end of flag leaf expansion to anthesis (degree days above TBASE) P4 - Thermal time from anthesis to beginning grain filling (degree-days above TBASE); P5 - Thermal time from beginning of grain filling to physiological maturity (degree days above TBASE), PHINT - Phylochron interval; the interval in thermal time between successive leaf tip appearances (degree days); G1 - Scaler for relative leaf size; G2 - Scaler for partitioning of assimilates to the panicle (head).

Table 2.3: Results of calibration of DSSAT sorghum model using generated genetic coefficients for three sorghum cultivars

Cultivars	Days to anthesis			Days to maturity			Grain yield		
	Observed	Simulated	RMSE	Observed	Simulated	RMSE	Observed	Simulated	RMSE
CSV 20	68	68	1.30	109	109	1.30	2694	2732	112
CSV 23	72	72	1.29	114	114	0.57	2188	2201	153
CSV 27	75	75	1.30	114	114	1.00	2908	2935	223

RMSE – Residual mean square error

Fig. 2.5: Status of district agricultural contingency plans

Operationalization of the contingency plans requires extensive planning both at 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 systematic sensitization exercise, the ICAR and DAC organized interface meetings with concerned line departments of the State Governments before the commencement of *kharif*, 2017 in Patna (Bihar), Ahmedabad (Gujarat), Jaipur (Rajasthan) and Bangalore (Karnataka). During the year 2017, following the forecast of India Meteorological Department and SASCOF (Fig. 2.6), state-wise interface meetings (a total of 6 states) were held with departments of agriculture, KVKs, SAUs, seed agencies and other stakeholders during May-June 2017.

Another two mid-season contingency meetings and one *rabi* interface meeting were held during the year. Since the commencement of organization of interface meetings for operationalization of contingency plans, a total of 37 meetings were held across different states. Updation of contingency plans is also being done with financial support from Department of Agriculture and Cooperation, MoA&FW for all districts.

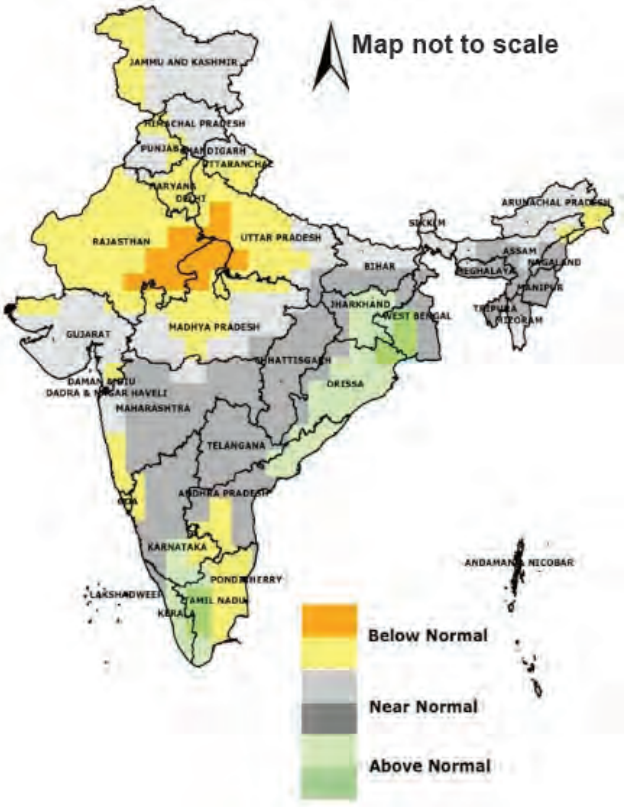


Fig. 2.6: SASCOF outlook for India – kharif 2017

2.2. Rainwater management

2.2.1. Integrated watershed management for resilient farming system and improved rural livelihood (RM/RM/24)

The project, initiated in 2015 and being implemented in the Gadda Mallaiah Guda watershed located in Yacharam mandal of Ranga Reddy district, has the goal of climate resilient watershed development through knowledge based optimal utilization of resources including efficient management of natural resource, diversified farming systems and allied enterprises to ensure food, nutrition and livelihood security.

The project activities are integrated across the objectives through different modules. The integrated module represents an effective approach to synergize and maximize operational efficiency. These modules include water resource development and management module, integrated farming system module, farm mechanization module, livestock sustenance module and climate resilience.

Interventions for rainwater harvesting and recycling of ground water were planned and taken up. Accordingly, structures to conserve rainwater and restore old water harvesting structures including percolation tanks/ponds were tried for recharging of open wells as well as deep wells in the farmers' fields in the watershed. These include rainwater harvesting structures, loose boulder structures and gabion structures. Artificial bore well recharge techniques for augmenting bore water were also developed and demonstrated. The major advantages of these techniques include low cost, easy implementability, more recharge in short time, use of local material and improvement in water table. The ground water levels in 27 bore wells and 3 open wells were also monitored on monthly basis.

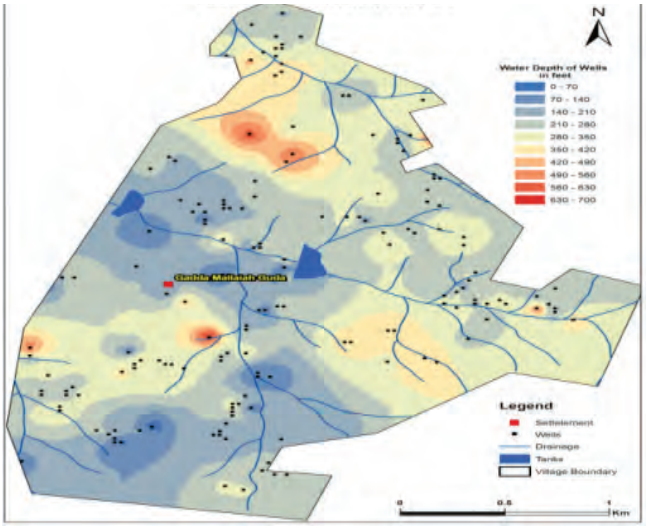


Fig. 2.7: Water depth of wells in Gadda Mallaiah Guda

Reconnaissance survey for farm pond

Gabion structure for groundwater recharge

Borewell recharge technique

Stone pitching at farm pond outlet

Percolation Tank

Fodder production in the watershed

2.2.2. Development and management of integrated water resources in different agro ecological regions of India (EF054 (CRP-Water))

An integrated farming system module with farm pond as a water source was implemented for a tribal farmer having 3 acres land in Petrallachenu village of Nagarkurnool district. The farm pond was filled 2 times, creating storage of 1200 m^3 from the 3 acres catchment. The integrated farming system included cotton (2.5 acres), vegetables (0.4 acre) and fodder (0.1 acre) along with 10 small ruminants. Cotton crop was given 2 critical irrigations of 30 mm during vegetative stage and 1 during boll development stage using water collected in the farm pond. The rainfall during the growth period of cotton was 343 mm out of which 130.3 mm was effective rainfall.

30 mm deficit supplemental irrigation to cotton substantially increased the yield (30 q from 2.5 acres) as compared to rainfed (12 q from 3 acres). The water productivity of cotton with supplemental irrigation was 3.41 kg/m^3 as compared to rainfed (1.92 kg/m^3). The green and blue water foot prints were 521 m^3 and 360 m^3 for the cotton and virtual water content (VWC) of cotton was 294 L/kg over the rainfed of 521 L/kg. VWC of cotton decreased by 43.63% with supplemental irrigation over rainfed, and productivity increased by 77%.

Integrated farming system module with 2.5 acres cotton (top left), 0.1 acres fodder (top right), 0.4 acre vegetables (bottom right), 10 small ruminants (bottom left) and 600 m^3 farm pond (centre)

Economic analysis indicated that there was a total net benefit of Rs. 96,065/- after meeting farmer's expenditure, with food security of having vegetables. The water productivity of tomato was 3.67 kg/m^3 with VWC of 272 L/kg. Vegetables were sold within the community contributing to the food security of 60 households in the village. The farmer, Mr. Yellaiah has cleared debt of Rs. 90,000/- as a result of the project interventions.

A gabion check dam was designed across the major stream passing through the tribal village of Petrallachenu to store 3000 m^3 water. The dimensions of the gabion structure are 30 m long head wall with 2.4 m bottom width and 0.6 m top width with 1:1 slope in U/S and 2 :1 in D/S of the structure. The structure was filled 3 times, recharging about 5400 m^3 after

Table 2.4: Net income before and after implementing the IFS module

Before			After		
Crops	Area (Production)	Net income (Rs.)	Crops	Area (Production)	Net income (Rs.)
Cotton	3 acres (12 q)	-3600	Cotton	2.5 acres (30 q)	71000
			Vegetables (Chillies, Brinjal, Tomato)	0.4 acres (3 q)	6600
			Fodder	0.1 acre (55 kg)	165
			Small Ruminants (10)	-	18300
Total (Rs.)		-3600	Total (Rs.)		96065

accounting for evaporation losses of 40% in the area, contributing to rise in ground water levels by 3 m in the tube wells.

Rainwater harvesting through gabion check dam for ground water recharge

2.2.3. Enhancing rainwater productivity under farm pond through solar powered micro irrigation system for small farmers [EF054 (CRP-Water)]

A 0.5 hp DC submersible pumpset having discharge of 70 L/min and 27 m max. head was installed in the farm pond connected with micro irrigation system for irrigating 1 acre plot under vegetables and for investigating the rainwater productivity in small holdings. Two solar panels of 250 watts each having dimension of 1.49 m^2 area, costing Rs. 70,000/- including installation, were installed as power source for DC submersible pumpset. Water melon was grown on beds having the size of 14x1 m. From early vegetative stage of the crop, solar powered drip irrigation was used to apply water on everyday irrigation schedule with treatments of plastic mulching and organic mulching at 5 t/ha and beds with no mulching. The highest water productivity of 5.6 kg/m^3 was obtained with plastic mulching as compared to organic mulching (4.8 kg/m^3) and no mulching (2 kg/m^3). The drippers were hydraulically tested by measuring the discharge rates in the morning, afternoon and evening as the energy potentials are different at different times of the day. There was a change in the dripper discharge, 3.3 L/hr in the morning (9-10 am), 4.41 L/hr in the afternoon (12-13 pm) and 3.1 L/hr in the evening (15-16 pm) with uniformity coefficient varying from 95 to 98% in the system.

Water melon production with solar powered micro irrigation system with different mulches

2.2.4. Impacts of meso-scale watershed development in Andhra Pradesh (India) and their implications for designing [EF040 (ACIAR)]

A research project is in progress with the objective to enrich and upgrade an integrated approach for the assessment of the environmental, economic and social impacts of current watershed development at a meso-scale in Andhra Pradesh. Based on the 0.25 degree resolution of daily rainfall dataset of Aphrodite, annual average effective rainfall and annual average runoff percentages were worked out for each of the stations covered in India (Fig. 2.8). The assessment would provide the expected runoff in various rainfall zones which could be used to estimate the runoff in watersheds for Integrated Watershed Management Programme (IWMP) projects.

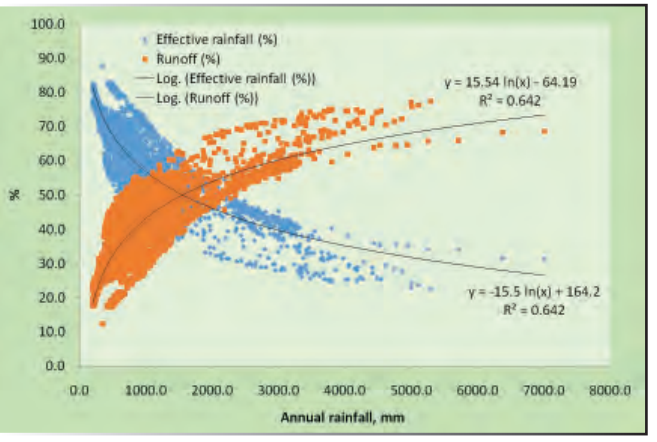


Fig. 2.8: Average annual effective rainfall (%) and runoff (%) in different rainfall regions

An attempt was made to understand the guidelines followed for water harvesting across states

in India. Detailed project reports of IWMP watersheds were studied and the salient features are given below:

- In spite of identification of IWMP watersheds of 3000-5000 ha, a few states are following the planning on a micro watershed basis, as it was done earlier and very few states are carrying out the planning in a whole IWMP watershed.
- Water budgeting is carried out by a few states wherein existing storage information is considered while planning for the new interventions.
- Information used for estimating the harvestable amount of water is varying across states. While states follow the norm of certain percentage of rainfall as runoff, few states assume a uniform quantity of runoff available for good, medium and bad watersheds, characterized based on vegetation in the watershed.

Groundwater recharge prospects

Rainfall distribution, coupled with total rainfall greatly influences the ground water recharge during the monsoon period. Exact estimation of groundwater recharge would require considerable time and large quantities of data. Qualitative estimation of groundwater recharge prospects was attempted by interpreting the rainfall received on a week to week basis for each district. For example, if scanty rainfall is received in more than 65% of weeks or deficit rainfall is received in more than 80% of weeks on cumulative basis, the recharge possibility is considered to be extremely low. Criteria followed for estimating groundwater recharge prospects are given in Table 2.5.

Rainfall data available from IMD (www.imd.gov.in) and other states (Andhra Pradesh, Telangana, Karnataka, Gujarat and Rajasthan) during the current monsoon was utilized for the analysis purpose. Based on the above criteria analyzed for about 660 districts in the country, the ground water recharge due to monsoon rainfall was extremely low to very low in about 123 districts (Fig. 2.9). About 213 districts (32% of total districts) had low to extremely low prospects for groundwater recharge. About 152 districts seem to have medium prospects for recharge. Prospects for groundwater recharge are normal in about 295 districts distributed across the country. Parts of Uttar Pradesh, Eastern Madhya Pradesh, Jharkhand, Chattisgarh, Bihar had limited prospects for recharge during the season. In Southern states, Tamil Nadu, Southern Karnataka had limited prospects for recharge. North East region also had limited prospects for recharge in many districts. In Uttar Pradesh, among 72 districts in the state, only 13 districts had prospects for normal recharge. In Madhya Pradesh, out of 51 districts 15 districts had prospects for normal recharge.

Table 2.5: Criteria for qualitative estimation of groundwater recharge prospects

Percent of deficit rainfall weeks	Percent scanty rainfall weeks	Groundwater recharge prospects
80	65	Extremely low
70	50	Very Low
50	30	Low
30	10	Medium
10	0	Normal

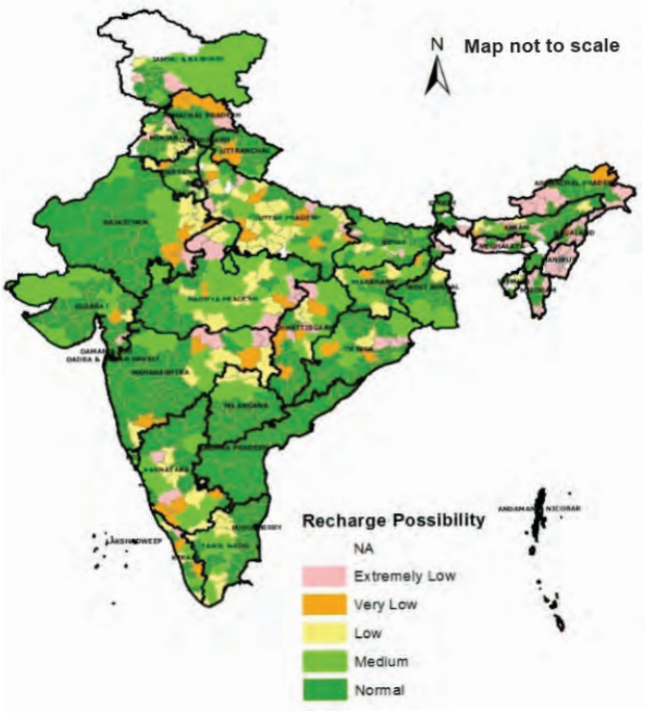


Fig. 2.9: Groundwater recharge prospects 2017

2.2.5. Assessment of stream flow variability in Godavari basin

Based on the available data of stream flow at different gauge stations, average runoff coefficient and precipitation elasticity to stream flow were estimated to understand the variability of stream flow for unit change in the rainfall (Fig. 2.10). Elasticity of stream flow was computed with the following formula

Elasticity = Median [$(Q_t$-Ave Q)/(P_t-Ave P)*(Ave P/Ave Q)}

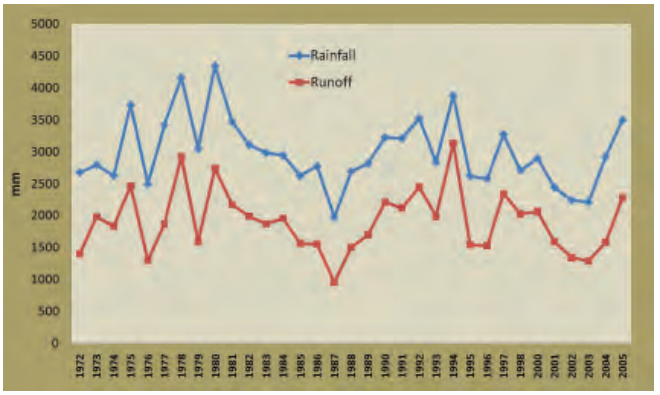


Fig. 2.10: Time series plot of rainfall and runoff

The elasticity was estimated for 50 stations considering the all data available on stream flows. The elasticity values indicate that except for stream flow at T. Ramapuram, the variability of stream flow at other stations is higher for unit change in rainfall.

2.2.6. Development of district drought proofing plans for selected districts in 3 states

The drought management division of Ministry of Agriculture and Farmers' Welfare, Government of India, made a new initiative to identify and implement suitable measures for agriculture and allied sectors with a view to withstand recurring droughts. As a pilot initiative, 24 districts spread over Karnataka (16), Andhra Pradesh (4) and Rajasthan (4) were identified to develop drought proofing action plans. These 24 districts were identified based on declaration of drought by respective states considering frequency of droughts during last 15 years (Fig. 2.11). The task has been entrusted to ICAR-CRIDA. Essentially the action plan needs to identify suitable interventions after thorough assessment of resources available (both internal and external) *vis a vis* prevailing farming systems. The scale of such study could be district/block/basin. In the present initiative, district was chosen as unit. However, considering large variability in rainfed regions, block/taluq has been taken as unit for planning purpose in the study to account for variability in available resources and to make use of finer resolution data available for planning purpose. Once the plans are developed at block/taluq level, they are being aggregated for each district.

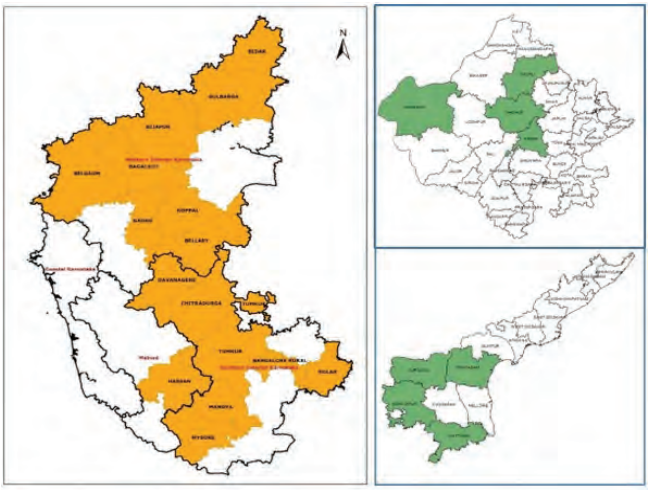


Fig. 2.11: Districts selected for the study

The plan process needs to understand the systems prevailing in the block/taluq and to identify the dependency of one over other and to link the systems very effectively to develop a sustainable plan which can take account of resources and develop systems matching the resources. The process of plan development becomes complex when external resources are available in plenty and when everybody vies for same resource and unknowingly clamors for systems of heavy resource use.

If available rainfall is more than the systems requirement, management of available resource is main option and one need not depend on external resources. By suitable planning it is easy to sustain *kharif* season. It is also possible to ensure assured *rabi* cropping season. The scenario is more visible in high rainfall areas and suitable interventions would depend on water conservation systems, reuse, better inputs and improved management practices. On the other hand, if available rainfall is less than the systems requirement, management of all available resources becomes important and one needs to consider systems perspective, efficiency measures, priority for systems, etc. The governance issues also play major role and such

plan would be sustainable with active participation of all stake holders.

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

A project is being implemented in collaboration with International Water Management Institute (IWMI), Sri Lanka for validation of the integrated drought severity index (IDSI) developed under IWMI's South Asia drought monitoring system project, for rainfed and irrigated agriculture for selected drought prone sub-districts on developmental scale. As part of the validating the product, *i.e.*, Integrated Drought Monitor Index (developed by IWMI) under Indian conditions, experimental sites were identified at Hyderabad (CRIDA research farms), and 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 is being monitored along with rainfall information which would be verified with IDSI. Progressive vegetative/crop growth changes during the same season were observed to identify the moisture stress conditions in these districts. Assessment is being made to compare this product with IDSI for selected districts.

2.3. Crops and cropping systems

2.3.1. Development of mapping population and genetic enhancement for drought tolerance in maize (CS/CP/29)

Drought is a major limiting factor severely affecting maize production especially under rainfed dryland conditions. Evaluation and characterization for various morpho-physiological traits associated with drought stress are required for efficient utilization of genetic resources in crop improvement programme for developing drought tolerant varieties/hybrids. Identifying QTLs linked to drought tolerance related traits will further help to accelerate the genetic enhancement of drought tolerance in maize through marker assisted selection (MAS) breeding. A project was initiated in 2014 to develop and characterize inbreds having drought tolerance to be utilized as parents for genetic enhancement and to develop mapping population for using in QTL mapping and association studies for drought tolerance in maize.

During *kharif* 2017, a field experiment was conducted with 25 maize genotypes including check (DHM117) under rainfed condition. Data were recorded on various yield attributes for identifying superior genotypes. In another experiment, 15 genotypes including 12 selected inbreds along with 3 hybrids were evaluated under rainfed conditions. Another 30 genotypes selected from maize field day at IIMR regional station, Rajendranagar, Hyderabad were also evaluated for various morpho-physiological traits during *kharif* 2017 under rainfed conditions. In hybrid trial, 11 hybrids including two commercial hybrids TMMH-806, TMMH-826 were evaluated.

The analysis of variance (ANOVA) of 25 genotypes revealed significant genotypic differences ($p \leq 0.05$) for all traits except ASI and cob girth. Performance of the genotypes was affected due to drought stress at different stages of crop growth. Genotypes DTL2, SNJ2011-03, SNJ2011-37, SNJ2011-26, Z101-15, Z32-12 performed relatively better for yield and its attributes (Table 2.6) as compared to others.

Table 2.6: Grain yield and yield attributes of better performing inbreds under rainfed condition

Genotypes	DT	DA	DS	ASI	PH	CH	CL	CG	NKR	NKPR	HSW	CW	SY
DTL2	53.0	55.6	57.6	2.0	178.0	38.5	12.3	13.7	15.0	22.0	21.6	103.4	83.1
SNJ201103	48.0	50.6	53.3	2.6	136.4	31.6	12.2	13.0	13.3	26.3	24.6	94.6	79.6
SNJ201117	47.0	50.0	53.0	3.0	112.7	31.2	13.7	12.3	12.8	25.0	22.6	86.4	61.5
SNJ201126	46.3	49.0	51.6	2.6	129.3	34.8	12.1	13.4	14.5	23.1	21.6	82.6	73.0
SNJ201137	52.0	54.6	57.3	2.6	158.3	41.7	12.7	13.1	12.2	28.5	24.0	98.8	78.0

Z10115	49.0	51.6	54.3	2.6	126.7	27.2	10.8	11.3	14.1	23.0	14.6	79.3	70.6
Z10168	52.6	54.6	57.3	2.6	158.2	60.6	15.5	12.7	14.7	30.1	22.3	102.2	68.0
Z3212	51.6	54.6	57.6	3.0	151.2	51.3	14.6	13.2	14.2	25.5	23.3	113.5	74.1
Z5911	52.3	54.0	56.6	2.6	169.0	52.6	14.0	12.3	12.6	29.6	24.3	91.7	61.2
DHM117	58.6	61.0	64.3	3.3	177.7	60.1	13.7	15.1	13.3	25.0	25.6	89.8	77.1
CD (5%)	3.02	3.19	3.32	1.16	9.49	8.27	1.97	1.58	1.66	3.97	2.19	9.57	8.70

DT=Days to tasseling, DS=Days to silking, DA=Days to anthesis, PH=Plant height (cm), CH=Cob height (cm), CL=Cob length (cm), CG=Cob girth (cm), NKR=No. Kernel row per cob, NKPR=No. kernel per row, SY=Seed yield (g/pl), FY=FY dry (g/pl), HSW=hundred seed weight (g), ASI=Anthesis silking interval, CW=Cob weight, CD= critical different at 5% level of significance

The analysis of variance (ANOVA) of 15 genotypes screened under rainfed conditions also revealed significant genotypic differences ($p \leq 0.05$) for all traits except ASI and cob girth. Genotype HKI766(0) performed relatively better for yield and its attributes as compared to other test genotypes but lower than the best checks (Table 2.7).

Table 2.7: Grain yield and yield attributes of better performing inbreds under rainfed conditions

Genotype	DT	DA	DS	ASI	PH	CH	CL	CG	NKR	NKPR	CW	HSW	TB	SY
EC842583	46.3	49.6	56.0	6.3	130.0	27.2	9.2	10.2	11.2	17.7	63.0	27.1	89.1	57.6
EC842592	48.0	50.6	53.3	2.6	128.4	27.2	10.3	10.7	13.3	20.0	63.6	23.1	85.8	44.5
HKI161	53.6	56.3	59.0	2.6	138.8	23.7	12.0	12.2	13.8	24.2	69.4	23.5	102.4	53.3
HKI164D4	52.6	55.3	58.6	3.3	116.0	37.5	11.7	13.1	10.7	16.2	69.3	25.7	95.4	43.7
HKI766(0)	48.6	53.3	56.0	2.6	123.0	22.8	16.0	13.7	14.4	30.2	95.2	25.5	125.2	71.5
NSJ189	56.6	60.3	64.0	3.6	137.4	35.1	13.1	11.8	11.5	25.6	74.4	19.5	145.6	58.5
PSRJ13099	49.6	53.0	56.3	3.3	122.1	27.0	9.5	10.5	11.2	22.4	35.7	20.9	51.8	29.1
RJR132	54.3	57.3	60.6	3.3	142.2	26.6	10.6	10.7	12.3	19.2	61.7	24.8	104.1	52.7
RJR385	46.3	49.3	51.6	2.3	131.7	25.8	11.1	11.6	12.8	22.1	61.7	23.2	86.2	42.1
SNJ201126	46.0	49.3	52.0	2.6	121.1	32.4	11.0	10.7	13.2	17.0	61.6	21.7	90.6	42.1
Z10115	49.3	52.0	55.0	3.0	126.8	35.3	10.8	10.0	10.6	23.0	57.6	24.7	93.5	39.7
Z965	47.3	51.0	53.6	2.6	133.1	33.1	10.7	11.8	13.2	22.5	80.3	29.3	108.6	53.2
DHM117	56.3	59.0	62.3	3.3	168.7	42.3	12.5	12.1	14.0	28.4	117.7	26.7	224.6	99.8
TMMH806	52.6	54.6	56.6	2.0	149.1	34.7	12.2	12.2	11.8	23.5	80.3	28.8	127.6	76.6
TMMH826	53.0	55.3	57.6	2.3	143.6	33.4	13.8	12.4	23.2	15.4	144.8	27.5	202.1	116.5
CD (5%)	2.14	2.4	2.92	1.75	7.52	6.62	2.03	1.64	1.93	3.52	13.96	2.54	47.7	27.79

In hybrid trial, nine new hybrids along with two commercial hybrids (TMMH806 and TMMH826) were evaluated under rainfed conditions. Three hybrids (HKI7660/SNJ201126, RJR385/SNJ201126, Z10115/SNJ201126) were found to be drought tolerant and high yielding at par with the commercial hybrids.

Thirty genotypes selected from IIMR, RS, Hyderabad were also evaluated for various morpho-physiological traits. There was high variability for seed yield, its attributes as well as physiological traits among genotypes. Some of these genotypes were found to be superior for yield and having traits related to drought tolerance.

Generation advancement of mapping population

One mapping population, *viz.* HKI161/SNJ2011-26 was advanced to $F_{7:8}$ through selfing of >270 single plant progenies. The population showed high variability for plant height, cob height, grain yield, number of kernel rows and kernel number per row.

2.3.2. Genotypic variability for yield and nutritional quality attributes in horse gram under abiotic stresses (CS/CP/32)

Pulses are considered to be the poor man's meat. It is the main source of protein, dietary fibre and energy essential for human health. Some of the underutilized legumes like, horse gram [*Macrotyloma uniflorum* (L.) Verdc] have great potential in ensuring nutritional security of rural, tribal and underprivileged masses. Horse gram is a potential grain legume having better climate resilience to adapt harsh environmental conditions. However, nutritional properties of pulses are known to be affected by several factors and processes. It is important to understand impacts of drought/heat stress on the various nutritional quality parameters including micro elements and antioxidants in cultivars grown under different levels of abiotic stresses. A project was initiated in 2016 to evaluate horse gram germplasm for growth and quality parameters, study nutritional and anti-nutritional quality parameters of selected high yielding cultivars and to characterize the genotypic variability of the response to elevated temperature in horse gram.

During *kharif* 2017, a field experiment was conducted at Hayathnagar Research Farm with genotypes of horse gram including five checks viz., CRIDA-18R, CRHG-4, CRHG-19, CRHG-22, AK-42 and VLG-15. Data were recorded on yield and its attributes. The seed samples of all these genotypes were analyzed for micro-nutrients (Mn, Fe, Zn and Cu) contents.

There were significant variations among genotypes for most of the traits studied except pod length, seeds per pod, zinc and copper content. Germplasm also showed high variation for micro-nutrient contents especially iron content (27 to 104 mg/kg). The results showed CRHG1, CRHG3, CHRG9 and CRHG10 as better performing among genotypes and comparable to released varieties. Seed yield showed high variation among genotypes tested (Fig. 2.12). The mean data was also used to calculate the correlation among different traits which revealed highly significant correlation between different traits. Seed yield per plot showed significant positive correlation with hundred seed weight, fodder weight per plot and iron content.

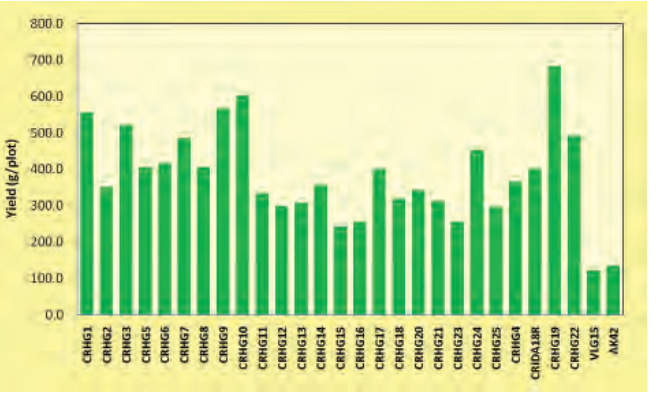


Fig. 2.12: Seed yield of horse gram genotypes

In another experiment, two released varieties namely CRHG-4 (black seeded) and CRIDA1-18R (brown seeded) were screened under open top chambers (OTCs) in ambient (aCO_2) and elevated (eCO_2) CO_2 to study their performance. The results revealed that both varieties performed better under elevated CO_2 as compared to ambient for all traits including total biomass and yield parameters (Fig. 2.13). Variety CRHG-4 had higher biomass and yield parameters compared to CRIDA1-18R. The trial needs to be repeated for confirmation.

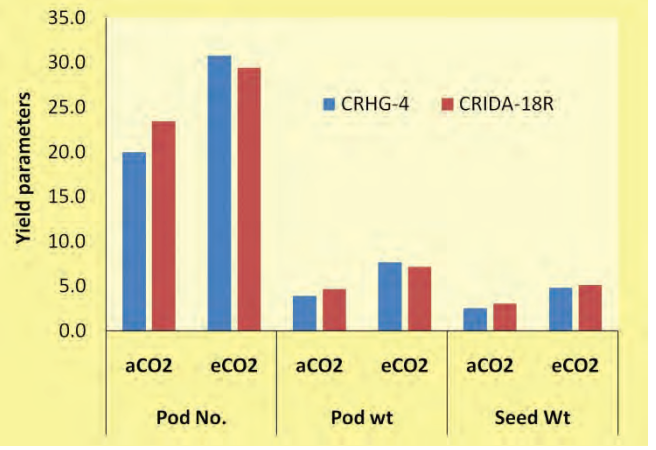


Fig. 2.13: Yield parameters of horse gram under ambient and elevated CO_2

2.3.3. Genetic improvement of arid legumes for dryland agriculture (CS/CP/27)

Arid legumes as a group of pulses are extremely important in the common vegetarian diet of the people in the area of their cultivation. Arid legumes also offer a new dimension as they have become foreign exchange earners through export opportunities. Due to uncertain rainfall and delayed monsoons the major dryland crops of southern zone of semi arid region are being affected.

Arid legumes such as horse gram and cluster bean are alternative remunerative crops with low production cost.

Mutation breeding programme was carried out at CRIDA to develop high grain and forage yielding horse gram cultivars with early maturity and tolerance to major diseases. A number of stable mutant lines were identified by selections in the advanced generations. Initial varietal trial of 13 horse gram entries was conducted at Hayathnagar Research Farm. Among the 13 horse gram entries, days to 50% flowering ranged from 35 (VLG-44) to 71 days (CRHG-22) and days to maturity ranged from 75 (AK-42) to 105 days (CRHG-26). Plant height ranged from 38 (VLG-15 and VLG-44) to 73 cm (VHG 935). Number of branches per plant ranged from 7 (VLG-15) to 12 (VHG 935). Number of pods per plant ranged from 90 (BSP 17-2) to 430 (VHG 935). Number of seeds per pod ranged from 5.7 (CRHG-22) to 6.7 (CRHG-19). Pod length ranged from 5.3 (CRHG-22) to 6.7 cm (VHG-15). Hundred seed weight ranged from 3 (AK-42) to 4 gm (VLG-44). Fodder yield per plot ranged from 280 (VLG-44) to 1302.7 g (CRHG-22). Seed yield per plot ranged from 202 (VHG-935) to 672 gm (CRHG-19).

As cluster bean cultivation is mainly concentrated in arid regions the adaptability of the varieties and genotypes in semi arid regions needs to be studied. Moreover the powdery mildew incidence is a major problem in this crop in semi arid regions. Identification of suitable genotypes, cultivation practices and development of high yielding and disease resistant varieties suitable to specific agro ecological conditions is needed to increase the productivity and enhance the production of this crop.

Thirteen cluster bean entries of initial varietal trial were evaluated in 4 replications in 8 rows of 4 meter length with spacing of 45x10 cm. Among the 13 cluster bean entries, seed yield per plot ranged from 661 (GAUG-1304) to 1648 g (RGr-16-7), fodder yield per plot from 915.8 (GAUG-1304) to 2788.8 g (RGr-16-7), days to 50% flowering from 31 (CAZG 15-7) to 42 days (GAUG-1304), days to maturity from 90 (CAZG 15-7) to 102 days (GAUG-1304), plant height from 54 (CAZG 15-7) to 93 cm (GAUG-1304), number of branches per plant from 1 (RGC-1066, RGr 16-7 and RGC-1066) to 12 (RGr 16-2) and number of clusters from 10 (RGr 16-2 and CAZG 15-7) to 23 (GAUG-1304). Pod length was 6 cm in all the entries except RGr 17-2 and CAZG 15-5 (5 cm). Seeds per pod ranged from 6 (RGr 17-2) to 8 (CAZG 17-4) and hundred seed weight ranged from 2.8 (GAUG-1304) to 4 g (RGr 17-2).

2.3.4. Potential of cropping systems as a climate resilient adaptive strategy for managing drought in rainfed agriculture: Strip cropping (CS/CP/34)

Utilizing the concept of strip cropping as a climate adaptive strategy, efforts are being made since 2016 to introduce an extra crop either as a relay or sequence crop into the space left by a short/medium crop of the system while the long duration crop of the system gets the extra rain event advantage. An experiment on a comparative study of mechanized sowing of sorghum + pigeonpea strip cropping (4:4 strips) with 2:1 intercropping accommodating either relay or sequence cropping of horse gram in place after harvest of sorghum (a medium duration crop) with the extra rain events during the post monsoon period was carried out during 2017-18. The strip intercropping of sorghum and pigeonpea was sown successfully with tractor drawn planter in the ratio of 4:4 and compared with the additive series of recommended 2:1 intercropping system. Relay intercrop of horse gram was sown at right soil moisture status and performed well compared to the sequence crop of horse gram, which was sown during the end of October month.

Strip intercropping system (4:4)

The results during 2017-18 showed that the 4:4 strip intercropping system (replacement series) with relay horse gram performed better (Fig. 2.14) with more number of branches in pigeonpea contributing to yield due to sufficient space availability for improved microclimate and good rainfall quantities for the relay sown horse gram. However, 2:1 intercropping system

(additive series) with the tall and lean growth of both sorghum and pigeonpea with reduced number of branches resulted in lower yields as compared to the 4:4 strip system. Horse gram sown in September as relay crop received 350 mm of rainfall whereas horse gram sown in sequence received 106 mm, affecting the yields.

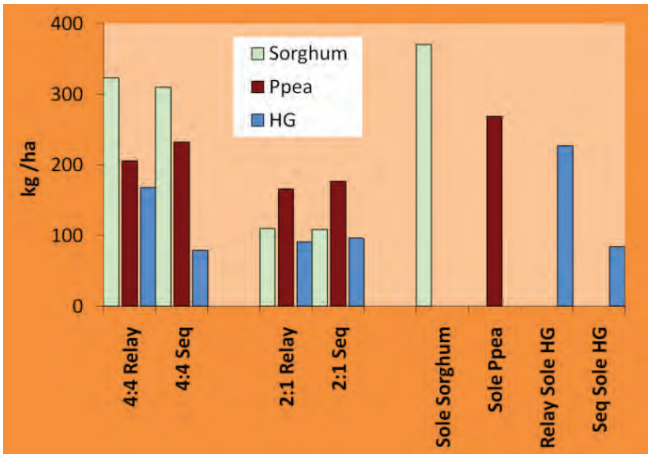


Fig. 2.14: Seed yields of component crops of different cropping systems (4:4 strip cropping and 2:1 intercropping) during 2017-18

2.3.5. Development of fodder based cropping system to improve livelihood security in rainfed areas (CS/CP/30)

A field experiment was carried out with 7 crops/crop-fodder combinations: CS 1 - sorghum/annual fodders (fodder cluster bean – fodder cowpea – fodder horse gram grown in succession on the same piece of land), CS 2 - sorghum + pigeonpea/hedge lucerne, CS 3 - sorghum + pigeonpea/guinea grass, CS 4 - castor/hedge lucerne, CS 5 - castor/guinea grass, CS 6 - sole sorghum, and CS 7 - sole pigeonpea, to identify sustainable fodder based cropping systems with higher system productivity and resource use efficiency to meet the fodder needs of rainfed farmers.

In the 3rd year after planting, guinea grass yielded 51.6 t/ha of green fodder (mean of CS 3 and CS 5) from 5 cuts, hedge lucerne yielded 31.2 t/ha green fodder (mean of CS 2 and CS 4) from 5 cuts, and annual fodders – cluster bean, cowpea and horse gram grown in succession on the same piece of land (CS 1) yielded 25.5 t/ha of green fodder.

Sorghum+pigeonpea/hedge lucerne system

Since the outputs from each system are different, they were compared on the basis of gross returns computed using prevailing market prices in case of fodders and minimum support prices in case of grain/seed. The highest gross returns of Rs. 1,18,054/ha (Fig. 2.15) were obtained with sorghum + pigeonpea/guinea grass (CS 3), followed by sorghum + pigeonpea/hedge lucerne (CS 2 - Rs. 1,12,766 /ha). In both these systems, the perennial fodder component contributed significantly to the gross returns. Sole pigeonpea was the third most remunerative system (Rs. 1,06,439 /ha).

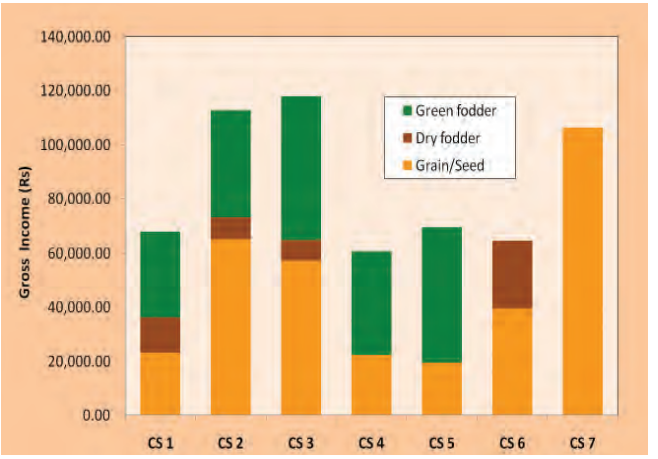


Fig. 2.15: Commodity-wise and total gross returns from 1 ha of the cropping systems

Among the 6 cropping systems (sole pigeonpea has no fodder component), soghum+ pigeonpea/guinea grass (CS 3) produced the highest dry matter (17.4 t/ha), and sorghum+ pigeonpea/hedge lucerne (CS 2) produced the highest crude protein (2.66 t/ha) and metabolizable energy (39.41 m cal/ha). Growth cum metabolic trial conducted for a period of 30 days on Nellore ram lambs using the crop residues and fodders available from different systems showed higher average

daily gain (Fig. 2.16) and live weight gain with sorghum/ annual fodders system (CS 1). However, considering the fodder biomass, crude protein and metabolizable energy available from one hectare area of each system, sorghum+ pigeonpea/hedge lucerne (CS 2) is the best fodder based cropping system as it meets the dry matter, energy and protein requirement of more growing lambs for longer period of time.

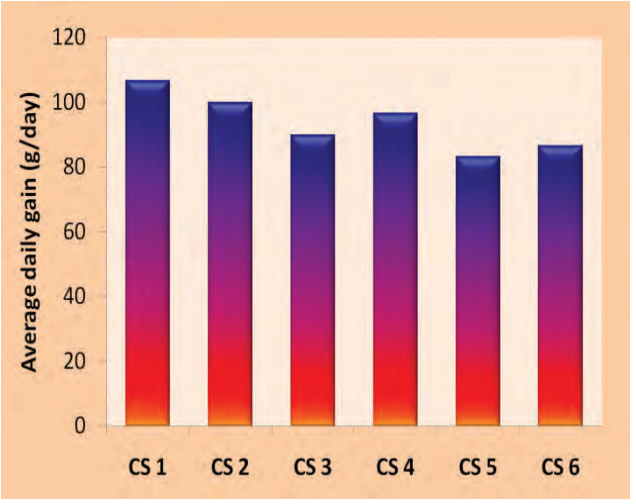


Fig. 2.16: Average daily gain of Nellore ram lambs fed with fodder available from different fodder based cropping systems

2.3.6. Biofortification for improved nutritional traits in selective dryland crops grown under rainfed conditions (CS/FN/01)

In order to deliver enhanced nutrition within a food-based system, it is necessary to increase the nutritional value of the food. By enhancing essential nutrient content of crops, severe deficiencies can be eliminated in developing countries. One of the ways by which this goal can be achieved is through natural biofortification of food crops. A field experiment was carried out with the following thirteen treatments : NP, NP+PSB, NP+FYM, NP+$FeSO_4$ (soil application, SA) with PSB, NP+$ZnSO_4$ (SA) with PSB, NP+$FeSO_4$+$ZnSO_4$ (SA) with PSB, NP+$FeSO_4$ (foliar spray, FS) with PSB, NP+$ZnSO_4$ (FS) with PSB, NP+$FeSO_4$+$ZnSO_4$ (FS) with PSB, NP+$FeSO_4$+$ZnSO_4$ (SA) + one $FeSO_4$+$ZnSO_4$ (FS) with PSB. Pigeonpea variety PRG-158 seed was biofortified/treated with PSB-3 at the time of sowing. The effect of biofortification with PSB-3 on the basis of its ability to solubilize inorganic forms of soil phosphorus and zinc and to produce siderophores in vitro, was studied in field situation at Hayathnagar Research Farm, to study the absorption of essential nutrients from soil to root, leaves and finally to the edible part of the pigeonpea crop. Seeds of pigeonpea grown with the above treatments were analyzed for protein, ash and nutrient contents.

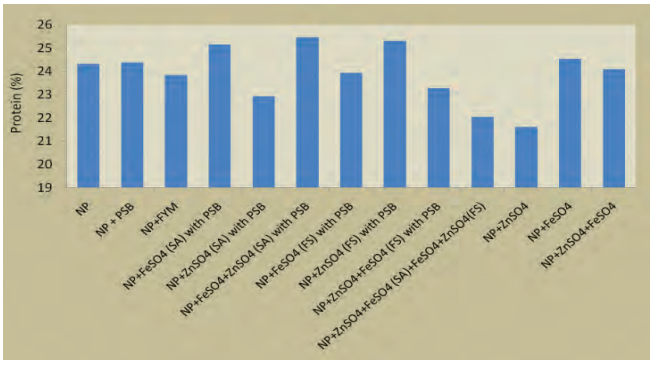


Fig. 2.17: Protein content of pigeonpea seed with different biofortification treatments

Protein content was significantly higher with NP+$FeSO_4$+$ZnSO_4$ (SA) with PSB (25.46%) followed by NP+$ZnSO_4$ (FS) with PSB (25.31%) and least with NP+$ZnSO_4$ (21.62%) (Figure 2.17).

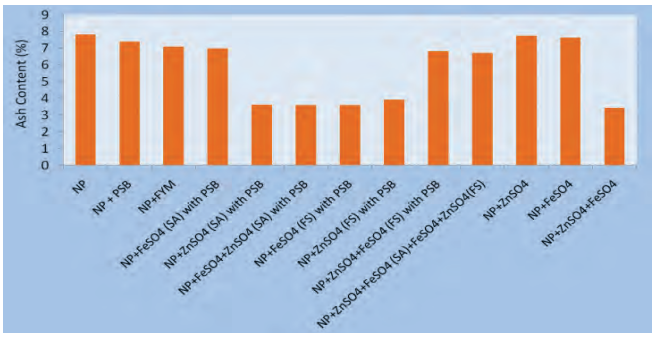


Fig. 2.18: Ash content of pigeonpea seed with different biofortification treatments

Ash content (Fig. 2.18) was higher with NP (7.83%) followed by NP+$ZnSO_4$ (7.76%) and the least ash content was seen with NP+$ZnSO_4$+$FeSO_4$ (3.43 %).

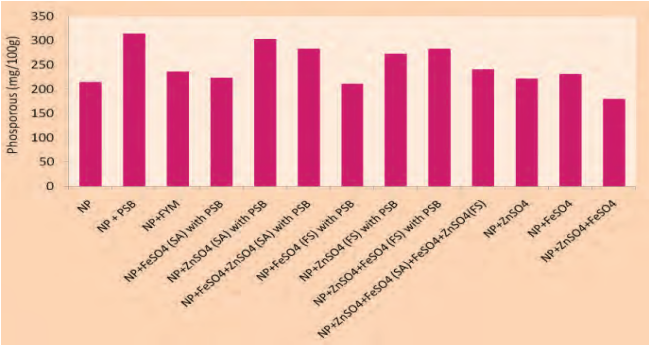


Fig. 2.19: Phosphorus content of pigeonpea seed with different biofortification treatments

Phosphorus content was significantly higher with NP + PSB (314.68 mg/100g) among the 13 treatments, followed by NP+$ZnSO_4$ (SA with PSB) (303.09 mg/100g), whereas, least was seen withNP+ZnSO4+FeSO4 (180.16 mg/100g) (Fig. 2.19).

2.4. Soil and nutrient management

2.4.1. Conservation tillage farming strategies and crop residue management for soil health improvement and higher crop productivity in sorghum- black gram system in rainfed Alfisol (RM/LU/13)

A project was initiated in 2013 to develop low till and residue management strategies for higher productivity of sorghum-black gram system, improved carbon sequestration and physical, chemical and biological soil health on long term basis, enhanced resource use efficiency and reduced energy requirement. Field experiment is being conducted at Hayathnagar Research Farm since 2013 with two tillage systems: conventional (CT) and minimum (MT) and three residue retention treatments, No residue application (S1), Cutting at 35 cm height (S2), Cutting at 60 cm height (S3) in case of sorghum and No residue (S0), 50% of the residue retention by clearing residue from alternate rows (S1), 100% retention (S2) in case of blackgram. During the current year, sorghum (CSV-27) was the test crop.

Sorghum crop under conventional (left) and minimum (right) tillage

Sorghum grain yield varied from 1108 to 1684 kg ha^{-1} across the treatments Fig. 2.20). Minimum tillage recorded (1497 kg ha^{-1}) significantly higher grain yield compared to conventional tillage (1263 kg ha^{-1}) and 100% residue retention of blackgram crop recorded significantly higher sorghum grain yield of 1565 kg ha^{-1} as compared to no residue retention (1229 kg ha^{-1}).

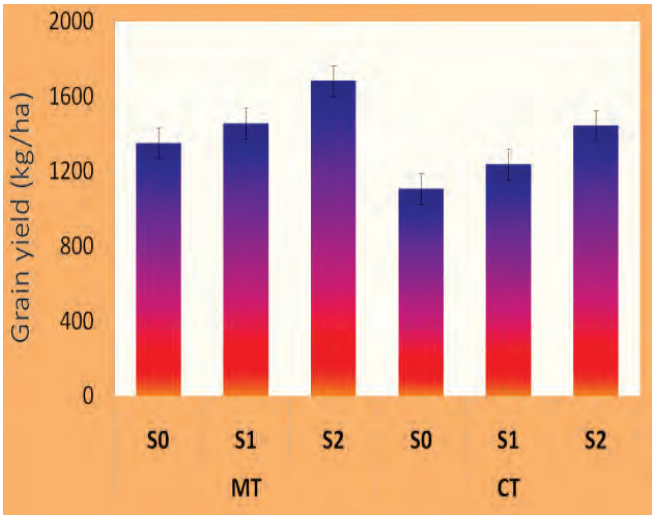


Fig. 2.20: Long term effect of conservation tillage and residue retention treatments on Sorghum grain yield (kg/ha)

After five years of experimentation, organic carbon content in the soil was significantly higher (5.1 g kg^{-1}) with S2 followed by S1 (4.4 g kg^{-1}) compared to no residue retention (3.9 g kg^{-1}). Long term minimum tillage recorded significantly higher OC content (4.7 g kg^{-1}) compared to conventional tillage (4.3 g kg^{-1}) (Fig. 2.21).

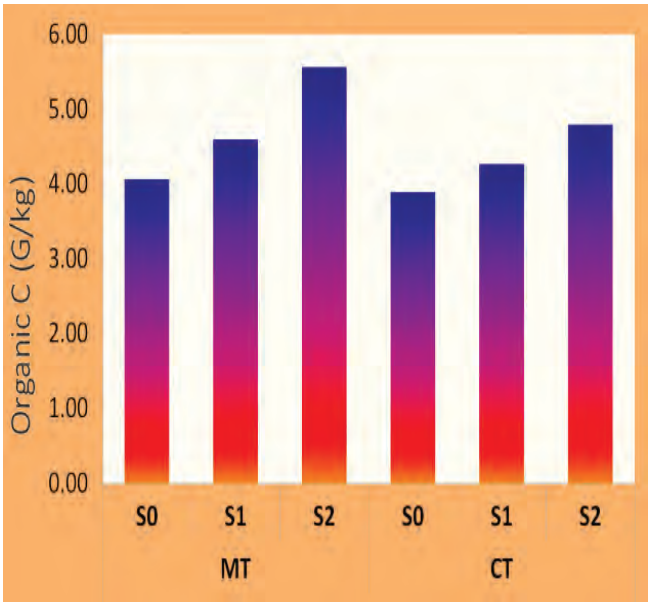


Fig. 2.21: Long term effect of tillage and residue retention on organic carbon (g/kg)

Mineral N (ammonical and nitrate nitrogen) content in the soil increased significantly with increase in the height of residue retention. Significantly higher NH_4^+-N (25.15 mg kg^{-1}) and NO_3^--N (36.94 mg kg^{-1}) were recorded with S2 treatment followed by S1 (21.37 mg kg^{-1}) and (28.75 mg kg^{-1}) compared to no

residue retention (18.46 mg kg^{-1}) and (24.56 mg kg^{-1}) respectively. Further, despite non significant values, minimum tillage recorded relatively higher NH_4^+-N and NO_3^--N contents (22.30 mg kg^{-1} and 31.40 mg kg^{-1}) compared to conventional tillage (21.02 mg $kg^{-1}$and 28.77 mg kg^{-1}), respectively.

Residue retention treatments of previous black gram crop influenced Sorghum grain yield as well as biomass and consequently carbon inputs to the soil. When averaged over residue retention (through sorghum stubble) treatments, it was observed that low tillage practice contributed higher amount of C inputs (1121 kg C ha^{-1}) compared to conventional tillage (1055 kg C ha^{-1}). On an average, S2 treatment contributed (1438 kg C ha^{-1}) equivalent carbon inputs followed by S1 (738 kg ha^{-1}).

2.4.2. Potential role of conservation agriculture in resource conservation and carbon sequestration (RM/RM/04)

Studies were initiated in 2009 at Hayathnagar Research Farm, CRIDA to assess the potential role of conservation agriculture practices including all the three components like different tillage practices, quantity of residue and its management for efficient resource conservation, increased productivity and profitability of pigeonpea-castor cropping system in rainfed Alfisols. In 2017, pigeonpea was sown after castor with three tillage practices - conventional tillage, CT (disc ploughing in off season, cultivator, disc harrow and sowing of crop), reduced tillage, RT (ploughing once with cultivator and disc harrow), zero tillage, ZT (direct sowing) and three crop residue levels created by harvesting the previous crop (castor in this case) at 0 cm, 10 cm and 30 cm height. The experiment was laid out in split plot design with tillage treatments as main plots and harvesting heights as sub plots. The quantity of residues was low due to poor distribution of rainfall and wide spaces between rows of castor. To utilize the space and increase residue on the soil surface *Sesbania* was sown in between the crop rows in 10 and 30 cm harvest height plots. *Sesbania* was cut at 45 DAS and applied as mulch. The additional advantage of this practice is that it supplies extra nitrogen to the soil.

Pigeonpea germination in zero tillage plots was good and was on par with conventional tillage and reduced tillage plots. Germination and growth *Sesbania* of was good and 1200-1600 kg of *Sesbania* residue was added to the soil. Pigeonpea yields in ZT was 30% and 20% higher over CT and RT. Pigeonpea seed yields increased with increase in residue (harvesting heights) and 10 cm and 30 cm harvest height recorded 25 and 30% higher yields over no residues (Fig. 2.22). The yield decrease in zero tillage with residues was low as compared to zero tillage without residues.

Higher species richness, diversity index and lower evenness index of weeds were observed in zero tillage as compared to conventional and reduced tillage. ZT recorded higher carbon sequestration in 0-7.5 cm where as at lower depths CT and RT recorded higher carbon sequestration. Carbon sequestration was negative in CT with 0 residues. Application of residues improved the organic carbon and carbon sequestration. ZT recorded lower nutrient and soil loss as compared to CT and RT but the water loss was higher in ZT. Residues (10 and 30 cm harvest height and *Sesbania* mulch) reduced soil, water and nutrient losses. ZT recorded higher available potassium, phosphorus as compared to CT and RT in 0-7.5 cm. At 15-30 cm, lower levels of available nutrients were observed in ZT. Residues recorded higher available nutrients in all the depths.

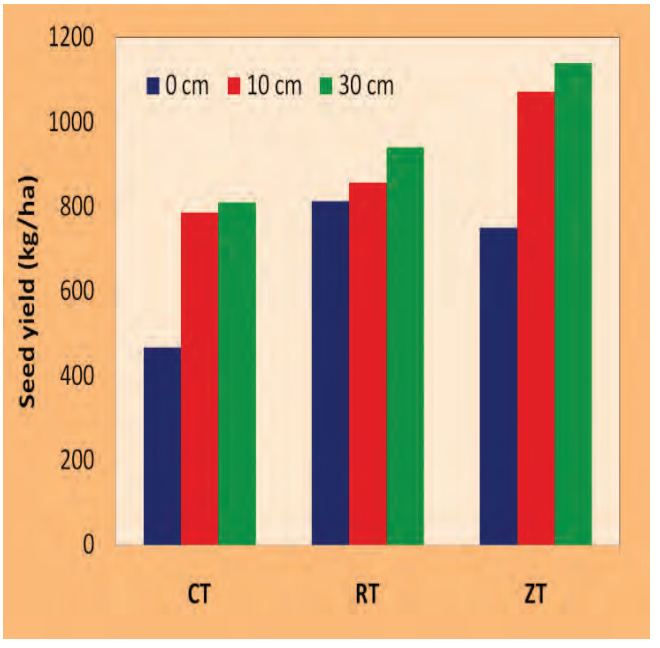


Fig. 2.22: Effect of tillage practices and residue levels on pigeonpea seed yield

2.4.3. Management strategies for resource conservation and carbon sequestration in rainfed Alfisols (RM/LU/13)

An experiment was laid out in RBD with different treatments (conventional planting without residues, conventional tillage with formation of raised bed every year, conventional planting with conservation furrow, CA flat sowing, permanent raised bed reshaping every year with residues, CA+ conservation furrows reshaped every year). The treatments were tested in maize - pigeonpea cropping system. This year maize is taken as test crop. The paired row and conservation furrow planter and bed and furrow planter were modified as per the requirements. A herbicide applicator was added to perform sowing, fertilizer application and herbicide application simultaneously. Integration of *in-situ* moisture conservation practices either through conservation furrow or bed and furrow method in both CA and conventional tillage recorded higher yield as compared to no moisture conservation treatments (Fig. 2.23).

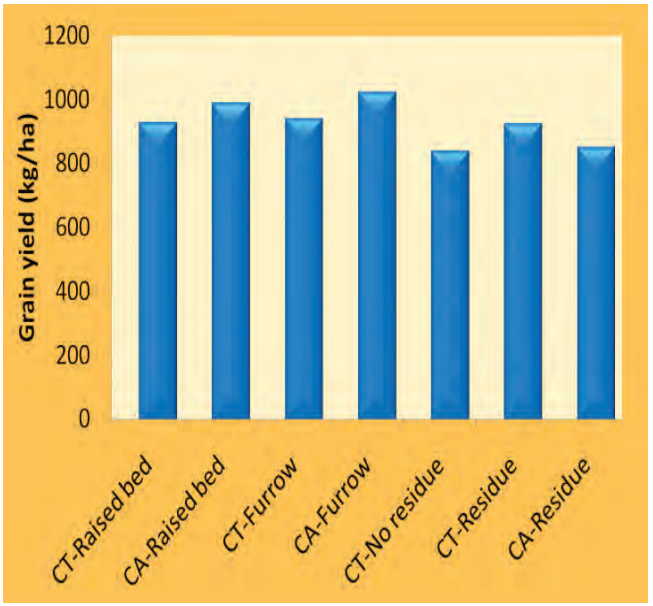


Fig. 2.23: Maize grain yields with integration of in situ moisture conservation with CA and CT

CT no residues recorded 10% lower yields as compared to CT residues. The bed and furrow stability were evaluated and it was observed that the reshaped beds and furrows are more stable as compared to the every year made beds and furrows. *In situ* moisture conservation treatments like conservation furrow and raised bed reduced the water loss by 50%. Conventional tillage without residue recorded 8% of runoff of the total rainfall, whereas in CA furrow 4% runoff of the total RF is recorded. Conventional tillage without residues recorded lowest OC, available phosphorus and potassium as compared to residue addition. Conservation agriculture practices either with or without integration of *in-situ* moisture conservation practices recorded higher available phosphorus and potassium. Among conservation agriculture practices permanent conservation furrow and permanent bed and furrow recorded higher OC, available phosphorus and potassium as compared to conservation furrow.

2.4.4. Development and validation of CA practices for rainfed systems [EF053 (CRP-CA)]

Field experiments were conducted at different locations, with different soil types, and rainfall at CRIDA, 2 AICRPDA centers and on-farm (3 KVK and farmers fields) to develop CA technologies for different soil types and crops. Cropping systems tested were maize-pigeonpea, pigeonpea-castor, sorghum-black gram, maize-horse gram, pearl millet-horse gram and cotton-pigeonpea at CRIDA, finger millet + pigeonpea, and soybean-chickpea at AICRPDA centres, and green gram-sorghum, foxtail millet-chickpea, finger millet and rice-pea at KVK farms and farmers fields. The project was initiated to address the constraints in rainfed agriculture for adoption of conservation agriculture, such as to enhance residue generation, to reduce termite infestation, nutrient management, weed management and integration of *in-situ* moisture conservation with CA principles.

Harvesting at 10-20 cm in pigeonpea and castor, and at 60 cm in cereals increased the residue availability to the soil and also increased the crop yields. A green manure crop like *Sesbania* can be grown in between the wide spaced crops like pigeonpea and castor, leading to higher residue yield and also increased nitrogen supply to the soil. A cover crop like horse gram, or field bean can be grown with pre-monsoon showers at Bengaluru and *Sesbania* with off season rainfall after harvest of maize. At Bengaluru, horse gram recorded higher dry biomass as compared to field bean. Termite infestation differed in different crop residues. Maize residues recorded higher termite infestation as compared to cotton and pigeonpea. Application of chlorphyriphos

or dung slurry on the termites reduced the termite infestation. At Bengaluru centre the yields of finger millet were higher in crop grown on horse gram residue than field bean residue.

Sesbania as live mulch in the crop rows

Sesbania as off season crop

Manipulation of harvest height

This year, conventional tillage recorded 15% lower maize yields as compared to conservation agriculture practices. Among the CA practices integration of *in-situ* moisture conservation with CA practices through permanent bed or conservation furrow recorded 20 and 25% higher seed yields of maize respectively, as compared to no moisture conservation practice. Reduction in crop yield in unweeded treatment in ZT was higher than in CT. Organic carbon and available phosphorus content in CA with integration of *in-situ* moisture conservation was 10% higher as compared to conventional tillage. Unweeded control recorded lower soil available phosphorus as compared to weed control treatments. Fuel consumption was lower under permanent bed and permanent conservation furrow as compared to conventional bed and furrow or conservation furrow (Fig. 2.24).

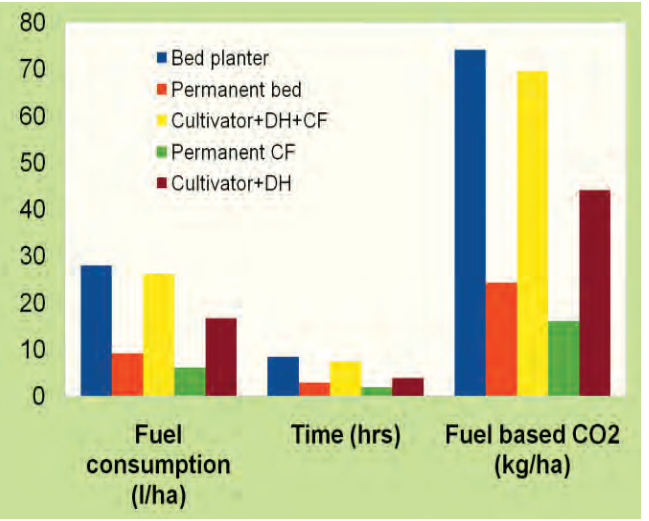


Fig. 2.24: Fuel consumption and fuel based CO_2 in different treatments

2.4.5. Impact of conservation agriculture practices on soil physical properties in maize-pigeonpea crop rotation under rainfed Alfisols (RM/NM/06)

A project was initiated in 2012 to develop sustainable tillage and nitrogen management strategies to improve the soil physical health of dryland farming system (maize-pigeonpea crop rotation) and farm productivity and profitability. Pigeonpea (PRG 158) was grown during *kharif* 2017 in a split plot design. Main plots consisted of three tillage practices, viz 1. Conventional Tillage (summer ploughing + cultivator + disc harrow before sowing and no residue retention of previous maize crop) 2. Reduced tillage (one time cultivator+ disc harrow before sowing + residue retention up to 60 cm plant height of previous maize crop) 3. No tillage (direct sowing + residue retention up to 60 cm stem height of previous maize crop). Sub plot consisted of four nitrogen levels, viz. 1. No nitrogen (N_0). 2. 75%

of the recommended dose of nitrogen (N_{75}). 3. 100% of the recommended dose of nitrogen (N_{100}) and 4. 125% of the recommended dose of nitrogen (N_{125}). Tillage practices significantly influenced the seed and stover yield (Fig. 2.25).

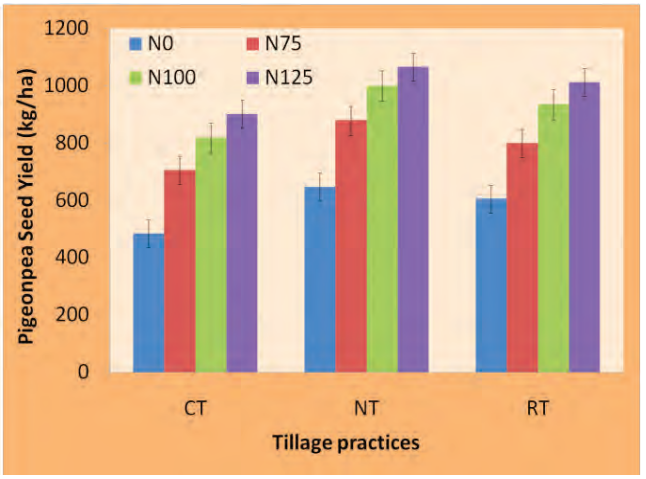


Fig. 2.25: Effect of tillage practices and nitrogen levels on pigeonpea seed yield

The mean seed yield was 23.4 and 15.1% higher in no-tillage (897.8 kg ha^{-1}) and reduced tillage (837.8 kg ha^{-1}), respectively over conventional tillage (727.6 kg ha^{-1}). Similarly, the mean stover yield was increased 18.0 and 12.4% in No-tillage (3304 kg ha^{-1}) and reduced tillage (3148 kg ha^{-1}), respectively over conventional tillage (2800 kg ha^{-1}). Nitrogen levels significantly influenced the mean seed and stover yield, and 71.5 and 56.3% increase was recorded in seed (993.0 kg ha^{-1}) and stover (3596 kg ha^{-1}) yield with the application of 125% N over no nitrogen application (579.1, 2301 kg ha^{-1}). No tillage and reduced tillage registered higher soil moisture as compared to the conventional tillage.

Pigeonpea growth in no tillage with 125% of recommended dose of nitrogen

2.4.6. Evaluation of system productivity and profitability in major rainfed cropping systems under conservation agriculture practices (RM/RM/09)

A set of field experiments on pearl millet (PHB-3) – horse gram (CRIDA-18R) and cotton (Ujwal BG II-243) – pigeonpea (PRG-158) rotation were initiated in 2016 at Gunegal Research Farm of CRIDA to evaluate system productivity and profitability, and green house gas (GHG) emissions with adoption of conservation agricultural practices. Experiments were laid out in split plot design consisting of 3 tillage treatments viz., Conventional Tillage (CT - one ploughing with disk plough, one harrowing and sowing), Minimum Tillage (MT - One ploughing, sowing with 100% residue retention) and Zero Tillage (ZT - no till, direct seeded with 100% residue retention) as main plots and 3 nutrient management practices of 75% RDF, 100% RDF (pearl millet - 80:40:30 kg of N, P_2O_5, K_2O ha^{-1} and pigeonpea - 20:50 kg of N, P_2O_5 ha^{-1}) and 125% RDF as sub plots.

Significantly higher grain yield of pearl millet was obtained in ZT (2664 kg ha^{-1}) which was at statistically at par with MT (2487 kg ha^{-1}) as compared to CT (2243 kg ha^{-1}) (Fig. 2.26). Significantly higher yield was obtained with application of 125% RDF (2644 kg ha^{-1}) which was at par with 100% RDF (2526 kg ha^{-1}) as compared to 75% RDF (2224 kg ha^{-1}).

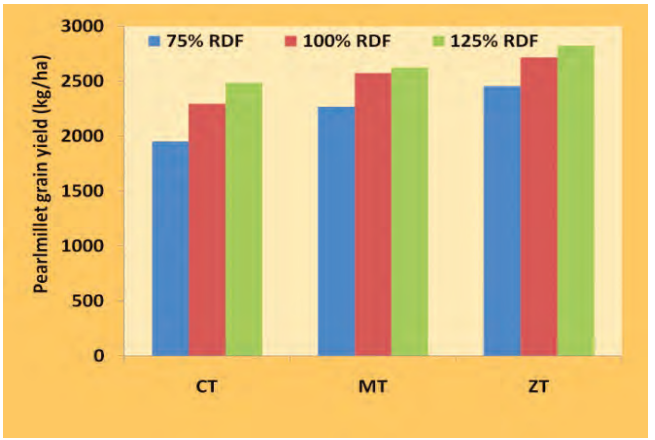


Fig. 2.26: Effect of tillage and different fertilizer doses on grain yield of pearl millet

While pigeonpea seed yields didn't differ significantly with tillage treatments, significantly higher yield was obtained with 125% RDF (990 kg

ha^{-1}) compared to 75% RDF (822 kg ha^{-1}). Interaction between tillage and nutrient management was significant (Fig. 2.27).

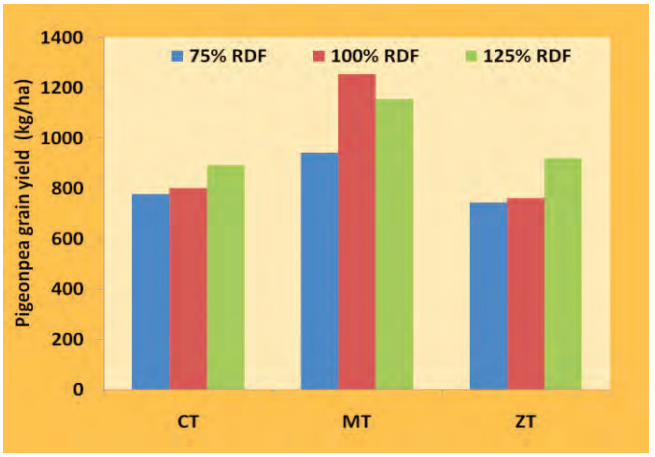


Fig. 2.27: Effect of tillage and different recommended doses of fertilizers on pigeonpea grain yield

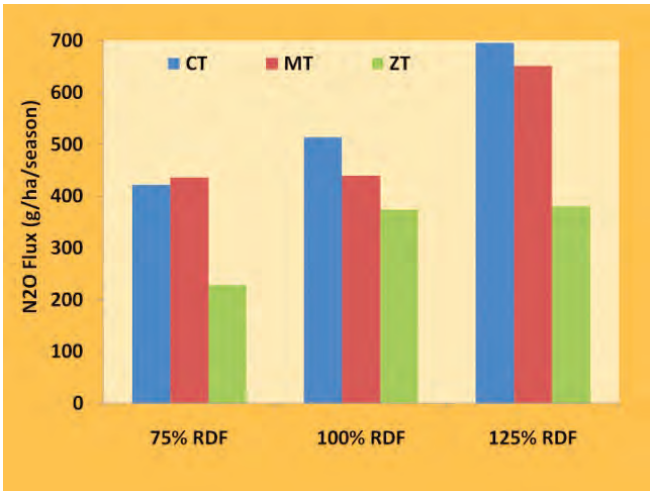


Fig. 2.28: Effect of tillage and different recommended doses of fertilizers on emission of N_2O in pigeonpea

Pigeonpea residue in ZT plot in the month of February, 2018

Significantly higher yield was obtained through 100% RDF with MT (1255 kg ha^{-1}) which was the best performing combination. Significantly higher N_2O emission (g ha^{-1}) was observed in CT (544) followed by MT (509) and ZT during crop growing season (Fig. 2.28). Higher N_2O emission (g ha^{-1}) was observed in 125% RDF (576 g/ha/season) followed by 100% RDF (442 g/ha/season) and 75% RDF (362 g/ha/season).

2.4.7. Soil quality assessment and developing indices for major soil and production regions of India

The concept of soil quality and its indexing provides a tool to quantify the combined biological, chemical and physical response of soil to management practices. A project was undertaken to develop grading functions/ratings for selected soil quality indicators, to make a quantitative assessment of soil quality in dominant cropping systems of India and prepare geo-referenced soil quality maps. The prepared agro-ecological sub region (AESR) wise soil quality maps shall form the baseline for long term soil health monitoring programs. Agro ecological sub region (AESR) 6.2 (rainfed) and AESR 18.3 were selected for the study. The AESR 6.2 includes parts of three states – Karnataka, Telangana and Maharashtra, while AESR 18.3 covers coastal Andra Pradesh.

The maps of both the AESRs were prepared on the basis of the 20*20 km grids basis. Soil sampling locations were geo referenced using GPS. Soil samples were collected from identified locations from Karnataka falling under the districts of Bidar, Raichur, Bijapur, Yadgir and Gulbarga. The basic information regarding the cropping system, fertilizer use, yields, irrigation facility, area under each crop and other information related to the study were also collected from the farmers. Analysis of the collected soil samples is in progress.

2.4.8. Impact of grass strip on soil carbon sequestration and soil physical properties in cropped field under semi-arid environment (RM/RM/23)

Use of grass strips is one of the low cost measures in soil and water conservation, especially for reducing run-off. A study was initiated in 2015 at Hayathnagar Research Farm to assess the effect of grass strips in cropped field on soil loss, soil properties and soil carbon sequestration. Grass strips of two species, *Brachiaria ruziziensis* and *Stylosanthes hamata* were established at

lower, and upper & lower ends of a field with castor-red gram crops grown in rotation.

Since grass had massive roots, <1 mm roots in particular, the soil physical properties such as pore space, including capillary and non-capillary pore space, was improved greatly leading to decreased soil bulk density, increased water infiltration and holding capacity, reduced runoff. Considerable earthworm activity was observed in the grass strips, and was higher in *Brachiaria ruziziensis* than in *Stylosanthes hamata* (Table 2.8). Untimely rain before harvesting of the crop resulted in fungal attack which affected the yield of the castor crop. Slope wise soil properties and fodder yield of the two grasses from 4 cuts, were recorded (Fig. 2.29).

Table 2.8: Slope wise soil attributes

Slope Class	Bulk density g/cm^3	Porosity (%)	Water holding capacity (%)	Volume Expansion (%)	Average clay %	Texture	Stone cover per m^2		
							>6"	6-3"	<3"
1%	1.36	24.44	21.34	10.6	10.9	Loamy fine sand	15	232	234
2%	1.25	19.68	29.99	15.9	11.6	Loamy fine sand	9	152	165
3%	1.38	21.46	27.31	11.6	10.1	Loamy fine sand	15	155	320

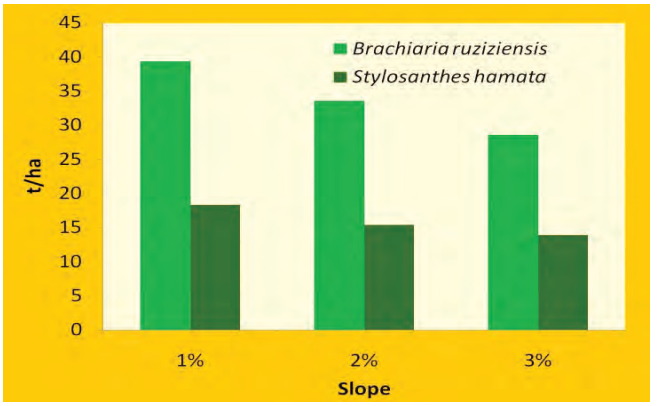


Fig. 2.29: Fodder yields in 2 seasons of the grass species under different slope classes

2.4.9. Effect of biochar amendment on soil properties and growth of crops (RM/RM/08)

Agricultural residues such as castor, cotton and pigeonpea stalk are a potential source of biomass for biochar production in rainfed areas. Slow pyrolysis of residues (thermo-conversion in the absence of unlimited oxygen) may offer an alternative to on-field residue burning to return carbon and nutrients to the soil. Interest in use of biochar as a soil amendment has increased because it offers an opportunity to reduce the potential negative impacts of biomass burning on soil quality. A long-term experiment was initiated during 2010 with pigeonpea (PRG 158) as test crop at Hayathnagar Research Farm to investigate the effect of different types (castor, cotton, pigeonpea residues), rates (3 and 6 tons/ha) and frequencies (every year and alternate year) of applications of biochar on soil quality and pigeonpea performance. The treatments were control, recommended dose of fertilizer (RDF) (20:50:0 N:P_2O_5:K_2O kg ha^{-1}), RDF + every year biochar @ 3 t ha^{-1} for each of the 3 biochars, RDF + every year biochar @ 6 t ha^{-1} for each of the 3 biochars, RDF + alternate year biochar @ 3 t ha^{-1} for each of the 3 biochars, RDF + alternate year biochar @ 6 t ha^{-1} for each of the 3 biochars. Recommended dose of fertilizers (20-50-0 kg N, P_2O_5, K_2O/ha) was applied uniformly every year in all the treatments except in control (without biochar and fertilizer). The above treatments were applied for 4 years, i.e., 2010, 2011, 2012 and 2013. Since 2014, the crop is being grown with only recommended dose of fertilizer to assess the residual effect of 4 years' treatments.

In the eight year of the experimentation, pigeonpea seed yield was higher (816 kg/ha) in plots that received RDF + alternate year application of pigeonpea stalk biochar @ 6t/ha followed by plots that received RDF + every year application of cotton stalk biochar @ 3t/ha (522 kg/ha).The lowest seed yield was recorded under control (125 kg/ha) followed by RDF alone (264 kg/ha). The soil available phosphorous and potassium status under the influence of residual biochars during 2017, revealed that the soil available P ranged from 19.3 to 26.0 kg/ha and soil available K varied from 144 to 299 kg/ha. Soil pH and EC ranged from 6.03 to 7.42 and 0.07 to 0.30.

2.5. Livestock management

2.5.1. Development of inventory of technologies for livestock production for counteracting seasonal stress in rainfed areas (TOT/LM/06)

Seasonality in productivity is the major problem faced by livestock rearers in drylands which becomes acute during summer or drought years. Under extreme weather conditions, productivity and health of animals are worst affected. The problems are seasonally exhibited due to dependency of these animals over natural resources. Thus, there is urgent need to identify the shelter, feeding and health management tools to counteract seasonality in production of livestock in rainfed areas. A project was initiated in 2012 to critically evaluate and document existing livestock production system in the rainfed areas and suggest suitable measures. During 2017-18, consolidation of results was done from the samples collected as soil, plant and animal (feces, urine, milk, etc) spread over 5 states, viz., Telangana, Andhra Pradesh, Maharashtra, Karnataka and Tamil Nadu. Apart from this, some farm level trials were carried out to suggest management methods to counteract seasonality as well as improving profitability.

Intensification of management system: Animals kept under intensive system of rearing achieved superior body weight as compared to extensive and semi-intensive system of rearing which may be attributed to superior management and nutrition conditions prevailing under intensive system of rearing (Fig. 2.30)

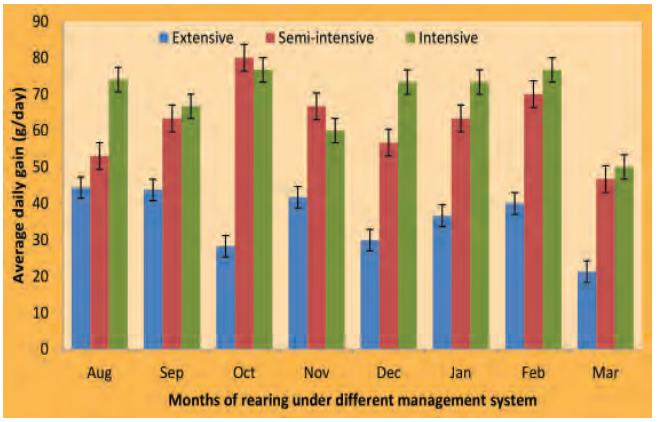


Fig. 2.30: Average daily gain in Deccani males reared under different systems spread over 8 months

Methane emission as determined by the Tier II method was estimated to be 14.12 ± 0.56, 8.76 ± 0.33 and 4.40 ± 0.16 kg CH_4 per sheep/year under extensive, semi-intensive and intensive system of rearing respectively, suggesting intensification as the as most adaptive and mitigating strategy too.

Soil-plant-animal micronutrient status: Most of the samples of all the five states were deficient in the minerals (Zn, Cu and Mg) (Table 2.9). Thus, a cost effective mineral mixture can easily be prepared by mixing dicalcium phosphate with zinc sulphate, copper sulphate and common salt in the proportion of 1.96:0.032:0.008:1 to overcome these deficiencies. A total amount of 3 kg of such mineral mixture costing Rs. 78.00 is sufficient for a herd of 30 sheep or 10 cows for a month.

Table 2.9: Status of minerals in soil-plant-animal continuum in dryland areas of five Indian states

States	Deficiency (>30% samples)		
	Soil	Plant (Fodder & Conc.)	Animals
Telangana	Ca, P, Cu, Zn, Mg	Zn, Cu, Mg	Zn, Cu, Mg
A.P.	Ca, P, Cu, Zn, Co	Zn, Cu, Co	Zn, Cu, Co, Mg
Maha-rashtra	Ca, P, Cu, Zn, Co	Zn, Cu, Co	Zn, Cu, Co, Mg
Karnataka	Ca, P, Cu, Co, Mn	Zn, Cu, Mg	Zn, Cu, Mg
Tamil Nadu	P, Cu, Zn	Zn, Cu	Zn, Cu, Mg

Silage bag technology for supplying nutrients during lean season: Through the use of silage bags, nutrient availability was improved. In male Deccani sheep, during the lean season (May-July, 2017), silage feeding was able to achieve average daily gain of 78.89 g/day as compared to 45.56 g/day in control (Fig 2.31).

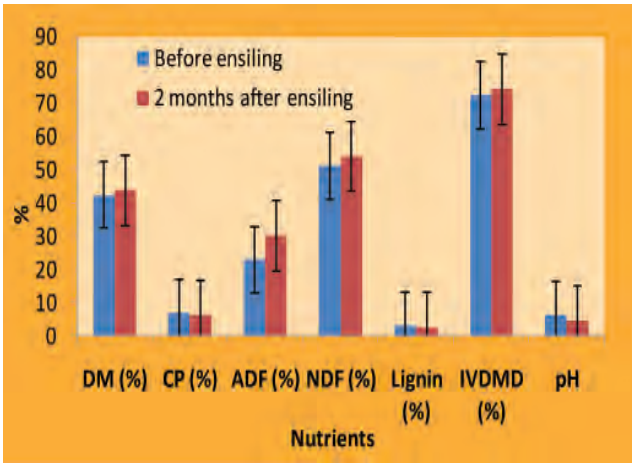


Fig. 2.31: Effect of ensiling on nutrient composition, digestibility and pH of green fodder

Prediction of body weight on the basis of body measurements: Based on the body biometry of 285 Nellore sheep, a prediction equation was developed with R^2=86.25 for prediction of body weight as:

B.wt. (kg) = (-29.156)+(0.75xBL)+(0.077xHG)+(0.007xPG)

Where, BL is Body length in cms, HG is Heart girth in cms and PG is Paunch girth in cms

Heat load index (HLI) vs Temperature Humidity Index (THI): Based on one year data of environmental variables and biomolecular data of 36 Deccani sheep reared under intensive, semi-intensive and extensive system of rearing, it was concluded that Heat Load Index (HLI) is a better choice for comparing heat stress in extensively reared sheep, whereas, Temperature Humidity Index (THI) is a better indicator for comparing heat stress in intensively reared animals.

2.6. Energy management

2.6.1. Development of variable width raised bed planter for resource conservation

Work on development of variable width raised bed planter for resource conservation was initiated in 2016. The implement was fabricated and tested in 2016 with pigeonpea and castor crops and showed promising results in terms of bed formation and retention, soil moisture conservation and crop yields. After the field trials and feedback gained from the 2016 season, the implement was refined. Industries were approached for technology transfer of the planter and the technology was transferred for fabrication and sale to M/s Avanti Bufa Ltd, Zahirabad, Telangana State through signing of a memorandum of agreement as per ICAR guide lines.

Experiments were also conducted with maize, horse gram and pigeonpea crops during the 2017 *kharif* with the newly developed variable width raised bed planter cum herbicide applicator. Farmer field trials were conducted at Byrapur village of Wanaparthi District in Telangana State. Field demonstration was also conducted for 60 farmers. Pigeonpea crop could survive dry spell of 12 days during the *kharif* season and yield increased by 35% with the use of the implement compared to conventional sowing with 6 row seed drill. Weeding was done with a specially designed tractor drawn harrow. Reshaping of beds was done for removing the weeds in the furrows apart from increasing the water conservation volume of the furrows.

Variable width Raised bed planter cum herbicide applicator

Pigeonpea sown with raised bed planter cum herbicide applicator in farmer's field

2.6.2. Development of track width and ground clearance enhancement system for small horse power tractor

To effectively utilize the high clearance and track enhanced attachment platform for low horse power tractor, a rotary tiller model implement was fabricated and attached to the power unit for intercultural operations. The developed machinery setup was tested in castor (90 cm row to row and 45 cm plant to plant spacing) and pigeonpea (90 cm row to row and 20 cm plant to plant spacing) crops during *kharif* 2017 season up to 50 days after sowing. The operator was able to steer the tractor

with ease with the new developments and very little plant damage occurred during operation. The field trials were taken up in sandy loam soil and respective crops were planted using tractor operated mechanical planter. The weeding efficiency of rotary implement varied 77-80% and 79-84% in castor and pigeonpea, respectively. The weeding efficiency was slightly higher in pigeonpea as the crop canopy spread was low, allowing the operator to go deeper into the soil under field conditions. In monitory terms significant advantage was not found with rotary implement over animal drawn blade harrow, but the equipment was highly helpful for timely completion of field operations and drudgery reduction.

Weeding implement in operation

2.7. Socioeconomic aspects

2.7.1. Farmer centric natural resource development for socio economic empowerment in rainfed areas of southern Telangana region (EF059 (Farmer FIRST))

Farmers' FIRST project is being implemented in villages of Pudur mandal of Vikarabad district with the objective to initiate a participatory technology development process and develop viable social institutions and linkages for whole village development through active participation of the stakeholders. All the 400 households in 4 villages namely Rakamcharla, Tirumalapur, Devonoiguda, and Pudugurthy comprise the stakeholders of the project. The project was envisaged through four components namely Farmers-Scientist interface, Technology Assemblage in various modules that comprises of crops and cropping system, livestock management, horticulture, soil and water conservation, small farm mechanization, socio economic and linkage development and content mobilization.

PRA and socio economic survey revealed problems of low efficiency in utilization of rainwater harvested through perennial stream surrounding the villages, low energy utilization, low productivity from field and vegetable crops, low milk productivity of dairy animals and shortage of fodder. 85% of farmers belong to small and marginal category and possess 2-3 goats in each household. Based on PRA and baseline survey information, an action plan and technology package for the area was implemented. Development of model irrigation system, vegetable nursery raising at farmers level utilizing portrays with cocopeat, seed and shade nets, back yard poultry, mineral supplementation, crop residue management by making total mixed ration and use of chaff cutter, ram lamb technology, fodder technology var. CO-4 series were taken up.

More than 150 soil samples from farmers' fields were collected and analyzed for fertility status and soil health cards were issued to farmers on the world soil day celebrated on December 5th, 2017.

Distribution of soil health cards

In *kharif* season, pigeonpea trials were conducted with new variety PRG-176, which gave 85% higher yield over control. In chickpea trials in *rabi*, variety NBeG-3 gave 71% higher yield over control (Table 2.10).

Table 2.10: Pigenpea and chickpea improved variety trials

Technology Assessed	No. of trials	Yield kg/ Acre	Net return (Rs Acre)	B:C Ratio
Pigeonpea (*kharif*)				
Local variety (Farmers practice)	Con-trol	730	20080	1.96
PRG-157 Variety	20	1050	32500	2.34
Chickpea (*rabi*)				
Local variety (Farmers practice)	Con-trol	580	9680	1.56
NBeG-3 Variety	10	730	16580	1.97

Soil and water conservation interventions: Plastic embedded gabion checkdams for rainwater harvesting and for groundwater recharge

In watersheds loose boulder structures or gabion checkdams are constructed in upper reaches to stabilize the gully or stream and reduce the flow velocity and thereby minimise soil erosion. Due to pore space of the structure, it will not store the water. In this project, an intervention was made; the gabion structures were embedded with 1 mm HDPE film at the centre of the structure. Three plastic embedded structures and one structure without plastic were constructed and evaluated in the farmers's fields/ watershed areas of the project cluster. These plastic film embedded gabion structures reduced the sediment concentration by 70% over the traditional gabion checkdams without plastic film. These gabions were able to store the rainwater in the range of 9000-15,000 m^3/structure and conserve the rainwater up to 60%, increasing the water table in the surrounding wells by 0.6 m. The stored rainwater in each structure can provide irrigation to an area of 1 ha.

HDPE film embeded Gabion checkdams

Efficient utilization of harvested water through micro irrigation systems

Micro irrigation system for vegetable crops was designed and installed in the field. Due to micro irrigation system farmers were able to plant chilli and tomato crops earlier. Due to early planting, farmers were able to produce chilli and tomatoes during peak/ high prices. Micro irrigation system and fertigation enhanced the productivity and efficient utilization of fertilizer with 60% saving of irrigation water and 35% higher yields.

Demonstration of micro irrigation of vegetables

Intervention in horticulture

Vegetable growing farmers faced problems of low productivity of tomato, chilli and coriander due to less use of organic manures, poor quality nursery seedlings, and severe fruit fly damage in gourds and sucking pest damage in chilli. Plastic mulching for enhanced yields and quality in vegetable crops, and integrated pest control through traps were demonstrated to farmers on tomato and chilli crops. A crop planning method was followed with staggered dates of sowing in tomato crop to coincide with high market prices.

Fruit flies in the cucurbits crops were controlled by placing fruit fly traps (Methyl eugenol and cue-lure traps) in the fields. Sticky Traps - yellow / blue / white were used for control of sap sucking insect pests. Installation of sticky traps at an early stage (15 days crop stage) controlled white flies, thrips, jassids, leaf miners and minimized the need for pesticide application.

Demonstration of IPM using yellow sticky trap in gourds

Plastic mulching for enhanced yields and quality in vegetable crops

Mulches are well known for modifying the energy and water balance at surface of soils and creating more favourable conditions for plant growth. This may include temperature moderation, weed control, soil conservation, nutrients uptake from the soil which ultimately enhance the growth and yield of crops.

Demonstration of plastic mulching

Small farm mechanization

Based on interaction with farmers, 7 types of implements - dryland weeders, self propelled weeders, bullock drawn weeders, brush cutters, crop stalk shredder, disc harrow, and six row planter were demonstrated to farmers during crop season. Exposure visits were conducted during *rabi* season for farmers to CRIDA research farm to sensitize them about operation of the implements. Small hand weeders were operated in farmers fields that help in reduction of drudgery and improve field capacity. Farmers feedback was positive. Demonstration with a manually operated hand weeder in maize crop provided important feedback about its use in black soils. Farmers suggested insertion of a plastic tyre that enables free mobility of tyre when run in black soils.

A custom hiring centre (CHC) established in Devanoniguda, Tirumalapur and Rakamcharla, villages ensured availability and accessibility of seeding implements, dryland weeders and powers sprayers to farmers. Power sprayers usage was found to be high during crop season to control pests.

Demonstration with a manually operated hand weeder in maize crop

Livestock based interventions

Chicks of Srinidhi, a superior breed of poultry, were given to 50 farmers at the rate 25 per farmer in Pudugurthy village and the households were geo tagged for Srinidhi breed of chicks. Training was imparted to them on improved poultry production and management. After 2 months of intervention with 14% mortality, chicks are growing well @ 52.12 gms per week on a diet of broken cereals. Scheduled vaccination against Ranikhet Disease, IBD and pox was done. Mineral block supplementation was carried out in all villages in 60 households of goat rearers. Kid mortality in goats was reduced to 5% from 15-20% due to mineral blocks. With each mineral block in a herd of 2-3 goats, benefit of 0.5 to 1.0 kg was accrued. Mineral block supplementation was also provided to cattle in 60 households in all villages. Animals (104 nos.) selected were in first stage of lactation. Mineral mixture was given @ 20 gms per day per animal. An improvement of 0.5 to 1.0 kg in milk yield and attainment of 20% higher peak yield was observed. Co-4 fodder cultivation was demonstrated in Rakamcharla and Pudugurthy villages to 50 households @ 4000 slips per acre. Total area covered is 3 acres and yield after 2 cuttings was 30-35 tons. Animal health camps were organized to treat animals affected by mastitis and gynaecological problems in about 50 households of Tirumalapur village. Training and exposure visits were also conducted for all livestock farmers of all 4 villages which improved knowledge on good management practices.

Participatory poultry management in Pudugurthy village

Introduction of mineral mixture to the dairy farmers

Training on fodder cultivation at CRIDA

Training and exposure visits and farmer field schools

Seeing is believing and farmers were exposed to state-of-art facilities for horticulture development through exposure visits. Two exposure visits cum training programmes were organized for 70 farmers to centre of excellence for vegetable and flowers, Jeedimetla during October, 2017. The centre of excellence has facilities like polyhouses, walk-in tunnels, shadenet houses & naturally ventilated polyhouses with tomato, capsicum, cucumber, leaf vegetables, lettuce, broccoli, cherry tomatoes and flowers like orchids, gerbera, rose, carnation, lillium, chrysanthemum, etc.

Exposure visit cum Training programme on value addition and processing of tomato was organised for farmers of Rakamcharla village to Srini Food Park, Madanapally, Chittoor district situated 550 km away from Hyderabad. The facility housed state of art processing plants for fruits and vegetables such as tomatoes, mango and papaya. Technicians in the plant briefed about quality management, cleaning, grading, extraction of pulp and maintenance of machinery. Farmers also visited polyhouses with chrysanthemum (var: Holland Denzigar) flowers cultivated in controlled conditions producing quality flowers with productivity of 6 tons/season.

Visit to polyhouse cultivating orchids

Visit to Srini Food Park, Madanapally

Chrysanthemum cultivation in polyhouse

2.7.2. Mera Gaon Mera Gaurav (MGMG) of ICAR-CRIDA

Teams of Scientists of ICAR-CRIDA have visited villages of Mahabubnagar, Nalgonda, and Medak districts in Telangana state under Mera Gaon Mera Gaurav (MGMG) program under the leadership of Nodal Officer, Dr G Nirmala. The derails of the team involved in MGMG activities are portrayed in the table 2.11.

CRIDA regularly participated in MGMG program with scientists carrying out different activities of general awareness building, conducted demonstration, imparting training and providing with regular SMS to farming community. Some of the achievements of MGMG activities of 2017-18 are as reported below:

Dr K Sammi Reddy, Director (Acting) addressing the gathering in MGMG village clusters of Ranga Reddy district

Adilabad farmers receiving power sprayers

Awareness and Demonstration: Demonstrations have been conducted on various aspects such as fodder cultivation 1 acre in Nagar Kurnool (Dr K S Reddy & team) and awareness building on cultivation of Maize varieties, zero tillage cultivation and conservation agriculture techniques and vermicomposting in Medak (Dr G Pratibha & team). The team members in Nalgonda (Dr K L Sharma & team) conducted a diagnosis of village problems related to agriculture were also discussed as part of MGMG programmes.

Training Imparted: Dr K S Reddy and his team imparted training to farmers of Nagar Kurnool in the areas of dryland crop production, animal health management and farm pond technology for 50 farmers. Team members of different districts namely : Adilabad (Dr Osman & team); Medak (Dr K Sammi Reddy & team), Warangal (Dr K V Rao & team); Nalgonda (B Sanjeev Reddy & team) and Ranga Reddy (I Srinivas & team) have provided training on use of power sprayers and also have introduced and distributed 25 power sprayers in each of the villages.

Discussion with farmers on agricultural problems

Mobile agro advisory Services: Regular weekly SMS messages on agro advisory services were provided to farmers of Medak district. Dr P Vijaya Kumar who led the team provided SMS content to farmers through SMS facility created for the program. The messages contained information on weather prevailed for the week and the agriculture operations to be taken up in accordance with short term weather projections.

Linkages Developed: The teams have created linkages with state department of agriculture and diagnosed problems related to general and agriculture problems. Awareness was created on need for farm pond development for storing harvested water, soil health management, small ruminant farming and timely plant protection measures.

Table 2.11: Details of MGMG Team

Team	Scientists (First in list are the team leaders)	Villages covered	District
1	S Desai, V Maruthi, B M K Raju, A G K Reddy	Pampanur, Pampanur thanda, Y. Kothpalli, Singhampally, Singhampally thanda	Anantapur (A P)
2	K Srinivas Reddy, P K Pankaj, N N Reddy, N Showri Raju	Padera, Chitlam Kunta, Udimalla, Petrallachenu, Ippalapally	Nagar Kurnool (T S)
3	Md Osman, R V Adake, R Rejani, G Nirmala, S K Bal	Chinna Malkapur, Pedda Malkapur Kotwalguda , Somwarpet,Garkampet, Arkavalli	Adilabad (T S)
4	G Ravindra Chary, S S Balloli, K Sridevi Shankar, R Nagarjuna Kumar	Rolmamada, Devulnaik Thanda, Yappulaguda, Bandem Regadi, Isrumguda	Adilabad (T S)
5	K Sammi Reddy, S K Yadav, M A Sarath Chandran, Ashish S Dhimate, B Krishna Rao	Jaffergudem, Satyanarayanapur, Ramanagudem, Kusumbai thanda	Warangal (T S)
6	K V Rao, K A Gopinath, V Visha Kumari, Rajkumar Dhakar	Chakal Zal thanda, Lokiya Thanda, Vapul Gadda Thanda,Cherla Thanda	Warangal (T S)
7	B Sanjeeva Reddy, K Nagasree, Sumantha Kundu	Kotha Thanda, Bapuji Thanda, Lackma Thanda and other two thandas	Nalgonda (T S)
8	K L Sharma, M Vanaja, N Jyothilakshmi, A K Indoria, T V Prasad, G Venkatesh	China Seetharam Thanda, Peda Seetaram thanda, Lalsingh tanda	Nalgonda (T S)
9	I Srinivas, N Ravi Kumar, K Arun Kumar Shanker, D B V Ramana	Yellamma thanda, Dadipalli thanda, Venkateswar thanda, Rangapur	Ranga Reddy (T S)
10	M Prabhakar, B Narasimlu, K Shalini, Kausalya Ramachandran	Gaddamalaiguda, Rangapur, Chintapatla	Ranga Reddy (T S)
11	G Rajeshwara Rao, P Vijaya Kumar, Pushpanjali, Josily Samuel, Jagriti Rohit	Chikpaldurthy thanda, Ginnaram,Venkataraopet	Medak (T S)
12	M Maheswari, G Pratibha, K Ravi Shankar, V Girija Veni, Anshida Beevi CN	Lagardem, Terpole, Machepallythanda, Uttapally	Medak (T S)
13	K Srinivas, J V N S Prasad, Manoranjan Kumar, A V M Subba Rao	Gangula Nacharam thanda, Badruthanda thanda, Rajulapalem, B N thanda	Khammam (T S)
14	M Srinivasa Rao, C A Rama Rao, B Sarkar, M Manjunath	Muniyathanda, Ontigudusa thanda, Medepalli, Himaytanagar	Khammam (T S)

3. National Innovations in Climate Resilient Agriculture (NICRA)

Phenomics facility

Achievements - NICRA

To sustain agricultural production, food security of the nation, and agriculture-dependent rural livelihoods in the face of changing climate it is very pertinent to evolve adaptation strategies to minimize adverse effects of climate change and also initiate mitigation strategies to reduce greenhouse gas (GHG) emissions from agriculture and allied sectors, the ICAR has launched a flagship project, National Initiative on Climate Resilient Agriculture during 2010-11 under the XI Plan, which later metamorphosed into the National Innovations in Climate Resilient Agriculture (NICRA) under the XII Plan. The project consists of four components viz. Strategic Research, Technology Demonstration, Capacity Building and Sponsored/ Competitive Grants. NICRA over the past six years has made considerable progress. The Central Research Institute for Dryland Agriculture (CRIDA) is the lead Institute and the National Nodal point for NICRA, which is being implemented at large number of Research Institutes of ICAR, State Agricultural Universities and KVKs in about 151 districts. The most important contributions like Contingency Planning and Vulnerability Atlas have gained visibility across Ministries. Significant progress has been made during 2017-18 under the Strategic Research and Technology Demonstration Components at CRIDA.

3.1. Strategic Research

3.1.1. Development of Strategies for Improved Agromet Advisories at Micro Level and their Dissemination (NICRA/26)

AICRPAM has developed a new concept based participatory technology for development and dissemination of micro-level agromet advisories using block-level weather forecast provided by India Meteorological Department (IMD). The Agrometeorologist of the AICRPAM center develops the Agromet advisory bulletins with the help of SMS at KVK using the field level crop information blended with weather forecasts and disseminated to farmers through FIFs. AAS is generated in the name of Program Coordinator, KVK and is disseminated by multiple communication agencies, *viz.*, mobile text as well as voice SMS, display at public places, personal contact, etc. The feedback obtained from the farmers is being evaluated for improving as well as expanding services for the benefit of farming community. The whole concept is represented in Fig. 3.1.

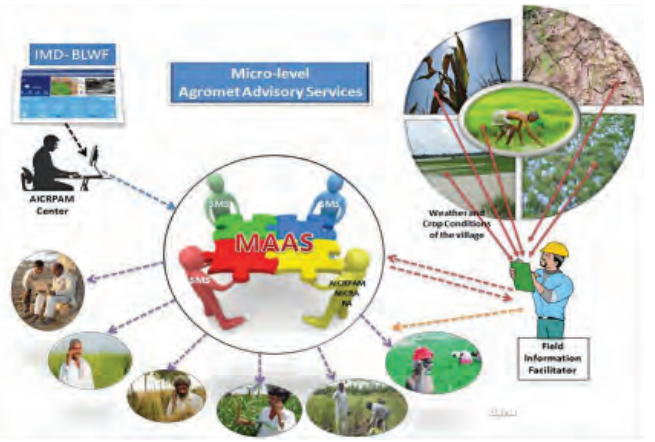


Fig. 3.1: Concept of participatory technology for development and dissemination of micro-level AAS developed by AICRPAM

The methodology can be up-scaled to national level by utilizing the already established infrastructure and human resource by establishing linkage with line departments and state agricultural universities and KVKs established in the country. A compilation of economic impact assessment of micro-level AAS since the inception of the project is presented in Table 3.1.

Table 3.1: Economic impact of micro-level agromet advisories issued at various locations of India

Region	Village	Crop	B:C Ratio	
			AAS-farmer	Non-AAS farmer
2016-17				
Akola, Maharashtra	Yelgaon	Soybean	2.17	1.76
Bangalore, Karnataka	Patrenahalli & Nayanahalli	Grape	9.21	5.45
Palampur, Himachal Pradesh	Dhamrol	Maize	2.74	0.73
Parbhani, Maharashtra	Shekta	Cotton	2.26	1.88
Udaipur, Rajasthan	Nakli	Maize	1.93	1.28
Anantapur, Andhra Pradesh	Yagantipalle	Pigeonpea	3.10	2.48
Kovilpatti, Tamil Nadu	Allikundam	Okra	2.41	1.98
2015-16				
Akola, Maharashtra	Devpur	Soybean	1.85	1.54
Palampur, Himachal Pradesh	Gwardu	Maize	1.22	0.77
Udaipur, Rajasthan	Nakli	Maize	1.22	0.59
2014-15				
Kovilpatti, Tamil Nadu	Allikundam	Cotton	2.30	1.71
2013-14				
Mohanpur, West Bengal	Bongheri	Lathyrus	1.50	1.20

3.1.1.1. Product generation using automatic weather station data

AICRPAM was entrusted with the assessment of climatic variability in selected 100 most climate change vulnerable districts of India under the NICRA project. For meeting this requirement, 100 automatic weather stations (AWS) were installed in these districts. Estimation of empirical constants of different solar radiation models was attempted using AWS data of Kangra (32.1 ^{0}N, 76.3 ^{0}E, 733 m). The data from April 1, 2012 to March 31, 2015 was used for calibration, whereas the data from April 1, 2015 to December 31, 2015 was used for validating the models.

The empirical coefficients presented in Hargreaves-Samani, Bristow-Campbell and their modified versions are determined using the Data fit (version 9.0 software) software. The measured and model's predicted global solar radiation data were analysed using Root Mean Square Error (RMSE), D-index and Normalised Orthogonal Function (NOF). The results are presented in Table 3.2.

The statistical analysis shows that among the 10 models validated, Donatelli-Campbell model (a modified version of Bristow-Campbell) gives good result in terms of high D-Index value (0.96) and low RMSE (2.58 MJ m^{-2} day^{-1}) and NOF (0.20) values. This implied that, the model can be used with confidence in estimating the solar radiation at Kangra location.

3.1.1.2. Validation of extended range weather forecast

Verification of extended range weather forecast (ERFS) provided by IMD was undertaken at meteorological sub-divisional level for *kharif* season during 2015-17. This study aimed to evaluate the utility of ERFS for agricultural planning. Measures of verification *viz.*, per cent accuracy, bias score, probability of detection, probability of false detection, false alarm ratio, success ratio, threat score, Hanssen and Kuipers discriminant, equitable threat score, Heidke skill score,

odds ratio and odds ratio skill score were used for both categorical and quantitative forecast of two weeks. The results indicated that forecast accuracy was better for first week for most part of the country as compared to the second week (Fig. 3.2).

Table 3.2: Empirical coefficients developed for Hargreaves-Samani and Bristow-Campbel models and their validation results

Empirical Models	Empirical Constant	Statistics RMSE	Statistics D-Index	Statistics NOF
Hargreaves-Samani (1982) $R_s = R_a * a * \sqrt{\Delta T}$	a=0.11	3.15	0.94	0.25
Hargreaves (1985) $R_s = R_a * a * \sqrt{\Delta T} + b$	a=0.17; b=-6.48	3.41	0.94	0.27
Annandale (2002) $R_s = R_a * a * (1 + 2.7 * 10^{-5} * z) * \sqrt{\Delta T}$	a=0.11	3.12	0.94	0.24
Chen (2004) $R_s = R_a * (a * \sqrt{\Delta T} + b)$	a=0.17; b=0.21	3.03	0.94	0.24
Bristow-Campbel $R_s = R_a * a * (1 - \exp(-b * \Delta T^c))$	a=0.63; b=0.04; c=1.29	2.94	0.95	0.23
Donatelli-Campbell $R_s = R_a * a * (1 - \exp(-b * (\frac{\Delta T^c}{T_m})))$	a=0.51; b=0.07; c=2.24	2.58	0.96	0.20
Goodin $R_s = R_a * a * (1 - \exp(-b * (\frac{\Delta T^c}{R_a})))$	a=0.44; b=0.14; c=2.63	3.00	0.95	0.24
Meza-Varas $R_s = R_a * 0.75 * (1 - \exp(-b * \Delta T^2))$	b=0.01	6.18	0.74	0.48
Weiss $R_s = R_a * 0.75 * (1 - \exp(-b * (\frac{\Delta T^2}{R_a})))$	b=0.10	5.66	0.86	0.44
Abraha-Savag $R_s = R_a * 0.75 * (1 - \exp(-b * (\frac{\Delta T^2}{T_m})))$	b=0.05	3.33	0.94	0.26

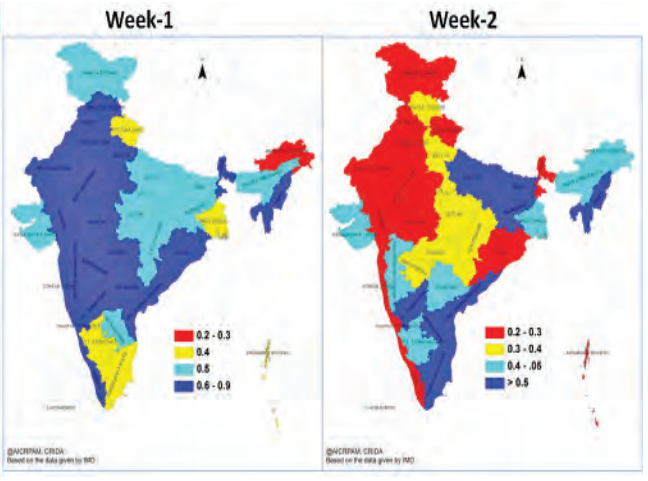


Fig. 3.2: Validation of ERFS based on forecast accuracy for both the weeks during southwest monsoon 2015-17

3.1.1.3. Development of frost prediction models

A work on developing frost prediction models using multivariate statistical techniques as well as thumb rules were undertaken for two geo-locations *viz.*, Ludhiana and Palampur. Statistical techniques like principal component analysis (PCA), logistic regression and artificial neural network (ANN) were used to develop prediction models and were validated with observed frost events recorded by AICRPAM centres. The results indicated that prediction model developed using logistic regression performed better for both locations (Table 3.3).

Table 3.3: Comparison of accuracy of prediction models developed using different methods at Palampur and Ludhiana

Name of Indices	Palampur			Ludhiana		
	LR	ANN	TR	LR	ANN	TR
Accuracy	0.81	0.73	0.60	0.750	0.741	0.65
Bias (frequency bias)	1.94	2.35	2.46	0.64	0.936	0.78
Probability of Detection (Hit Rate)	0.57	0.4	0.35	0.39	0.519	0.29
False Alarm Ratio (FAR)	0.70	0.82	0.86	0.38	0.445	0.63
Probability of False Detection	0.16	0.22	0.36	0.10	0.169	0.19
Success Ratio (SR)	0.29	0.17	0.14	0.61	0.555	0.36
Threat Score(Critical Success Index)	0.24	0.13	0.11	0.31	0.367	0.19
Hanssen & Kuipers discriminant	0.41	0.17	-0.01	0.29	0.351	0.092
Odds Ratio (OR)	7.15	2.27	0.96	5.71	5.325	1.65
Odd Ration Skill Score	0.75	0.38	-0.02	0.70	0.684	0.24

(LR-Logistic regression; ANN-Artificial neural network; TR-Thumb rule)

3.1.1.4. Dynamic crop weather calendar

A work on development of crop-specific algorithms for preparation of semi-automated agromet advisory services was initiated. A preliminary test of algorithms developed was carried out using field experimental data of AICRPAM centres. The new algorithms for integrating simulation model, district-level contingency plans and weather forecast for issuing agromet advisories is in progress.

3.1.2. Satellite - Derived NDVI Variations to Assess Agricultural Vulnerability in Rainfed Regions due to Climate Change (NICRA/12).

Variations in satellite based vegetation index were identified as indicator of agricultural vulnerability in India owing to climate change. To corroborate Normalized Difference Vegetation Index (NDVI) variations, Standard Precipitation Index (SPI) for a 30 year period i.e., 1982 - 2012 was calculated. A total of 125 districts in 12 states in India were identified as vulnerable to climate change based on coefficient of variation in NDVI wherein over 47 million ha of net sown area was identified as vulnerable.

The objective of the study was to estimate spatial extent of agricultural vulnerability in India at national, state and district-levels using Vegetation Index and validation using SPI. Analysis of change in land use and land cover in identified vulnerable districts was also carried out in order to guide in implementation of adaptation and mitigation strategies.

Over 47 million ha of net sown area in 125 districts in 12 states in India has been identified as agriculturally vulnerable to climate change. During the year the factors behind the change in land use and land cover were also analyzed. Change in length of crop growing period (LGP) was identified as a major driving factor in NDVI variations. Study indicated a decline in LGP in area with <60 days of crop growing period (Table 3.4). In agro ecological sub-regions with 120-150 days LGP, there was an increase in LGP.

Table 3.4: LGP variations

LGP classes	Trend in CV of Max NDVI	Prevalent cropping systems
<60 days	Declining	Fodder, Pearl Millet, Cluster Bean
60-90 days	No change	Oilseeds, Pulses
90-120 days	No change	Paddy, Chilli, Maize
120-150 days	Increasing	Cereals & other cash crops
150-180 days	No change	Oilseeds – Soybean, Wheat, Paddy

CV of Max NDVI obtained from MODIS-TERRA NDVI data composites indicated a change in upper-limit of LGP. Table 3.4 indicates the trend in variations in NDVI and the resultant change in trends in LGP. Study indicated that there was a decrease in LGP in 4 districts, increase in case of 65 districts and

no-change in the upper-limit in case of 53 districts. Further it was seen that there was a decline in lower-limit of LGP in 53 districts, an increase in case of 60 districts and no change in the lower-limit in case of 9 (Fig. 3.3).

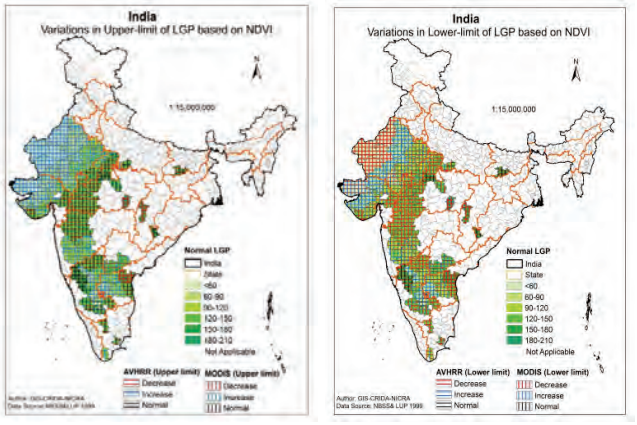


Fig. 3.3: Change in upper & lower limits of LGP identified based on CV of NDVI

3.1.3. Assessment of Vulnerability and Adaptation to Climate Change (NICRA/02)

During the year, the analysis of potential impact of climate change on productivity of major crops continued and is summarized in Table 3.5. An understanding of potential impacts of climate change on productivity of food grain crops at the scale of district, which is the development planning unit in the country, is a useful starting point for adaptation planning and investment prioritization. With this in view, the potential impact of climate change as represented through PRECIS regional climate model outputs for A1b scenario on productivity of food grain crops *viz.*, green gram, black gram, rice and wheat was analysed. The impact coefficients were derived by establishing a relationship between productivity and monthly mean temperature, monthly rainfall and variability therein through panel data regression approach using historical time series data for major districts growing the crop concerned. The coefficients so obtained and the projections of temperature and rainfall were used to estimate the impact of climate change. The analysis showed that impacts are likely to be more towards the end-century (2071-98) compared to mid-century (2021-50). The productivity of rice was estimated to decrease by more than 400 kg in 122 districts during end-century period compared to 14 districts during the mid-century period. Similarly, the yield of sorghum is likely to decline by more than 300 kg/ha in 68 districts towards the end of the century. The results indicate the need for location specific adaptation planning and provide a basis for prioritizing investment in the districts with likely more severe impact on crop productivity.

Table 3.5: Distribution of number of districts according to yield impacts due to climate change

Crop	Yield effect (kg/ha)														Tot. no. of dist.
	>-400		-400 to-301		-300 to -201		-200 to -101		-100 to -1		0 to 100		>100		
	MC	EC	MC	EC	MC	EC	MC	EC	MC	EC	MC	EC	MC	EC	
Rice	14	122	19	49	20	22	35	14	38	5	42	1	51	3	219
Maize	5	85	11	32	21	11	39	8	36	1	21		4		137
Finger millet	1	2	5	2	9	-	6	-	15	6	10	2	13	47	59
Sorghum				13		55	12	74	45	30	49		66		172
Pearl millet		9		20	5	44	21	45	40	14	28		38		132
Pigeonpea						1		14	13	27	26	15	42	24	81
Chickpea					1	37	27	83	60		72		29		189
Groundnut				1	1	7	5	18	16	16	23	13	21	11	66
RSM									29	03	74	58	21	63	124
Soybean		16		17	1	10	6	12	8	4	13	3	35	1	63
Wheat	1	57	19	67	41	72	33	6	47	2	55		8		204

MC: Mid-century (2021-50) EC: End-century (2071-98)

3.1.4. Runoff Potential Availability in Rainfed Areas in Different Agro-ecological Regions of India for Rainwater Harvesting Under Changing Climatic Scenarios (NICRA/36)

3.1.4.1. Determination of irrigation requirement of different crops under changing climatic scenarios at Indore district

The irrigation requirement was determined for *kharif* and *rabi* crops such as soybean, wheat, sorghum, pigeonpea, chickpea, maize, onion, potato, chilli, mustard, green gram, groundnut, cotton, etc. at Indore district. Considerable increase in the irrigation requirement of *rabi* crops like wheat, *rabi* sorghum, *rabi* maize, potato etc. was predicted at Indore.

3.1.4.2. Spatial and temporal estimation of runoff under changing climatic scenarios from domain districts of Indore centre using SWAT

The SWAT model was calibrated (1990-1994) and validated (1995-1998) for Malwa region of Madhya Pradesh. Runoff was estimated spatially and temporally for the domain districts of Indore Centre under changing climatic scenarios (RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5) using SWAT model and ENSEMBLE data. Around 2% increase in runoff is predicted by 2050's whereas 3% increase in runoff is predicted by the end of the century under medium emission scenarios. Indore is plagued with groundwater overexploitation and is characterized by high runoff potential. An increase in rainfall and runoff are expected at Indore under changing climatic scenarios shows an increased potential for rainwater harvesting. Hence, adoption of rainwater harvesting and optimum utilization of water resources is one of the recommended climatic resilient adaptation strategies for this area.

3.1.4.3. Development of runoff estimation models (block-wise) using GIS SCS-CN method coupled with GIS and its validation for domain districts of Vijayapura

A spatial runoff estimation model was developed for estimating the daily runoff using SCS-CN method coupled with GIS and the model was validated using recorded data for Vijayapura Centre (Fig. 3.4). The rainfall was below 800 mm in major portion of the Vijayapura domain districts and runoff ranged from 10 to 20% of the annual rainfall.

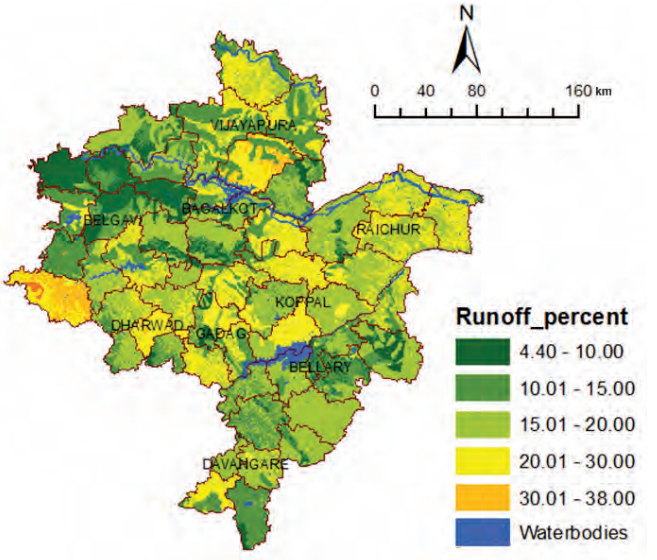


Fig. 3.4: Spatial variation of runoff (%) in the domain districts of Vijayapura

Runoff was estimated spatially and temporally under changing climatic scenarios (ENSEMBLE data) for the domain districts (block-wise) of Vijayapura Centre using SCS-CN method coupled with GIS. Under changing climatic scenarios, the runoff is not expected to vary considerable under low or medium emission scenarios. By 2050's, it is expected to increase by 2.5% under high emission scenarios, 2.0% under medium emission scenarios and negligible under low emission scenarios. Spatial and temporal variation of runoff during above normal, normal and drought years was also determined for domain districts of Vijayapura Centre. Considerable spatial variation in the rainfall and runoff are observed during above normal, normal and drought years. The runoff from major portion of the area was below 32% of the rainfall in above normal year, below 15% in normal year and below 10% in drought year.

3.1.5. Development of SCADA Based Rainfall Simulation Facility and Precision Type Lysimeter with Open Top Climate Chambers for Assessing the Impact of Climate Change to Resource Loss and Soil Water Balance for Rainfed Crops (NICRA/06)

SCADA based rainfall simulator and precision type Lysimeters facilities were established for assessing

the climate change impacts on resource losses at extreme weather events of the rainfall intensity varying from 25 to 150 mm/hr in different soils and upto 10% slope with moving type simulator over the soil bins and with temperature and CO_2 control in climate chambers in CCRC, Hayathnagar. SCADA has the provisions to operate the system from the computer terminal itself and the control of the system. The flowcharts of process automation of rainfall simulator and precision Lysimeters is shown in Fig. 3.5.

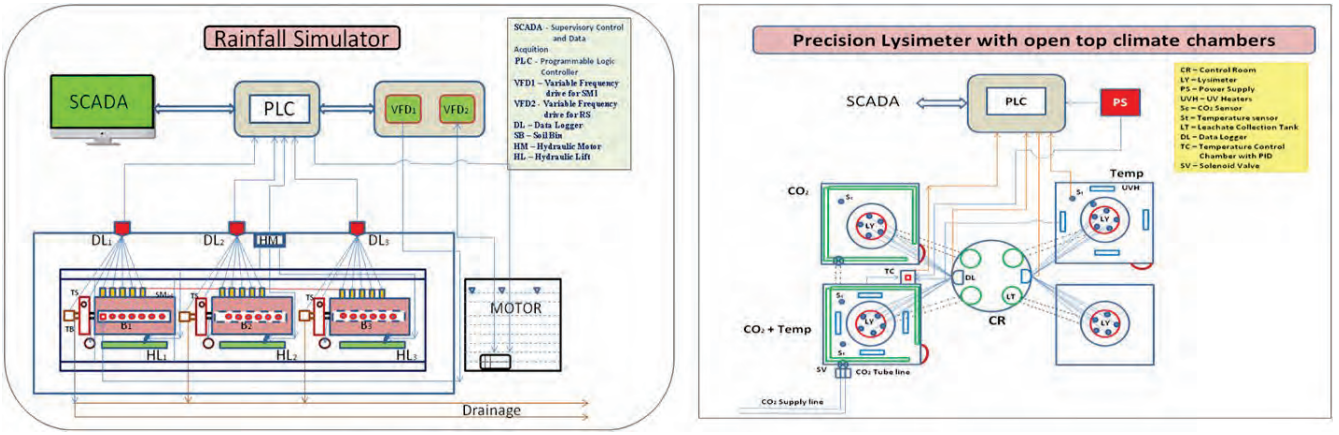


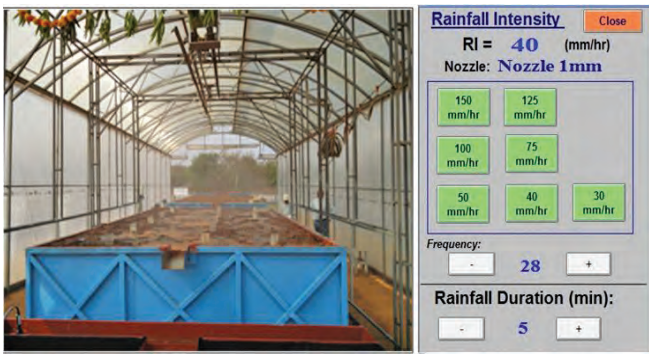
Fig. 3.5: Process flow diagrams for data acquisition through PLC in SCADA for Rainfall Simulator and Precision Lysimeters

Calibration of rainfall intensity, soil bin slope, tipping buckets and soil moisture sensors have been done for accuracy of the measurements in the rainfall simulator facility. The soil bins slope was also calibrated from the SCADA screen with average accuracy of 3%. In precision Lysimeter facility, the CO_2 sensor and soil moisture sensors were calibrated for their accuracy. An additional feature of increasing temperature from 1-5°C in the open top chambers and CO_2 control of 550 ± 50 ppm was set in the SCADA through PLC and the sensor was calibrated for 550 ppm.

Soil bin slope calibration

3.1.5.1. Nozzle calibration for different intensities

Different nozzle sizes of 4, 3, 2 and 1 mm size were used to get different intensities at different frequencies of the motor, controlled through frequency regulating drive (FRD). They have been calibrated for 30-150 mm/hr rainfall intensities with uniformity of 87%. Accordingly, the screens in SCADA were modified for selection of intensity and nozzle size and duration of the time.



Calibration of nozzles and SCADA screen

3.1.5.2. Impact of Extreme Rainfall and eCO_2 and eTemperature on Green Gram and Maize

An experiment was conducted with test crops of green gram (MGG 347) and maize (DHM 117) to study the impacts of extreme rainfall in soil bins under rainfall simulator. 100 mm/hr rainfall intensity was imposed on the crop during flowering stage in the green gram in different slopes of 0, 2, 4%. The seed yield was affected by the slope with minimum yield in flat slope (0%) and increased the yield as slope increased (133 to 150 g/m^2) against 100g/m^2 in flat slope. The experiment on impact of eCO_2 and eTemp on green gram in the Lysimeters indicated that the crop responded well to eCO_2 at 550 ppm with maximum yield of 35 g/m^2 followed by e CO_2 + eTemp (1 ^{0}C) over the ambient temperature. The

yields of green gram obtained in the open top chambers in other treatments are 26.55g/m^2 in CO_2 + etemp, 22.12g/m^2 in e Temp and control of 17.7 g/m^2.

SCADA based experiments under controlled environmental conditions

3.1.5.3. Maize growth in rainfall simulator and precision Lysimeters with CO_2 and temperature controls

In maize, extreme rainfall intensity of 100 mm/hr was imposed at the tasselling and silking stage and the impacts are drastic in terms of yield reduction, dimension of the cobs, etc. The maximum reduction in the yield was 94% obtained in 4% soil bin as compared to control and followed by 2% and 0% slopes. The physical dimensions were also reduced due to extreme rainfall.

Maize seed yield and cobs in different soil bins of rainfall simulator and Lysimeter chambers

3.1.6. Phenotyping of Rainfed Crops (Maize and Pigeonpea) for Enhanced Tolerance to Climatic Stresses (NICRA/32)

Developing tolerant genotypes is crucial for stabilizing yields under drought stress conditions as it is one of the most important abiotic stresses affecting crop yields. The objective of the present study was to develop climate resilient varieties of maize and pigeonpea by conventional and molecular approaches. In *kharif* 2017, morpho-physiological traits related to water deficit

Table 3.6: Combined ANOVA for various morpho-physiological traits in maize

Source	DF	DA	DS	ASI	PH	CH	CL	CG	NKR	NKPR	SY	HSW	Photo	TR	SC	LT	NDVI
Manage-ment	1	71.11	182.04	587.77	56034.20**	45127.49**	161.33**	74.76**	6.76	445.24**	6282.54**	61.86	6271.68**	388.46**	0.68**	27.87**	0.0006
Rep (Manage-ment)	4	4.84	6.57	0.75	426.95	339.27	2.45	0.06	2.45	12.92	328.27	4.13	2.85	2.59**	0.006**	0.25	0.002
Genotypes	14	97.63**	97.46**	2.29	237.15	306.07	21.88**	6.95**	26.60	76.51**	4243.81**	45.38**	168.35**	9.40**	0.03**	4.92**	0.06
Manage-ment* Genotypes	14	11.25**	18.02	1.70	517.24	108.87	6.79	2.12	7.09	51.82**	741.68	24.57	101.34	14.30**	0.04**	11.76**	0.0005
Error	56	5.64	7.16	0.92	131.38	93.46	1.78	0.83	1.44	24.08	328.81	5.99	1.68	0.20	0.0008	0.25	0.003
GM		52.88	5.44	0.53	159.12	53.37	13.01	12.54	13.46	124.08	67.13	24.01	35.73	10.36	0.45	30.50	0.68
CV		4.49	4.82	180.06	7.20	18.11	10.26	7.30	8.91	12.12	27.01	10.19	3.63	4.39	6.35	1.64	8.83
SEd		0.96	1.09	0.39	4.67	3.94	0.54	0.37	0.49	1.29	7.40	0.99	0.53	0.18	0.01	0.20	0.02
CD (5%)		2.74	3.09		13.25	2.00	1.54	1.05	1.38	3.65	20.97	2.83	1.50	0.52	0.03	0.57	0.06

DS=Days to silking, DA=Days to anthesis, PH=Plant height (cm), CH=Cob height (cm), CL=Cob length (cm), CG=Cob girth (cm), NKR=No. Kernel row per cob, NKPR=No. kernel per row, SY=Seed yield (g/pl), FY=FY dry (g/pl), HSW=hundred seed weight(g), ASI=Anthesis silking interval, Photo=photosynthesis, TR=transpiration rate, SC=stomatal conductance, LT=leaf temperature, GM=Grand mean, CV=Coefficient of variation (%), SEd=Standard error of mean difference, CD= critical different at 5% level of significance.

stress tolerance such as, canopy temperature, SPAD, anthesis silking interval (ASI), photosynthesis, NDVI, stomatal conductance, leaf temperature, plant height, ear height were analysed in 15 selected genotypes of maize under both well watered and rainfed conditions. Yield contributing traits *viz.,* total biomass, cob length, number of kernels per row, number of kernel rows, cob weight, seed yield and 100 seed weight were also analysed.

The analysis of variance (ANOVA) of 15 genotypes revealed significant genotypic differences ($p< 0.05$) for majority of the traits (Table 3.6). Among genotypes, HKI7660, NSJ189 and Z101-15 performed relatively better for yield and its attributes as compared to others, while hybrids TMMH806 and TMMH826 were best performers under well watered conditions. Under water stress conditions, genotypes HKI7660 and NSJ189 performed comparatively better than other genotypes, while hybrids were the best performers.

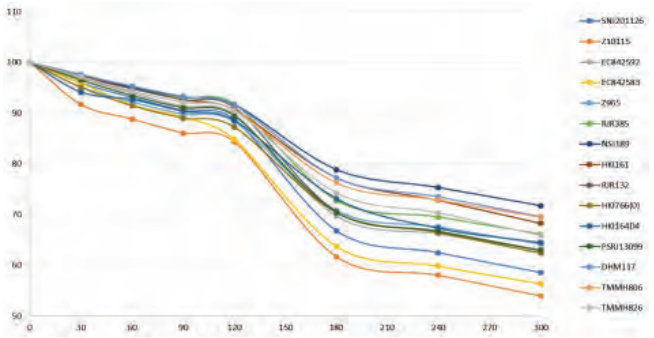


Fig. 3.6: Excised leaf water retention capacity in maize genotypes

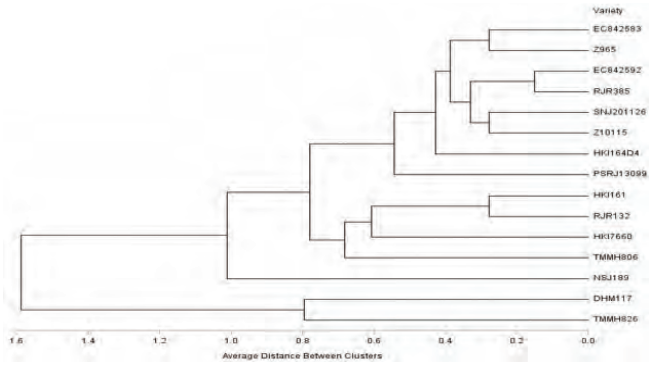


Fig. 3.7: Clustering based on various morpho-physiological traits in maize genotypes under rainfed conditions

Excised leaf water retention capacity (ELWRC) of genotypes revealed NSJ189 maintained higher ELWRC along with DHM117 and TMMH806 (Fig. 3.6). Clustering analysis grouped genotypes into three cluster under water stress conditions (Fig. 3.7). Analysis of various morpho-physiological traits revealed significant positive association of seed yield with plant height and yield attributes under both well watered and rainfed conditions. Among the genotypes tested, NSJ189, HKI7660 performed better and were comparable to checks DHM117, TMMH806 and TMMH826.

3.1.6.1. Genotyping and phenotyping of pigeonpea

Twelve medium duration genotypes of pigeonpea were evaluated under irrigated and rainfed conditions to identify drought tolerant genotypes. Genotyping studies were also carried out using 72 collections of pigeonpea mini core, with an idea to identify diverse genotypes. Genotyping of genotypes of minicore collection was done using genic and genomic SSRs. Genomic DNA isolated from 20 days old young leaves of each genotype was amplified using 30 polymorphic genic and genomic SSR markers. The SSR amplification profiles were scored based on the size (bp) of the amplicons using Biovision Software, USA. Gene diversity, heterozygosity and PIC for each of the primer pair was calculated using Power Marker v.3.25 software. Genetic distances between the genotypes were also calculated according to Nei 1973. Phylogenetic tree was constructed using UPGMA by neighbor-joining method and dendogram was generated by MEGA software version 5.0. The STRUCTURE 2.3.4 software was used to detect population structure and to assign individuals to subpopulations.

Based on overall performance across years the genotypes, GRG1761, RVK272 and RVK274 were identified to perform well in terms yield and its attributes implying that these genotypes were relatively more tolerant to drought. Thirty polymorphic SSR markers revealed considerable genetic diversity among genotypes and identifying 66 alleles, with an average of ~2.20 alleles per SSR. A maximum of 3 alleles were amplified by markers ASSR5, ASSR9, ASSR93, ASSR148, ASSR236 and ASSR352. The average PIC of SSRs was 0.24 with a range of 0.03 for ASSR100 to 0.56 in ASSR236. Cluster analysis grouped mini core accessions into five clusters. Cluster III and cluster II were found to be largest with 35 and 27 genotypes respectively. On the other hand, population structure analysis grouped genotypes into five sub-populations, with varying degrees of admixture amongst them.

Cluster and population structure analysis using the SSR data revealed five subpopulations, with varying degrees of admixture among subpopulations and the genetic relatedness among genotypes (Fig. 3.8). The present study provided a good insight of genetic diversity and population structure among pigeonpea mini core used in the present investigation. This will be useful in selection of diverse genotypes for development of new cultivars with adaptation to a broad range of environments.

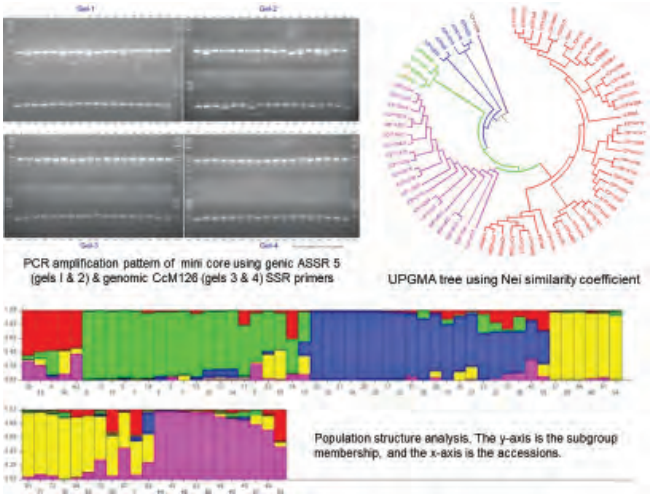


Fig. 3.8: Model based clustering and structure analysis of pigeonpea mini core using SSR marker data

3.1.6.2. Transcriptome analysis in maize under water deficit stress

Transcriptome profiles of two maize genotypes used in developing mapping population drought-tolerant SNJ2011-26 and drought-sensitive HKI161 were analyzed at well watered and water deficit stress conditions to elucidate the mechanism of drought tolerance.

Fifteen days old seedlings were subjected to water-deficit stress. The relative water content ranged about 96% in the control (HKI161–96.04%, SNJ201126–96.33%) and about 74–78% in water-deficit stress (HKI161–73.75%, SNJ201126–78.3%), while the soil moisture content of the control was around 17% and under water deficit stress it was around 11% (HKI161–16.83%, SNJ201126–17.13%) and water-deficit stress (HKI161–11.12%, SNJ201126– 11.43%) (Fig. 3.9).

Analysis of differentially expressed genes (DEGs) in the susceptible genotype under water deficit stress conditions indicated an upregulation of 389 transcripts and downregulation of 563 transcripts, while in case of tolerant genotype, upregulation of 240 and down regulation of 131 in comparison with those under well watered conditions. Comparison of the susceptible and tolerant genotypes under well watered conditions indicated an upregulation of 201 transcripts and down regulation of 242 transcripts. On the other hand, under water deficit stress conditions, 531 transcripts were upregulated and 305 were down regulated.

DEGs of both the susceptible and tolerant genotypes were classified into various gene ontology categories such as biological component, cellular function and molecular function. The DEGs belonging to macromolecular complex, catalytic function and binding were found to be significantly upregulated in tolerant genotype compared to the susceptible one. Also the exclusive expression of salicylic acid induced pathway genes in tolerant genotype might be a contributing factor to the tolerance (Fig. 3.10). RNA-seq data of Zea mays tolerant (SNJ2011-26) and susceptible genotype (HKI161) subjected to water-deficit stress at seedling stage was deposited in SRA database with accession number SRP133547.

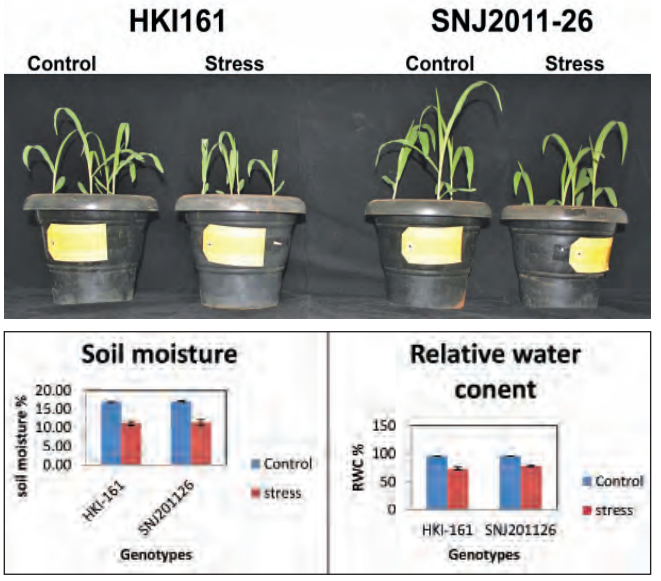


Fig. 3.9: a) Fifteen days old seedlings of susceptible (HKI161) and tolerant (SNJ2011-26) varieties under control and water-deficit stress conditions b) Soil moisture content and relative water content of susceptible (HKI161) and tolerant (SNJ2011-26) varieties under control and water-deficit stress conditions

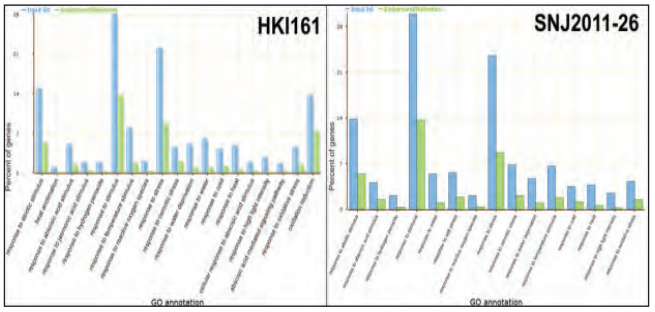


Fig. 3.10: Significant stress responsive Gene ontology terms in HKI161 and SNJ2011-26

3.1.7. Physiological and Metabolic Indices for Heat Stress Tolerance in Maize (NICRA/33)

Maize (*Zea mays* L) is one of the most versatile emerging cereal crops having wider adaptability under varied agro-climatic conditions. In order to understand the physiological and biochemical mechanism associated with high temperature stress tolerance in maize and to develop heat tolerant material, a cross was made between NSJ 221 a genotypes which possessed heat tolerant traits and PSRJ 13099 which was observed to be susceptible to heat stress. The resultant F_1 generation from this cross was raised during *kharif* season and advanced. The ensuing F2 generation is being raised during current *rabi*-summer to expose its reproductive stage to high temperature stress. Observations are being recorded for photosynthetic rates, transpiration, chlorophyll fluorescence, canopy temperature and SPAD at the reproductive entry and grain filling stage of the plants. Infra-red images of aerial parts of the plants were captured using a FLIR camera to understand the distribution of temperature within the plant and plant population (Fig. 3.11).

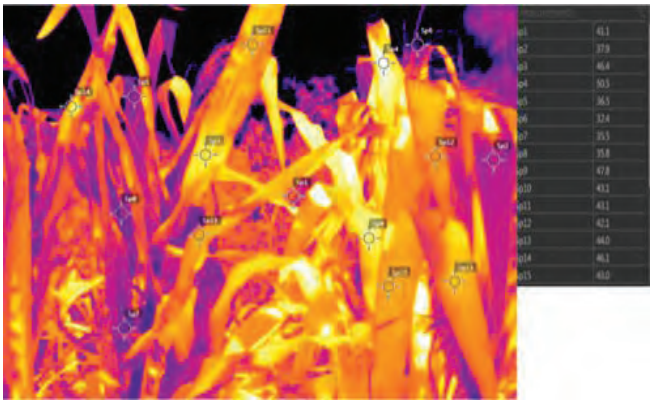


Fig. 3.11: Thermal image of maize to understand the distribution of temperature within the plant

3.1.8. Genetic Enhancement of Pigeonpea Germplasm for Moisture Stress Tolerance (NICRA/27)

Terminal drought and heat stress have become serious problems in pigeonpea particularly coinciding with reproductive phase which reduces the yield. To identify the pigeonpea germplasm accessions with moisture stress tolerance, 12 pigeonpea germplasm accessions selected from earlier experiments were evaluated under rainfed and unstressed conditions. Biometrical characters *viz.,* plant height, number of branches, number of pods, pod weight, 100 seed weight and seed yield and physiological parameters like SPAD value and canopy temperature, net photosynthetic rate, stomatal conductance, transpiration rate and osmotic potential were recorded.

Among the 12 germplasm accessions, days to 50% flowering ranged from 77 (PUSA-33) to 119 days (PRG-158). SPAD reading at vegetative stage ranged from 45.4 (PRG-158) to 57.1 PUSA-33) in unstressed condition and from 43.6 (RVK-274) to 56.2 (GRG-276-1) in rainfed conditions. SPAD reading at flowering stage ranged from 45.9 (ASHA) to 53.2 (PUSA-33) in unstressed condition and from 45.8 (Bennur Local) to 53.4 (AL-1817) in rainfed conditions. Canopy temperature in vegetative stage ranged from 28.7 (GT-101) to 31.8 (GRG 276-1) in unstressed condition and from 28.2 (RVK-286) to 30.5 (ASHA) in rainfed condition. Canopy temperature in flowering stage ranged from 28.2 (ASHA) to 31.6 (GRG 276-1) in unstressed condition and from 31.7 (AL-1817) to 34.4 (PRG-158) in rainfed condition. NDVI values ranged from 0.77 (GRG 276-1) to 0.86 (PRG-158). PRG-158 (175) recorded lowest % of increase in accumulation of compatible solutes in rainfed condition whereas GT-101 (406) exhibited higher per cent of increase in accumulation of compatible solutes in rainfed condition as compared to unstressed condition. Bennur local and Asha recorded high net photosynthetic rate, stomatal conductance and transpiration rate in unstressed condition and RVK-274 and AL-1817 recorded high net photosynthetic rate, stomatal conductance and transpiration rate in rainfed condition. PRG-158 recorded high water use efficiency in both unstressed and rainfed condition.

Plant height ranged from 117 (AL-1817) to 218 cm (BDN-2) in unstressed condition and from 148 (AL-1817) to 207.7 cm (PUSA-33) in rainfed condition. In unstressed condition number of pods ranged from 80.7 (AL-1817) to 548 (AKT-8811) and in rainfed condition it ranged from 77.7 (RVK-274) to 324 (Bennur Local). Pod weight ranged from 45.3 (AL-1817) to 291.3 gm (AKT-8811) in unstressed condition and from 37.7 (AL-1817) to 176 gm (AKT-8811) in rainfed condition. Seed yield ranged from 31.7 (AL-1817) to 179gm (AKT-8811) in unstressed condition and from 14.7 (AL-1817) to 98.3gm (AKT-8811) in rainfed condition.

3.1.9. Phenotyping Sub-Project - Productivity of Rainfed Crops under Enhanced Carbon Dioxide and its Interaction with Water Deficit and Elevated Temperature (NICRA/31)

The ongoing climate change, driven by the anthropogenic increase of atmospheric CO_2 and characterized by increased global temperatures and altered rainfall patterns, poses a major threat to agriculture. To quantify the impact of increased temperature and its interaction with elevated carbon dioxide concentration and moisture stress on productivity and quality of rainfed crops, a field experiment was conducted under Free Air Temperature Elevation (FATE) facility with four maize hybrids - DHM-117, DHM-121, NK-6240, 900M Gold to assess the impact of elevated crop canopy temperature (eT) and its interaction with elevated CO_2 ($eT+eCO_2$) on phenological, morphological, physiological, biochemical and yield parameters. During the crop growth period, the maximum temperature was 35.6 ^{0}C at initial growth stage. The canopy temperature of eT was elevated by 3 ^{0}C± 0.5 ^{0}C in 8.0m dia FATE rings fitted with an array of 24 IR heaters. A reference plot with similar fittings without warming served as ambient control (aT).

The ASI increased under eT with two public hybrids DHM-117 (2 days) and DHM-121 (1.3 days) while there was no change with NK-6240, and reduced ASI with 900M Gold. Among the four maize genotypes, 900M Gold recorded highest net photosynthetic rate (Anet), stomatal conductance (gs), transpiration rate (Tr) at aT. The eT reduced Anet, gs, Tr of all the genotypes (Fig. 3.12). With eT, the reduction in Anet ranged from 9.69% (900M Gold) to 25.30% (DHM-117), while $eT+eCO_2$ condition improved it to that of aT level in 900M Gold, better than aT in DHM-117. The gs and Tr reduced under both eT and $eT+eCO_2$ conditions, however the magnitude of the response differed with genotype. Both DHM-117 and 900M Gold registered higher WUE at $eT+eCO_2$ condition due to improved response of Anet and higher reduction in Tr.

The response of selected four maize hybrids varied significantly with eT and $eT+eCO_2$ conditions. At harvest, the total biomass, cob weight, grain weight was highest at aT with DHM-117, DHM-121 and NK-6240 while at eT with 900M Gold (Fig. 3.13). The eT reduced the total biomass by 6.8% (NK-6240) to17% (DHM-117) while in the presence of eCO_2 the reduction ranged from nil (900M Gold) to 7.8% (DHM-121) (Fig. 3.14a). With eT, the grain yield reduced by nil (900M Gold) to16% (DHM-117) and the impact of $eT+eCO_2$ condition was positive only with DHM-117, while negative with NK-6240. Both eT and $eT+eCO_2$ conditions improved or not impacted the HI of these maize hybrids revealing that these conditions are impacting more of vegetative parameters than reproductive parameters. The presence of eCO_2 along with eT was not impacted significantly the biomass and seed yield of this C4 crop and even further reduced the cob and grain weight in NK-6240 (Fig. 3.14 b). The variability in response of maize genotypes revealed that the genotype 900M Gold was stable performer at eT and not responding to eCO_2, while DHM-117 was sensitive to eT and responsive to eCO_2.

FATE facility

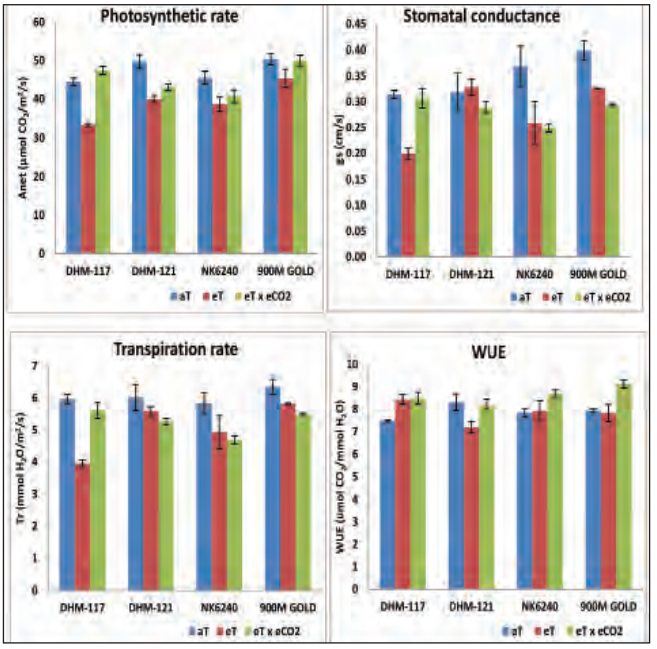


Fig. 3.12: Photosynthetic rate, stomatal conductance, transpiration rate and WUE of maize hybrids under aT, eT and eT+eCO2 conditions at vegetative stage

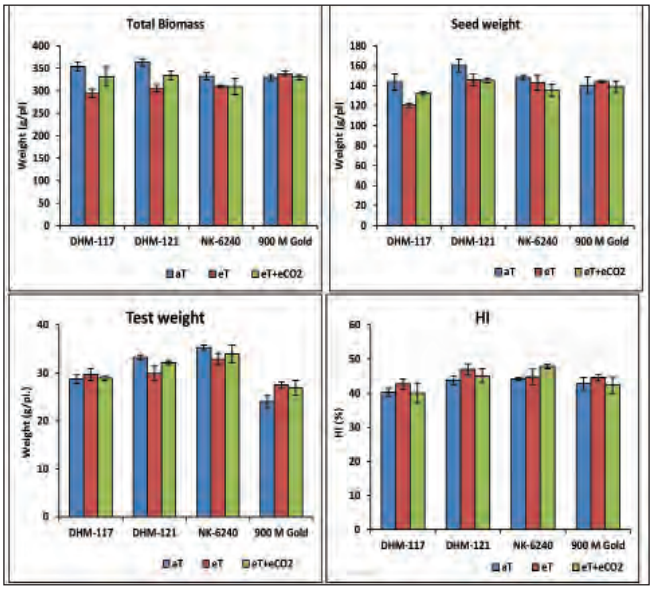


Fig. 3.13: Total biomass (g/pl), seed yield (g/pl) test weight (g) and HI (%) of four maize hybrids at ambient (aT), elevated (eT) canopy temperature and eT+eCO2 decrease (%) in biomass, seed yield and yield contributing traits with elevated temperature over ambient control.

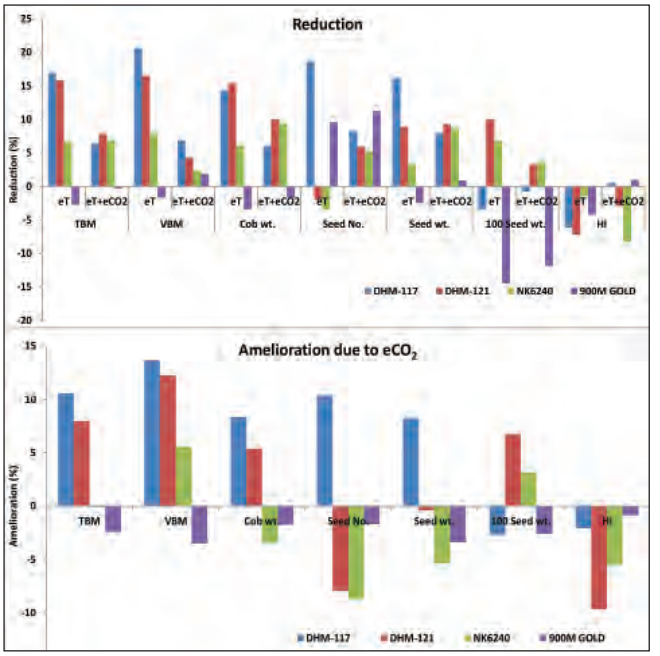


Fig. 3.14: a). Reduction (%) in biomass, seed yield and yield contributing traits of four maize hybrids with eT and eT+eCO$_2$ over aT control, b). Amelioration (%) of eT effects due to eCO$_2$ for biomass, seed yield and yield contributing traits of four maize hybrids

3.1.10. Effect of Elevated Atmospheric CO$_2$ Concentration and High Temperature on Nutrient Quality of Dryland Crops (NICRA/19)

Elevated CO$_2$ concentrations and temperatures under global climate change scenarios projected for coming decades could impact food crop quality. Hence, there is a need to understand the effects of these changing environmental factors on nutrient quality parameters of edible part of the crop.

Four genotypes DHM 117, DHM 121, NK 6240 and 900M Gold of maize grown under three treatments (Control, Elevated temperature and Elevated temperature + Elevated CO$_2$ (550 ppm)), under FATE facilities and two treatments grown under moisture stress and irrigated conditions were taken up to analyse and study phyto-chemical parameters of whole maize for minerals (Fe, Zn, Cu, Mn, Ca, Mg, P and Protein). Among the four genotypes, significantly higher content of Fe (6.12 mg/100g) was recorded in DHM 121 under control conditions followed by genotype 900M Gold (6.41 mg/100g) under moisture stress whereas significantly least has been recorded with 900M Gold (2.16 mg/100g) under control conditions. In case of Zn (2.13 mg/100g) significantly higher content was seen

in DHM 117 under irrigated conditions followed by genotype DHM 121 (2.08 mg/100g) under irrigated conditions whereas less accumulation was observed with DHM 121 (0.87 mg/100g) under elevated temperature and carbon dioxide (Fig. 3.15 & 3.16).

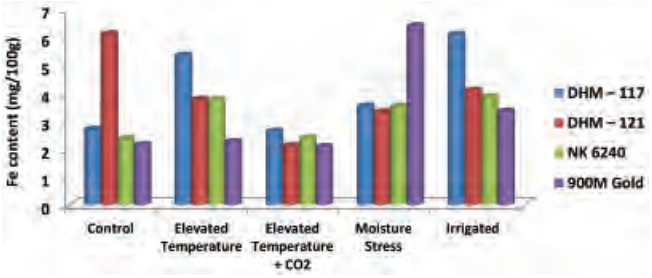


Fig. 3.15: Iron content (mg/100g) of Maize genotypes grown under FATE facility

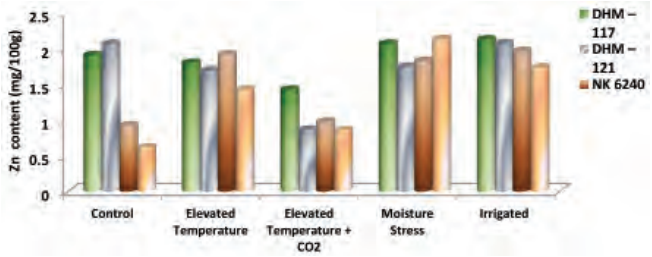


Fig. 3.16: Zinc content (mg/100g) of Maize genotypes grown under FATE facility

In case of Ca (41.52 mg/100g), significantly higher content was found with DHM 117 under control conditions followed by NK 6240 (36.66 mg/100g) under elevated temperature, whereas, significantly lower content was found in 900M Gold (9.83 mg/100g) under moisture stress conditions. For magnesium, significantly higher content was recorded with DHM 117 (126.76 mg/100 g) under elevated temperature, whereas, significantly lower content was found with 900M Gold (82.25 mg/100g) under moisture stress conditions (Fig. 3.17 & 3.18).

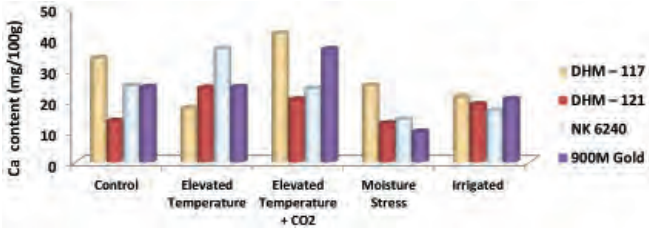


Fig. 3.17: Calcium content (mg/100g) of Maize genotypes grown under FATE facility

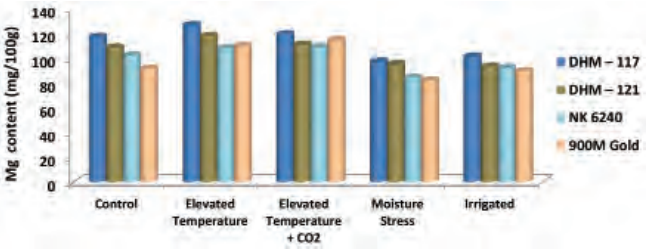


Fig. 3.18: Magnesium content (mg/100g) of Maize genotypes grown under FATE facility

Regarding Cu, significantly higher content was recorded with 900M Gold (0.90 mg/100 g) under elevated temperature and carbon dioxide conditions followed by control condition (0.79 mg/100g) in same genotype, whereas, significantly least content was recorded with DHM 121 under moisture stress (0.12 mg/100g). In case of Mn, significantly maximum and minimum content was observed with 900M Gold (0.45 mg/100g) under elevated temperature and carbon dioxide and irrigated conditions (0.14 mg/100g) followed by DHM 117 (0.42 mg/100g) under elevated CO_2 concentration (Fig. 3.19 & 3.20).

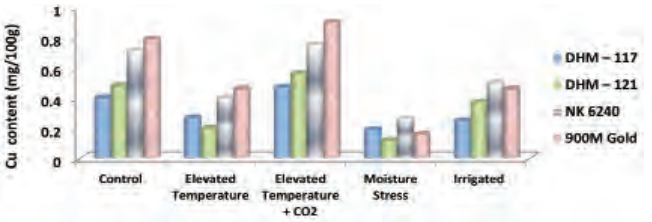


Fig. 3.19: Copper content (mg/100g) of Maize genotypes grown under FATE facility

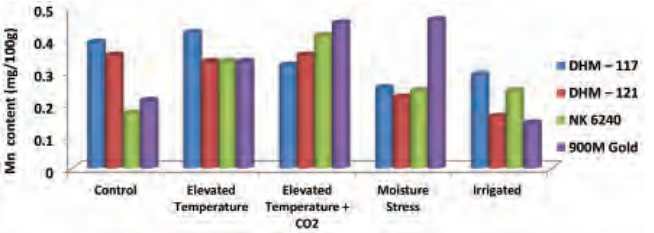


Fig. 3.20: Manganese content (mg/100g) of Maize genotypes grown under FATE facility

Regarding protein content, significantly higher content (15.08 %) was noted with DHM – 121 under control conditions followed by (14.00 %) with NK 6240 under irrigated conditions, whereas, least seen with DHM – 121 (6.02 %) under moisture stress conditions. In case of P (320.61 mg/100g) significantly higher content was found in DHM – 117 under moisture stress conditions followed by (315.46 mg/100g) in DHM – 117 under control, whereas, least was observed with

900M Gold (127.35 mg/100g) in elevated temperature (Fig. 3.21 & 3.22).

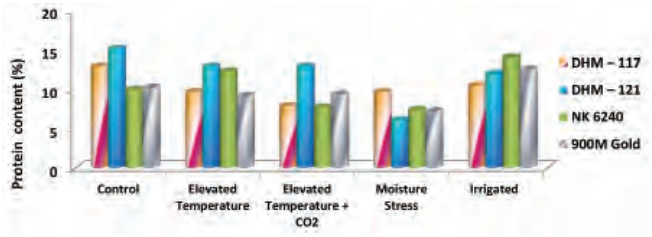


Fig. 3.21: Protein content (%) of Maize genotypes grown under FATE facility

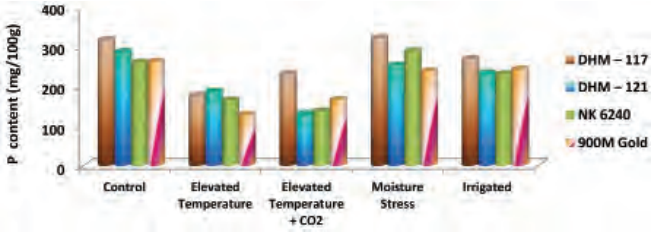


Fig. 3.22: Phosphorus content (mg/100g) of Maize genotypes grown under FATE facility

It was observed that the effect of increased temperatures was higher than effect of elevated CO_2 on Cu and Mn content among the genotypes. Most of the nutrients in grains result from the mobility of nutrients from vegetative pools (source) to grain filling. Elevated temperature and CO_2 resulted in decrease of Fe, Zn, Ca, Mg and P, across the genotypes in the study. It was also reported that the effects of CO_2 on grain quality will depend on the level of future CO_2 atmospheric concentration, its interactions with the biotic and abiotic stresses such as elevated temperature, drought, and soil conditions), and agronomic practices such as irrigation and growth conditions. To properly quantify the effects of potential climate change on crops, studies on interactions of CO_2 and temperature are more important than effects of CO_2 and temperature alone, because in the future climate both of these factors is likely to increase which can also affect human nutrition.

3.1.11. Pest and Disease Dynamics under Climate Change Scenario (NICRA/13)

3.1.11.1. Impact of elevated CO_2 and temperature on *Aphis craccivora* Koch. on groundnut and prediction of pest scenario during climate change periods

Studies were conducted to quantify the direct effects of temperature and indirect effect of elevated CO_2 (eCO_2), on *Aphis craccivora* Koch. On groundnut (*Arachis hypogaea* L.). The future daily temperature (maximum and minimum) for 11 groundnut cultivating regions of the country was obtained using PRECIS model. Future pest status in terms of predicted life table parameters of *A. craccivora* at 11 locations was estimated. The per cent variation in predicted r_m & T during Near Future (NF) and Distant Future (DF) climate change periods over baseline were calculated and represented across locations. The per cent change in 'r_m' was predicted to be significantly higher at all locations during both NF (up to 79.75 %) and DF (up to 98.75 %) periods. At majority of locations substantial shift was noticed over baseline and also between NF and DF periods. The highest reduction of generation time 'T' is expected to be in DF (up to 37.86 %) than NF period (up to 26.95 %) and shift was also noticed (Fig. 3.23). At majority of locations, λ and R_o was expected to increase in both NF (23.29 %) and DF (27.12 %) periods.

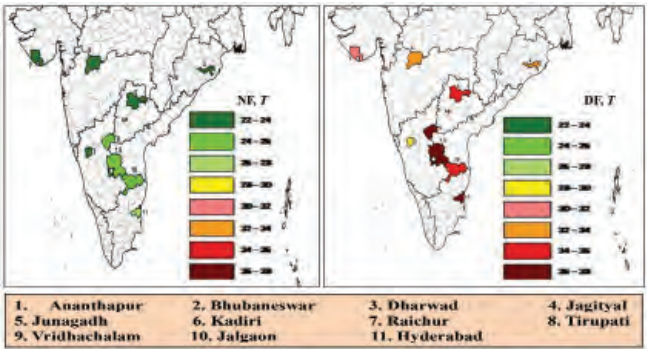


Fig. 3.23: Per cent change in 'T' of A. craccivora on peanut in NF & DF periods over BL

3.1.11.2. Impact of eCO_2 on Tritrophic Interactions in Cowpea-*A. craccivora*-coccinellids

Experiments were conducted to understand the direct and indirect effects of temperature and elevated CO_2 (eCO_2), on tritrophic interaction in cowpea (*Vigna unguiculata* subsp. *unguiculata* L.) (first trophic), legume aphid *Aphis craccivora* (second trophic) and coccinellid predator *Menochilus sexmaculatus* Fab. (third trophic). Data on change in biochemical constituents of cowpea foliage and Development Time (DT), fecundity of aphids and predation capacity and grub duration of coccinellids were recorded. Reduction of the leaf nitrogen (6%), amino acid (6%) and protein (7%) of cowpea foliage with increased carbon (13%) and C: N ratio (21%) at eCO_2 over aCO_2 indicated the dilution of biochemical constituents at first trophic

level. Shortened development time, DT and increment of reproductive rate, RR at eCO_2 over ambient CO_2 (aCO_2) was significant with increase in temperature from 20 to 35 ^{0}C. Reduction of the mean degree day, DD requirement of both nymphal (75.79±15.163) and adult stages (157.15 ± 67.04) at eCO_2 over aCO_2 and same was reflected in the summation DD for both the stages at eCO_2 (232.96±80.32) and aCO_2 (247.07±64.77) across six temperatures. The 'r_m' and 'R_0' increased gradually with increase in temperature in the non-linear fashion and reached maximum values at 27 ^{0}C with shortened 'T' across 20 to 35 ^{0}C temperatures at eCO_2 indicating the significant variation of growth and development at the second trophy c level (Fig. 3.24). Decreased grub duration (23%) with increased predation capacity (19%) of *M. sexmaculatus* on *A. craccivora* at eCO_2 over ambient was noted, indicating the incidence of *A. craccivora* is likely to be higher with increased predation in the future climate change scenario.

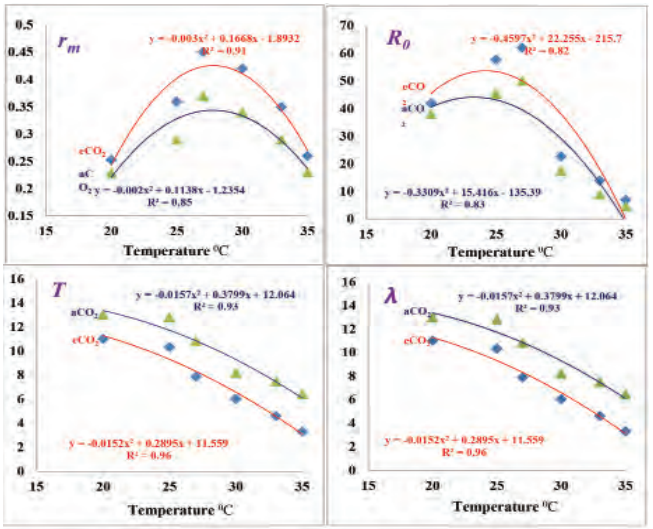


Fig. 3.24: Relationship between temperature and life table parameters of A. craccivora on cowpea at eCO2 and aCO2

3.1.11.3. Interactive effect of elevated CO_2 and temperature on insect pests using CTGC facility

Groundnut crop was sown in CTGC chambers during *kharif* season and crop was maintained at four set conditions *viz.*, i.) Reference, ii.) Chamber with temperature gradient of 5 ± 0.5 ^{0}C over reference and referred as elevated Temperature, - '*e*Temp', iii.) Chamber with Temperature gradient 5 ± 0.5 ^{0}C over reference with elevated CO_2 concentration of 550±50 ppm – '*e*Temp+ eCO_2' and iv.) Chamber with elevated CO_2 concentration of 550±50 ppm which serve as -'eCO_2'. Data on insect pest incidence was recorded as per the standard procedure to understand the interactive effect of elevated CO_2 and temperature on insect pests. The data on incidence of *Spodoptera litura, Aphis craccivora* and other insect pests were recorded at weekly intervals in a standard data format. The estimated mean population of *S. litura* showed the significant temporal variation and severe incidence on groundnut crop at *e*Temp and *e*Temp+ eCO_2 conditions.

Groundnut crop sown in the Carbon Dioxide and Temperature Gradient Chambers (CTGC)

3.1.11.4. Assessment of pink bollworm damage on cotton in Wardha and Amravati districts of Maharashtra

Due to the alarming situation and peak infestation of pink bollworm, a team of scientists from ICAR-CRIDA along with scientists from ICAR-CICR, Nagpur KVK, Wardha and KVK, Amravati visited affected villages and Tahasils of Wardha and Amravati districts of Maharashtra to assess the damage of PBW on cotton. The infestation was found more in unopened green bolls with the presence of early to late instar larvae of PBW causing considerable damage on locules. Survey indicated that the per cent boll damage by PBW was in the range of 60 to 100%. The data on frequency of locule damage revealed that more than 50% of bolls are with damage of 4 locule/ boll in majority of fields followed by 2 and 3 locule damage. In case of Amravati, the fields recorded 61 to 82% of boll damage with about 33 to 50% of 3 and 4 locule damage per boll. On an average 3 to 3.23 locule per boll were damaged by PBW in majority of fields of both the districts. The main reason for his considerable damage was cultivation of Bt cotton without adoption of IPM. The team felt the dire need to promote and adopt the

IPM consisting of various integral components *viz.*, deep summer ploughing, optimum date of sowing, crop rotation, monitoring through pheromone traps, residue management, clear cut adherence to crop duration (150-180 days), use of bio control agents, etc. Identification of impact of climate variability and climate change on severe incidence of PBW in Bt cotton and the associations should be characterized and quantified so that the adaptation measures can be followed well in advance in the future.

3.1.11.5. Plant pathogens under climate change scenario

Plant pathogens and their biocontrol agents have co-evolved and hence any impact on crops will also have significant bearing on plant pathogens and biocontrol agents. *Trichoderma* sp. is one of the most popular biocontrol agents used for management of soil-borne plant pathogens. The biocontrol agent exhibits several modes of action against plant pathogens *viz.*, production of hydrolytic enzymes, mycoparasitism, production of antibiotics and competition. Isolates of *Trichoderma* sp. were evaluated for these traits under elevated CO_2 conditions.

β - 1, 3-glucanse and Chitinase activities

Activities of chitinases and glucanases of Trichoderma isolates have a significant role in determining their biocontrol potential. Any impact on these enzymes will not only impact disease management schedules but also biocontrol industry. Thirteeen isolates of *Trichoderma* sp. and *Fusarium oxysporum f.* sp. *ricini* were cultured on maltose dextrose agar and spores were harvested into sterile distilled water. β-1,3-glucanse activity was determined using laminarin at 0.75% (w/v) in sodium acetate buffer (50mM), pH 5 as a substrate. Chitinase activity was determined using colloidal chitin at 0.5% (w/v) in acetate buffer (50mM), pH 5.5 as a substrate. The amount of reducing sugar was determined at 540 nm for both the enzymes.

Exposure of the *Trichoderma* isolates to eCO2 (550 ppm) conditions altered glucanase and chitinase activities (Fig. 3.25). Only in T13 isolate, there was a marginal increase in activities of both enzymes. In T10, there was increase in gulcanase activity whereas decrease in chitinase activity. Most of the isolates showed an increase in glucanase activity under eCO_2 conditions, whereas decrease in chitinase activity was observed in most of the isolates with drastic reduction in T1, T2 and T6 isolates. Hence, while choosing the potential biocontrol isolates, care should be taken to pick isolates which do not show fluctuations in these enzyme activities.

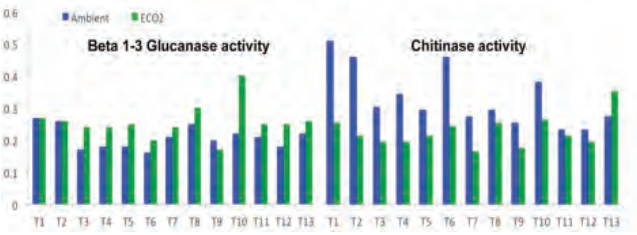


Fig. 3.25: Specific activities of β-1, 3-glucanse and Chitinase of Trichoderma isolates

Siderophores production

Siderophore production is a mechanism employed by bio control agents where the free iron availability to the pathogens is curtailed by producing siderophores. Quantitative assay for siderophore production showed that isolates again varied in their response to eCO_2 conditions. Out of 13 isolates, 8 isolates showed increase in siderophore activity whereas remaining isolates showed reduction. Interestingly, in T2 and T1, there was maximum increase in siderophore production (Fig. 3.26).

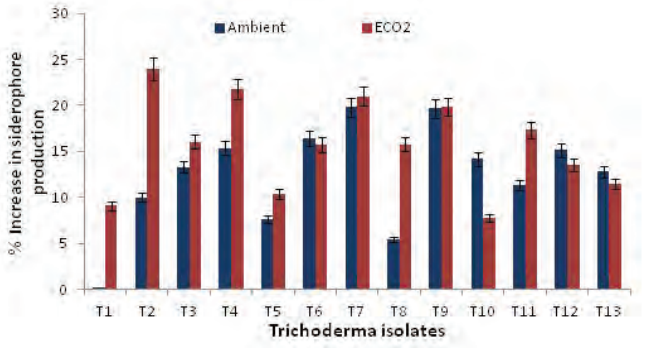


Fig. 3.26: Percent siderophore production in Trichoderma isolates

Plant growth promoting rhizomicro organisms and chitosan mediated biotic and abiotic stress tolerance in rainfed crops

Chitosans are naturally occurring compounds with a potential in crop disease management. They could be antimicrobial or resistance inducers. Four

chitosans were used in the current study C124, C134, C651 and C10% DA at different concentrations (500, 1000, 1500 and 2000 ppm) to examine their affect on reduction in growth of castor wilt pathogen *Fusarium oxysporum f. sp. ricini*. All chitosans had inhibitory effect on the pathogen showing their ability to inhibit growth of the fungus. Least growth of the pathogen was recorded when chitosans 124 and C134 were used at 2000 ppm concentration Fig. 3.27. Interestingly, in all treatments, it took some time for the chitosans to act on the pathogen whereas in C134, there was immediate action of the chitosan on the pathogen resulting in inhibition of the growth immediately.

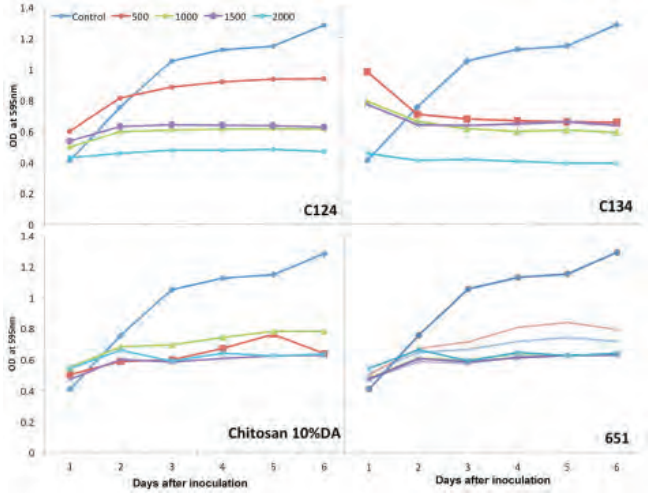


Fig. 3.27: Effect of different concentrations of chitosans on growth of Fusarium oxysporum f. sp. ricini in vitro

PGPRs for tomato

Twenty isolates each of *Bacillus, Pseudomonas, Azotobacter* and *Azospirillum* were screened for their plant growth promoting ability on tomato for 45 days. Among *Bacillus* isolates, maximum shoot biomass was recorded in B81 (2.13 g), whereas maximum root biomass was recorded in B111. Similarly maximum leaf area and chlorophyll content were recorded in B 120 (20.93 cm^2) and B86 (39.47 µmol per m^2) treated plants, respectively. Highest root volume and seedling vigour index were recorded in B365 (1.68cc) and B 111 (2219), respectively. Among *Pseudomonas* isolates, maximum shoot and root biomass were recorded in P72 (2.46 g) and P69 (0.7g), respectively. The root volume, leaf area and chlorophyll content were highest in P70 (2.4cc), P67 (38.27 µmol per m^2) and P55 (20.02 cm^2) treated plants, respectively. Among *Azospirillum* isolates, maximum shoot and root biomass were recorded in ASP21 (3.28 g) and ASP34 (0.86g), respectively. The root volume, leaf area and chlorophyll content were highest in ASP34 (1.1cc), ASP36 ((39.80 µmol per m^2) and ASP16 (27.95 cm^2) treated plants, respectively.

Based on the growth parameters top two effective isolates each of *Bacillus, Pseudomonas, Azotobacter* and *Azospirillum* were identified for further studies. Similarly, among *Azotobacter* isolates, AZB 31 outperformed all other treatments by showing maximum root volume (1.13g) root biomass (0.8g) and chlorophyll content (35.47 µmol per m^2). While AZB31 treated plants showed maximum shoot (2.30g) biomass, highest leaf area (22.62 cm^2) was recorded in AZB17 treated plants. Based on 'Z' score analysis, among *Bacillus* isolates B120 and B365; among *Pseudomonas* isolates P48 and P69; among *Azospirillum* isolates ASP25 and ASP34 and among *Azotobacter* isolates AZB17 and AZB31 were shortlisted for further studies. These isolates were characterized for their PGP traits like ammonia production; solubilisation of phosphorus and zinc; siderophore production and compatibility with common pesticides used in crop production.

When tested for ammonia production, B120, ASP34 were strongly positive; P48, P69, AZB17, AZB31 were moderately positive whereas B365 and ASP25 were weakly positive. All isolates solubilized ZnO and $ZnCO_3$, except ASP34, which failed to solubilize ZnO. Similarly, B120, B365, AZB31 and ASP34 were positive for 'p' solubilization whereas others were not. All the 8 test isolates were positive for siderophore production. Among 6 pesticides (mancozeb, carbendazim, acephate, dimethoate, imidacloprid and quinolphos) tested at 8 concentrations, only mancozeb inhibited growth of the test isolates at 0.05%, 0.1%, 0.2%, 0.5%, 1%, 1.5%, 2% concentrations.

3.1.12. Quantitative Assessment of Potential Positive Impacts of Long-Term Conservation Agricultural Practices on Climatically Resilient Soil Parameters in Rainfed Alfisols (NICRA/14)

An experiment with surface application of 4 levels of sorghum residues @ 0, 2, 4, 6 t ha^{-1} in combination with N (30 kg N ha^{-1} for cowpea and 60 kg N ha^{-1} for

Sorghum through urea) and uniform dose of 30 kg P_2O_5 ha^{-1} (through super phosphate) with minimum tillage, was initiated during 2005 at Hayathnagar Farm of ICAR-CRIDA, Hyderabad to study the effect of long term application of graded level of surface residue on grain yield, organic carbon, mineral nitrogen, microbial organic carbon and labile carbon under minimum tillage in Alfisol. The cropping system adopted for this study was Sorghum-Cowpea with yearly rotation. During the current year (2017), Sorghum (CSV-27) was grown as a test crop.

Sorghum grain yield varied from 1434 to 1858 kg ha^{-1}. Significantly higher Sorghum grain yield (1858 kg ha^{-1}) was observed with surface application of sorghum residue @ 6 t ha^{-1} followed by @ 4t ha^{-1} (1667 kg ha[1]) and 2 t ha^{-1}(1513kg ha^{-1}) compared to control (No residue) (1434 kg ha^{-1}). The increase in grain yield due to application of sorghum residue @ 6, 4 and 2t ha^{-1} was to the extent of 29%, 16% and 5%, respectively over no residue application (Fig. 3.28).

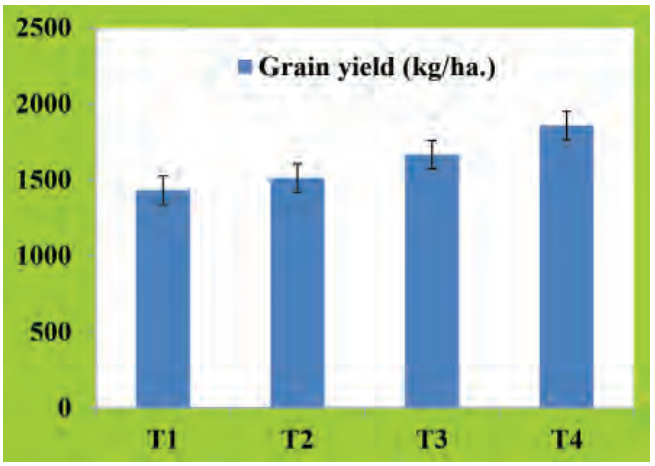


Fig. 3.28: Effect of graded levels of surface residue application on sorghum dry biomass and grain yield of (kg ha^{-1}) under minimum tillage

Organic carbon varied from 4.9 to 7.2 gm kg-[1]. Significantly higher OC (7.2 gm kg^{-1}) was observed with the application of sorghum residue @ 6 t ha^{-1} followed by @ 4t ha^{-1} (6.3 gm kg^{-1}) and 2 t ha^{-1} (5.5 gm kg^{-1}) compared to control (4.9 gm kg^{-1}). The increase in Organic carbon due to application of sorghum residue @ 6, 4 and 2t ha^{-1} was to the extent of 46%, 28% and 12%, respectively over no residue application (Fig. 3.29).

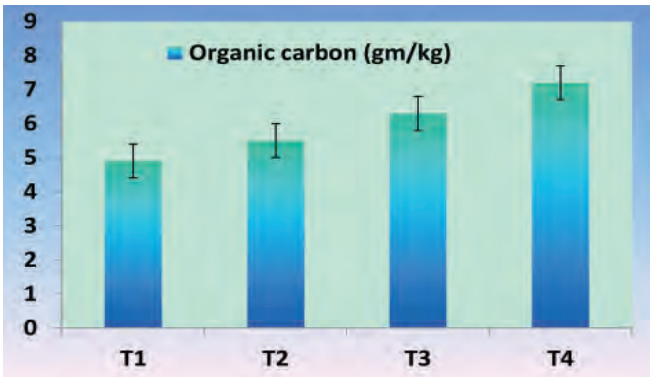


Fig. 3.29: Effect of graded levels of surface residue application on organic carbon (g kg^{-1}) under minimum tillage.

Ammonical N in these soils varied from 19.43 to 29.88 mg kg^{-1}across the treatments. Significantly higher ammonical N (29.88 mg kg^{-1}) was observed with the application of sorghum residue @ 6t ha^{-1} compared to control (19.43 mg kg^{-1}) at flowering stage of the sorghum crop. (Fig. 3.30). Nitrate nitrogen in the soil varied from 24.68 to 45.44 mg kg^{-1}across the treatments. Significantly higher (45.44 mg kg^{-1}) nitrate N was observed with the application of sorghum residue @ 6t ha^{-1} followed by @ 4t/ha (36.58 mg kg^{-1}) compared to control (24.68 mg kg^{-1}).

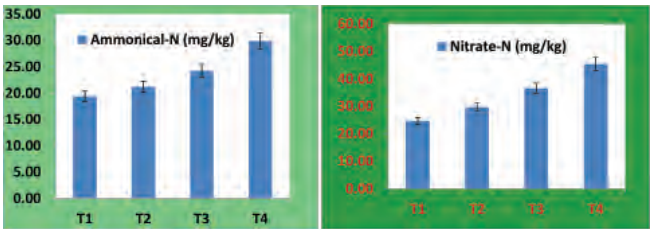


Fig. 3.30: Effect of graded levels of surface residue application on mineral nitrogen (mg kg^{-1}) under minimum tillage.

Microbial Biomass Carbon was significantly influenced by surface application of crop residue and it varied from 121.96 to 158.92 mg kg^{-1} soil. Significantly higher MBC (158.96 mg kg^{-1}) was observed with the application of sorghum residue @ 6t ha^{-1} followed by 4t ha^{-1} and 2t ha^{-1} which was higher to the extent of 30.3%, 19.6% and 8.5%, respectively over control (121.96 mg kg^{-1}) (Fig. 3.31).

Soil Labile Carbon varied from 252.85 to 295.29 mg kg^{-1} across the treatments. Significantly higher labile carbon (295.29 mg kg^{-1}) was recorded with the application of sorghum residue @ 6t ha^{-1} as compared to control (252.85 mg kg^{-1}). The increase in labile carbon due to application of sorghum residue @ 6, 4 and 2t ha^{-1}

was to the extent of 16.8%, 9.7% and 4.2%, respectively over no residue application. (Fig. 3.31).

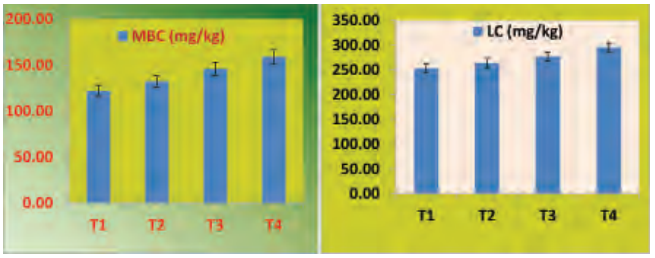


Fig. 3.31: Effect of graded levels of surface residue application on microbial activities (mg kg^{-1}) under minimum tillage

3.1.13. Biochar Amendments for Improving the Performance of Maize in Dry Lands as Climate Change Adaptation and Mitigation Strategy (NICRA/17)

Biochar management may provide a significant opportunity for sustainable improvements of soil health and hence increase the growth and yield of maize in rainfed systems. A long-term field experiment was established in 2011 at ICAR-CRIDA. The aim of this study was to evaluate the effect of different residual biochars on soil health and maize (DHM 117) yield in rainfed Alfisol. Four types of biochar were produced from maize, castor, cotton and pigeonpea stalk at 450-500 ^{0}C slow pyrolysis temperature by using CRIDA biochar kiln, was applied at two rates, *i.e.,* 2 and 4 t ha^{-1}, once at the beginning of the experiment (2011) to a rainfed Alfisol (Typic Haplustalf). Experiments for each biochar were conducted in RBD consisting of eight treatments with three replicates. The treatments were T_1 - Control, T_2 - RDF, T_3 -Biochar (2 t ha^{-1}), T_4 - Biochar (4 t ha^{-1}), T_5 - RDF + Biochar (2 t ha^{-1}), T_6 - RDF + Biochar (4 t ha^{-1}), T_7 - RDF + Biochar (2 t ha^{-1}) + FYM, T_8 - RDF + Biochar (4 t ha^{-1}) + FYM . Recommended dose of fertilizer (RDF) (120-60-60 kg N, P_2O_5, K_2O ha^{-1}) and FYM (5 t ha^{-1}) were applied yearly as per treatments.

Seven years of experimentation on effect of different types of biochar in alfisols under maize revealed that the application of biochar prepared from maize stalks was proved better than biochar prepared from castor, cotton and pigeonpea in influencing the maize yield. Seven years of experimentation on the residual influence of different biochars in rainfed Alfisols under maize revealed that the application of biochar prepared from maize stalks was proved better than biochar prepared from castor, cotton and pigeonpea stalks. Application of maize stalk biochar @ 4.0 t ha^{-1} with RDF + FYM to maize produced comparatively less yield in the first year (23% increase over RDF alone) but it gave higher yield in second year (135% increase over RDF alone), third year (126% increase over RDF alone), fifth year (155% increase over RDF alone), sixth year (163% increase over RDF alone) and seventh year (143% increase over RDF alone) after application. Biochar applications have strong potential to, over time, increase soil health, carbon storage in the soil and maize yield in rainfed Alfisols. Soil sample analysis from different biochar residual plots is under progress.

3.1.14. Potential of Organic Crop Production as A Climate Change Adaptation and Mitigation Strategy in Rainfed Agriculture (NICRA/03)

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* 2017 at GRF to evaluate the performance of sunflower, green gram and pigeonpea 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% of equivalent recommended N was applied through farmyard manure. The remaining 75% N and 100% P and K was applied through chemical fertilizers. The plots under inorganic management received recommended dose of chemical fertilizers (20:50 kg N & P_2O_5/ha for pigeonpea and green gram; 60:60:30 kg N, P_2O_5 & K_2O/ha for sunflower).

In general, the seed yield of all three crops was less across different treatments due to poor rainfall distribution during crop season with 2 dry spells of 18 days in July and 9 days in September. There was no rainfall from 24 October till harvest of pigeonpea. The seed yield of sunflower was 14 and 7% higher in the plots under integrated management (1374 kg/ha) than that under inorganic and organic management, respectively. However, plots under

organic management gave marginally higher seed yield of green gram (706 kg/ha) compared to integrated (673 kg/ha) and inorganic management (664 kg/ha). Similarly, pigeonpea seed yield was similar in the plots under organic and inorganic management (898-911 kg/ha) and the plots under organic management produced 9% higher seed yield as compared to inorganic management (836 kg/ha) (Fig. 3.32).

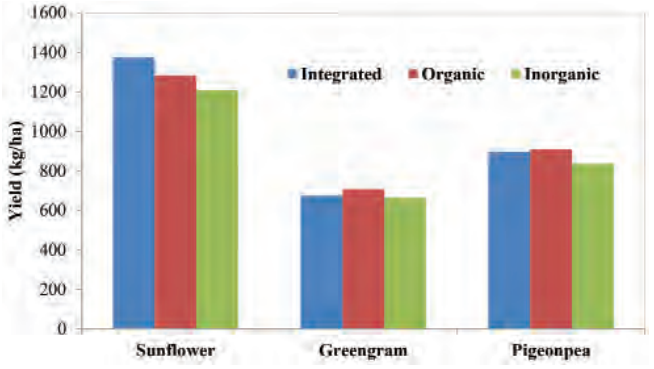


Fig. 3.32: Performance of crops under different production systems

Different production systems had no significant effect on soil pH, available N and Mn. However, plots under organic management recorded significantly higher soil organic C (0.67%), as compared to inorganic and integrated production systems. Plots under organic management being on par with integrated production systems also recorded significantly higher available K (263.1 kg/ha), Cu (2.54 ppm), Fe (7.92 ppm) and Zn (0.57 ppm) compared to inorganic production system. However, integrated production system recorded significantly higher available P (28.2 kg/ha) compared to other production systems. The bacteria, fungal and actinomycetes counts (6, 3.22 and 5.51 $\log_{10}$ CFU/g soil, respectively) were highest in plots under organic management compared to other treatments in green gram. Similarly in sunflower, bacterial and fungal counts (6.73 and 3.56 $\log_{10}$ CFU/g soil, respectively) were higher in plots under organic management compared to other treatments. In case of pigeonpea, bacterial counts (6.00 $\log_{10}$ CFU/g soil) were higher in plots under organic management than other treatments.

3.1.15. Mitigation of Climate Change through Conservation Agriculture in Rainfed Regions of India (NICRA/30)

An experiment was conducted at HRF, CRIDA with different *in-situ* conservation practices, tillage practices, and mulch treatments to identify the climate resilient resource conservation practices. GHG emissions were recorded in different treatments with closed vented static chamber. Another experiment was conducted to identify climate smart tillage implements for land preparation since land preparation contributes 23-44% of total CO_2 emissions from fossil fuel consumption and soil organic carbon oxidation.

The CO_2, N_2O and CH_4 fluxes were measured using a vented insulated non steady state closed chamber technique. The CO_2 fluxes in different treatments ranged from 0.87 to 15.58 kg C $ha^{-1}hr^{-1}$. The cumulative CO_2 fluxes in a season ranged from 67 to 86 kg C $ha^{-1}hr^{-1}$.

In conventional tillage there was increase in CO_2 emissions for a period of four to five days but later it decreased. Similar increase in CO_2 emissions were observed in reduced tillage after land preparation with cultivator. Conventional tillage recorded higher CO_2 emissions in August, September, November, December and January during crop growing season of pigeonpea but in high rainfall months like June, July, October the CO_2 emissions are high in zero tillage. It was observed that when there is a continuous rainfall of high intensity the CO_2 emissions were lower in conventional tillage as compared to zero tillage.

The CH_4 and N_2O fluxes were also influenced by the tillage and residue levels. Methane absorption was observed in conventional tillage but methane emission was observed in zero tillage. Methane absorption was observed in all the tillage treatments in May, August, September, November, December and January but methane fluxes were observed in June, July and October. This may be due to high intense rainfall during these months.

Higher N_2O fluxes were observed after fertilizer application. Cumulative seasonal N_2O fluxes were influenced by tillage and anchored residue heights. N_2O fluxes in conventional and reduced tillage were on par with each other but these two treatments recorded 20% higher fluxes as compared to zero tillage. Higher CO_2 and N_2O fluxes were observed in 10 cm anchored residue height but CH_4 absorption was observed at 30 cm harvest height. The GHG fluxes were correlated with soil moisture content and soil temperature.

Another experiment was initiated to evaluate different resource conservation technologies to improve the productivity and mitigation of climate change. Apart from crop yields GHG emissions were recorded with a vented insulated non steady state closed chamber technique.

Conservation furrow and paired row conservation furrow recorded 15 and 16 % higher yields respectively as compared to flat sowing without conservation furrow. Mulch treatment (growing of daincha crop between pigeonpea rows and application of daincha at 45 DAS as mulch in pigeonpea) recorded higher yields as compared to no mulch treatment. Among the nutrient management application of RDF, RDF+FYM recorded 20 and 12% higher pigeonpea yields as compared to control.

GHG emissions were influenced by different moisture conservation and fertilizer treatments. The tillage implements and depth of the tillage influenced the soil physical properties, GHG emissions and GWP. Rotavator, cultivator and Disc plough+harrow recorded higher GHG emissions and GWP, whereas animal drawn implements recorded lower emissions and energy. Even though the GHG emissions and GWP was low in animal drawn equipments but this was not recommended since animal power is decreasing due to their higher feeding expenditure and labour cost against their utilization.

These results suggest that the primary tillage implement with minimum soil disturbance could help to reduce CO_2 loss. Hence, in the present context of growing environmental concerns choice of suitable tillage implement is crucial, as it can decrease the negative effects of agriculture on the environment by reducing GHG emissions, energy input and CO_2 emissions, along with the reduction in cost of cultivation (Table 3.7).

Table 3.7: Global warming potential of different tillage implements

S. No.	Treatment	CO_2 emissions based CO_2 equivalents	Fuel consumptions based CO_2 equivalents	N_2O emissions based CO_2 equivalents	CH_4 emissions based CO_2 equivalents	Total CO_2 equivalents / GWP
1	Cultivator	559.90	22.51	5.17	-0.0270	587.56
2	C+H	484.10	44.61	6.90	-0.0701	535.53
3	DP	340.09	48.03	3.86	-0.1379	391.84
4	DP+H	518.07	69.44	7.22	-0.0204	594.72
5	MBP	387.08	52.12	3.69	0.0037	442.89
6	MBP+H	344.63	73.53	3.28	0.0687	421.51
7	Rotavator	591.94	34.17	5.08	-0.0211	631.17
8	BDP	256.12	0.00	1.99	-0.0676	258.04
9	BDP+H	254.90	0.00	3.67	-0.1066	258.46
10	NT	261.04	0.00	3.13	-0.0458	264.12

C- cultivator ; CH- cultivator + disc harrow; DP- Disc plough; DPH- Disc plough + disc harrow; MBP- Mould board plough; MBPH- Mould board plough + disc harrow; R- Rotavator, BDP- Bullock drawn plough; BDPH- Bullock drawn plough + disc harrow, NT- No Tillage.

3.1.16. Conservation Agriculture for Productivity Enhancement and Mitigating GHGs Emissions in Maize (*Zea mays L.*) - Horse gram (*Macrotyloma uniflorum L.*) Cropping Sequence in Alfisols of Semi-arid Tropics (NICRA/24)

Land degradation, low soil fertility, erratic rainfall is the prime constraints for low agricultural production in the semi-arid region. Conservation agriculture (CA) is a concept for optimizing crop yields, and economic and environmental benefits with key elements of no-tillage, adequate retention of crop residues on the soil surface for

mulching, innovative cropping systems and measure to reduce soil compaction through controlled traffic.

A field experiment on Maize-Horse gram cropping sequence was started since 2010 in sandy loam soil of Gunegal Research Farm at ICAR-Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad, Telangana with 2 tillage treatments *viz.*, conventional tillage (CT) (2 ploughings with disc+ harrowing+ complete removal of residues) conservation agriculture (CA) (No tillage, sowing the seeds by dibbling+ except economic product, retention of entire residues of both the crops; For maize, stover was cut at 30 cm height and spread in the field) as main plots and nutrient management *viz.*, Control, NPKSZnB (120:60:40:55:10:0.5 kg of N, P_2O_5, K_2O, S, Zn and B ha^{-1} respectively), N, P, K, S, Zn and B omission as sub plots in a split plot design. An amount of 169.1, 132.2, 138.3, 148.1 and 144.1 mm of rainfall was received in the month of June, July, August, September and October respectively, in the crop growing season of 2017 at GRF, Hyderabad. Maize crop was grown during June-October and horse gram was sown in the month of October after the harvest of maize with residual moisture and fertility. Significantly higher grain yield of maize was obtained in CT (4.51 Mg ha^{-1}) as compared to CA (2.84 Mg ha^{-1}) (Fig. 3.33a). There was a yield decline in CA after 8 years of experimentation. In initial years at par or higher yield of maize was obtained in CA as compared to CT.

Maize crop grown in CT and CA under different nutrient management practices

Higher yield was obtained through balanced fertilization with NPKSZnB (4.39 Mg ha^{-1}) which was at par with yield obtained through K, S and B omission. Yield reduction was observed in the control, N, P and Zn omission treatment. Significantly higher CO_2 emission (kg ha^{-1}) was observed in CA (5069) as compared to CT (4060) during maize growing season (Fig. 3.33b). Among nutrient management, higher CO_2 emission (kg ha^{-1}) was observed in NPKSZnB (7510) followed by N omission (3258) and control (2927). Significantly higher N_2O omission (g ha^{-1}) was observed in CT (243.7) compared to CA (188.9) (Fig. 3.33c). Higher N_2O emission (g ha^{-1}) was observed in NPKSZnB (365.7) followed by N omission (147.2) and control (136.1).

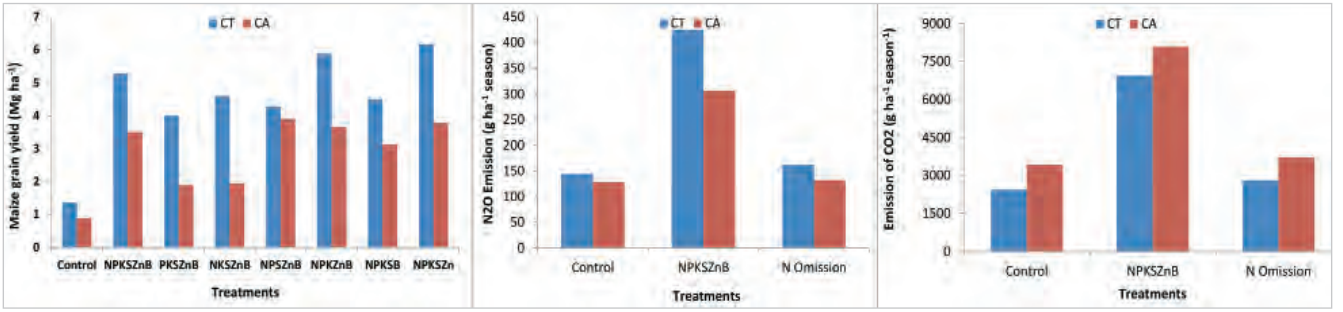


Fig. 3.33: Effect of CA and nutrient management practices on (a). grain yield, (b). CO_2 emission and (c). N_2O emission

3.1.17. Impact and Scope for Enhanced Adaptation Strategies for Climate Resilience in Horticultural Crops through Improved Management Practices (NICRA/22)

Best orchard management practices like usage of the best sources and methods of application of nutrients, water and other inputs while maintaining proper canopy architecture and improving soil health by ways and means of enhanced organic carbon content to sustain the useful micro flora in the soil. Reorientation of plant architecture and their root systems for optimum crop growth under less moisture available situations will augment production and productivity under less rainfall/ frequently drought prone environments in a fast changing climate scenarios. In this direction, additional trials were monitored in order to economize supplemental irrigation under different moisture deficit situations in citrus and mango. In spite of a good annual rainfall of 881 mm at GRF during 2017,

long dry spells of 3 months from January to March and 2 months from November to December were observed with no rainfall at all. There was flowering and fruit set with May (65.1mm) / June (230.5mm) rainfall; the fruits did not develop to normal size. Increased temperatures were also witnessed during the year.

The yields of guava and custard apple in terms of fruit numbers were above normal in 2017. During the months of July to October, rainfall never crossed 150 mm in any month hampering fruit growth and development i.e., size. Although September and October are supposed to be the wettest months in the region, the year witnessed below normal rainfall for these two months. However, number of fruits and yield per tree were significantly higher for all the treatments when compared to control. A rainfall of 171.5 mm during June, July and August yielded maximum yields (307.1 kg/plant) in Neeleshan hybrid variety and a rain fall of 551.7mm during the above months could yield only 36.22 kg/plant during a ten year study indicating varietal response to moisture stress and its impact on yield in mango.

3.1.17.1. Effect of regulated deficit irrigation and partial root zone drying on yield and quality.

The maximum fruit number and yield was noticed in RDI at100 % Ep followed by RD at 75% Ep during different stages of growth and development in mango. The maximum fruit wt, pulp wt, % pulp was observed with RDI at100% and the maximum TSS and less acidity were noticed with RDI at 50% Ep.

In Sweet orange (*citrus sinensis*) cv. Mosambi, maximum number of fruits set per shoot, number retained per shoot, fruit set (%), number of fruits per tree and yield was noticed in 100% irrigation followed by 75% partial root zone drying during both the seasons representing the importance of water on yield. Percent of pulp, percent of juice, fruit volume, fruit length, fruit equatorial diameter and number of seeds per fruit were also highest in 100% irrigation.

3.1.17.2. Field trials with integrated nutrients and bio-inputs

In Mango, maximum fruit number and yield was noticed in 1kg urea + 1kg MOP + 2kg SSP on par with *Azatobactor* + *Azospirillum* + *Trichoderma* + Phosphate solubiliziling bacteria. Maximum available N, P, K was noticed with 1kg urea + 1kg MOP + 2kg SSP. Combination of four bio-fertilizers made more availability of N, P, K in the soil over other treatments except control.

Fruit yield and quality of Sweet orange (*citrus sinensis*) cv. Mosambi was highly benefited by application of *Azatobactor* + *Azospirillum* + *Trichoderma* + Phosphate solubilizing bacteria + 75% RDF and it produced the maximum number of fruits set per shoot, number of fruits retained per shoot and fruit set (%), fruit number per tree, average fruit weight and yield per tree.

3.1.17.3. Effect of Paclobutrazol and other chemicals on flowering, fruiting and yield

A gibbrelin biosynthesis inhibitor, Paclobutrazol (PBZ) was applied in view of achieving floral induction in biennially bearing mango trees. In the study, more hermaphrodite flowers were noticed in PBZ @ 4 ml m^{-1} followed by PBZ @ 3 ml m^{-1}. Highest number of fruits, yield, max fruit wt, pulp wt, pulp to seed ratio was noticed with P_3S_3 (PBZ @ 4 ml m^{-1} + NAA@ 25ppm). Fruit quality TSS, reducing, non-reducing and total sugars were noticed highest with PBZ @ 4 ml m^{-1} + Borax – 0.6%. Thus, Paclobutrazol in combination with borax will improve the fruit quality. However, more microbial count was observed in control over treated soil samples after 30 days and 60 days of paclobutrazol application indicating negative impact of paclo on microbial count (Table 3.8).

In sweet oranges, application of 10 mg L^{-1} GA_3 recorded highest per cent of fruit set (75.77%), highest number of fruits retained per shoot (10.48), highest total sugars (7.90) and highest reducing sugars (4.62). Treatment with 20 mg L^{-1} GA_3) has pronounced effect on fruit length (6.80), fruit equatorial diameter (7.11), fruit volume (161.80), lowest pulp % (22.39), maximum peel % (27.62) and juice % (49.99).

3.1.17.4. Effect of weather parameters on flowering, fruiting and yield of Sweet orange.

Sweet orange yield was correlated and the results revealed that annual rainfall is significant positive correlation with sweet orange yield during the period under study. The mean minimum temperature recorded during October, November and December of three seasons is congenial to flower bud initiation and differentiation. Maximum temperature and sunshine

hours were negatively correlated with sweet orange fruit yields during this period, whereas, the minimum temperature and rainfall was positively correlated with sweet orange fruit yields during the same period.

Table 3.8: Soil microbial count as influenced by Paclobutrazol application in Mango

Treatments	Bacteria (10^{-5}) (cfu/g soil)				Fungi (10^{-2}) (cfu/g soil)				Actinnomycetes (10^{-4}) (cfu/g soil)			
	30 days after application		60 days after application		30 days after application		60 days after application		30 days after application		60 days after application	
	I year	II year	I year	II year	I year	II year	I year	II year	I year	II year	I year	II year
2ml/m^{-2} dia	32.6	28.4	43.2	39.7	71.3	68.1	69.4	57.5	42.3	37.4	36.4	34.2
3ml/m^{-2} dia	27.3	24.2	31.1	27.3	62.2	58.4	64.2	52.1	38.3	36.5	31.2	26.4
4ml/m^{-2} dia	21.6	19.4	23.4	21.6	54.4	42.3	42.4	56.3	32.2	28.6	28.4	24.5
Control	78.4	64.2	67.2	56.4	90.1	86.4	85.1	83.2	61.4	58.3	54.3	51.5

3.1.18. Evaluation of Elite Clones of Multipurpose Trees for Biomass Energy and Industrial Uses (NICRA/21)

India's energy consumption has been increasing at a relatively fast rate due to population growth and economic development. During the last six decades, India's energy use has increased 16 times and installed capacity by 84 times. The forest and woody crops are a source of renewable energy through the conversion of woody biomass into convenient solid/ liquid and gaseous fuels to provide energy for industrial/ commercial and domestic use. Energy and bio/energy is becoming increasingly interesting and important subject for planners and policy fmakers due to its safe, renewable and socio/economic impacts. A project was initiated during 2017 for characterizing and evaluating new and fast growing tree species clones with higher fuel characteristics under dryland situations. Thirty six elite clones of short rotation tree species viz, *Melia dhubia* (16), *Euclyptus* (14), *Dalbergis sissoo* (1), *Casuarina latifolia* (4) *and Bambusa balcoa* (1) were planted on July 14, 2017 at HRF, Hayathnagar. The growth parameters of the plants were taken during December, 2017, as the plants are only five months old the data on this aspect was not presented. The initial soil samples were taken both inside (between the rows of trees) and outside experimental area and presented in table 3.9.

Details of experiment

Plantation of clones

There was not much difference between soil physical and chemical parameters between inside plantation and open area because the experiment is at starting stage.

3.1.19. Adaptive Management of Small Ruminants under Grazing Conditions to Climate Change (NICRA/18)

To identify the physiological indicators of stress in grazing small ruminants and development of consolidated adaptation strategies under grazing conditions, a study was conducted and effects of dietary chromium propionate on physiological, blood biochemical and growth performance were assessed in grazing Nellore ram lambs supplemented with either control or a 200 ppm or a 300 ppm chromium concentrate mixture. Eighteen ram lambs (126.3± 5.6 d, age) were randomly divided into three comparable groups and studied for a period of 4 months (March to June months) during summer. Control group (T0) lambs were fed with concentrate mixture without chromium, whereas T1 and T2 group lambs were fed

Table 3.9: Initial (start of trial) soil physical and chemical properties

Location	pH	EC (dSm^{-1})	OC (%)	$CaCO_3$ (%)	N (Kg/ha)	P_2O_5 (Kg/ha)	K_2O (Kg/ha)
Within plantation	6.76	0.06	0.29	6.86	317	40.88	183.91
Open (outside plantation)	6.78	0.07	0.25	6.83	305	39.32	184.94

200 ppm and 300 ppm chromium, respectively. All the lambs were allowed for grazing for 6 hrs (early morning (0700 – 1100hrs) and late evening (1600-17hrs) in a day and supplemented with respective concentrate mixture @ 3 per cent of body weight at 1200 hrs noon.

Ten parts of Chromium propionate 0.4% dry mineral supplement was mixed with 90 parts of rice bran so as to get a premix which contains 0.04% chromium. Concentrate mixture was prepared using maize (30 kg), groundnut cake (37kg), wheat bran (30 kg), salt (2kg) and mineral mixture (kg). The premix having 0.04% chromium was added @ 45.4 and 68.0 g to 100kg concentrate mixture so as to get 200 and 300-ppb chromium, respectively.

Data from weather station located at HRF was used for development of thermal humidity index (THI) during March to June. THI was calculated by using the following equation; THI = Tdb – [0.55 – (0.55 x RH/100)] x (Tdb – 58). Live weight gain was recorded at fortnightly intervals. Physiological parameters (Rectal temperature (RT), body temperature, respiration rate (RR) and pulse rate (PR) of animals at fortnight intervals are noted in the morning (0600hrs) and evening (1800hrs) during study period. Respiration rate was determined by counting flank movements over 20 seconds.

The counts were then converted to breaths per minute (bpm). Rectal temperature was measured using a digital rectal thermometer. Body temperature was measured using an infrared digital thermometer. Pulse rate was recorded per minute from middle coccygeal artery located on ventral aspect of tail. Five ml blood was collected prior to supplementation (d 0) and on d 30, 60, 90 and 120d from the jugular vein from all the animals in lithium heparin coated vaccutainer for blood biochemical analysis. Blood samples were brought to the laboratory in ice immediately after collection. Serum was separated by centrifugation and upper plasma layer were separated and stored at –20 ^{0}C until completion of biochemical assays.

Results indicated that the mean maximum ambient temperature and THI ranged from 26.0-42.0 ^{0}C and 86.8 to 95.7, respectively during March to June months. THI was above 75 except two days in June and reached 90 during May (Fig. 3.34) indicating apparent heat stress on grazing lambs during April to June months. Weight gain and average daily gain were higher (Fig. 3.35) in lambs received chromium through concentrate mixture, however the differences were significant ($P<0.01$) during May and July months (Fig. 3.36). The body temperature and rectal temperature were almost normal and comparable among the lambs at 0600 hrs, however relatively higher values were observed at 1800 hrs in lambs irrespective of supplementation.

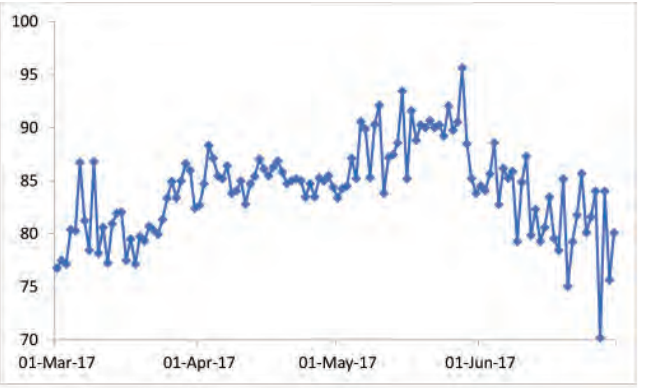


Fig. 3.34: THI during March to June, 2017 at HRF, Hayathnagar

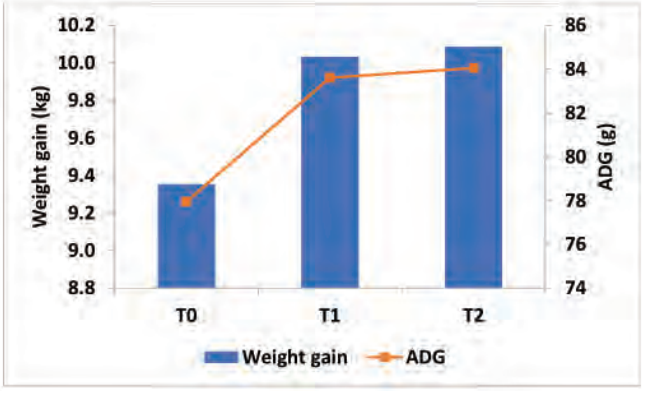


Fig. 3.35: Weight gain and average daily gain (ADG) in lambs with or without chromium supplementation

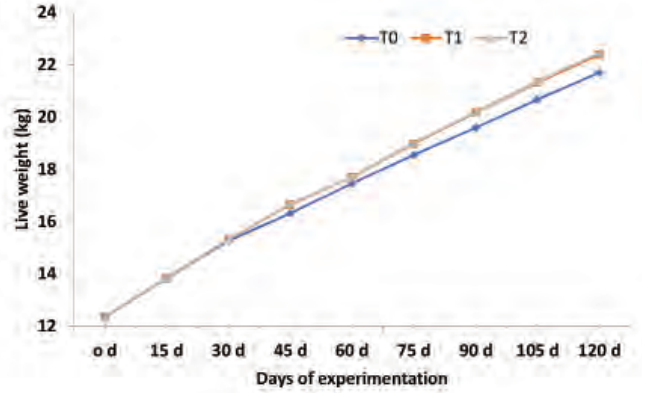


Fig. 3.36: Live weight gain dynamics of lambs with or without chromium supplementation

A similar trend was also observed in respiration and pulse rate of lambs. Increase in body and rectal temperature as well as respiration and pulse rate were

significantly (P<0.05) higher in May compared to other months and relatively lower in lambs received chromium supplemented concentrate mixture. Blood glucose and triglyceride concentrations were slightly lower, HDL cholesterol levels were higher in chromium supplemented lambs. Concentration of total and LDL cholesterol, total protein, albumin levels were comparable among the lambs. Slightly lower creatinine and blood urea nitrogen was observed in lambs supplemented with chromium. In conclusion, chromium supplementation could alter carbohydrate and lipid metabolisms and help in mitigation of heat stress in grazing lambs.

3.1.20. Knowledge Management for Climate Resilient Agriculture (NICRA/01)

Tackling impacts of climate variability requires specific focus and attention addressing the knowledge needs of various stakeholders. Access to various forms of knowledge improves the users understanding on climate variability, impacts, adaptations and mitigation strategies with a range of available options and opportunities for effective decision making. An assessment was done under the study to analyze the knowledge needs and priorities of various stakeholders, i.e., farmers, field level extension professionals and researchers to manage climate variability. Preferential analysis of knowledge needs assessment was done using Likert 5 point scale methodology. A web based data collection format for collection of knowledge resources is being prepared and pre testing is under progress.

3.1.20.1. Databases on Climate resilient agriculture

The existing databases of publications/websites / video films on providing information on climate resilience in agriculture and allied sectors developed during previous years of project are updated with new additions to the database(s) during the current year. Data on capacity building activities of NICRA KVKs (2017-18) are being compiled by deploying data collection formats. Social media like facebook (https://www.facebook.com/nicracrida/) is used as a platform in the project to share the promising technologies and events happened. Review of literature and content aggregation for an e learning module on drought management is completed. Preparation of draft module using freeware is under progress.

A study on adoption of climate resilient technologies in NICRA KVKs of Anantapuramu district of Andhra Pradesh and Nalgonda district of Telangana revealed that all the independent variables such as age, education, farming experience, farm size, availability of water resources, frequency of occurrence of drought, farming systems, socio economic status, social affiliation, training undergone, source of information utilization, credit availability, food security, weather based agro advisory services and community infrastructural facilities together explained the variation to the extent of 64.30 per cent. Farming systems and risk taking ability were significantly influencing the adoption ($p<0.01$). While Availability of water resources, frequency of occurrence of drought, social affiliation and training undergone had positive and significant ($p<0.05$) relation with the adoption. Mann-Whitney U test was employed to find out the difference between the overall level of adoption of CRA technologies among the NICRA and Non NICRA. Results revealed that there was significant ($p<0.01$) difference between the overall level of adoption of CRA technologies.

3.2. Technology Demonstration Component (TDC)-(NICRA/16)

Technology Demonstration Component (TDC) of NICRA aims at reducing the impact of climatic variability and enhances the adaptive capacity of farmers by way of demonstrating the resilient technologies. The programme is being implemented in 121 climatically vulnerable districts of the country spread across the country. Location-specific resilient technologies of natural resource management, crop production, livestock and fisheries are being demonstrated for imparting resilience against climatic vulnerabilities like drought, flood, cyclone, heat stress, cold stress, coastal salinity, etc.

During 2017, about 31 KVKs of the TDC have received a deficit rainfall of about 30% or more, 10 districts have received a deficit rainfall of 20-30% and 26 districts have received a deficit rainfall of less than 10-20% of the *Kharif* seasonal rainfall. The distribution of the rainfall was erratic as several parts of the country have received deficit rainfall during the months of August and September and crops experienced moisture stress at grain filling and maturity.

In NICRA village of Datia district in Bundelkhand region, about 530 mm rainfall was received against a normal rainfall of 786 mm. During August, 73% deficit rainfall and in the month of September 42% of the deficit rainfall was observed. As part of

NICRA, renovation of 11 water harvesting structures in the NICRA village has helped in recharging 28 wells and increased the water storage capacity to the extent of 100000 m^3, providing opportunity for critical irrigation to crops during the months of September in an area of 91 hectares benefiting 111 farmers in the village, thus minimizing the impact of dry spells and deficit rainfall and significantly enhancing the crop yields.

Increased water storage in renovated water harvesting structures in NICRA village of Datia district, M.P

Tumakur district in Karnataka is frequently impacted by drought. About 80 farm ponds were either renovated or constructed, four check dams were renovated resulting in enhancing the water storage capacity in the NICRA village (D. Naganahalli) significantly. The harvested water helped to recharge the ground water and rejuvenated defunct borewells in the village. During 2017, significant rainfall was received during September and October months resulting in storage of water in the reservoirs in the village which has contributed to increase in the area under second crop (*rabi*) by 36% of the total cultivated area of the village which is otherwise monocropped. During the *rabi*, farmers opted for cultivation of high income flower crops, thus increasing income with the harvested water.

Water harvesting structures (checkdam and dugwell) and growing of flower crops with the harvested water in Tumakuru, Karnataka

In Kapari village of Jhabua, renovation of defunct check dam and water harvesting structures through poly bag check dam has enhanced the water storage capacity which has provided critical irrigation to an area of 31 ha covering 43 farmers. Crops such as maize, and pigeonpea, were provided critical irrigation in the village during the year and water harvested was used for growing wheat and mustard in an area of 52 ha which has significantly increased the cropping intensity and returns to the farmers.

Renovated water harvesting structure with water, polybag check dam and soybean crop in Jhabua, M.P

In Sarkho village of Guna district, new water harvesting tank was constructed for harvesting of rain water which is being used for providing supplemental irrigation to crops during dry spell. Before the construction of the water harvesting tank only 2 irrigations were possible for wheat crop in an area of 4 hectares. Due to the availability of harvested rain water from tank, 3 irrigations were possible for 10 ha of wheat crop. Water from the tank was also used to give one supplemental irrigation each to chickpea (4 ha) and coriander (2 ha) crops, which has enhanced yields by 18.3% and 17.14%, respectively. The B:C ratio for chickpea was 2.8 as against 2.36 before intervention; and BC ratio for coriander was 3.21 as against 2.73 before intervention.

Water harvesting tank, chickpea and coriander crops grown in the fields at Guna, M.P

In Yacharam village of Khammam, where uneven distribution of rainfall, seasonal drought and prolonged dry spells are a common phenomena. Under NICRA, four farm ponds were constructed with a storage capacity of 6200 m^3 to provide irrigation to crops, which otherwise are grown as rainfed. This has helped in recharging the 2 nearby bore wells. Cotton, paddy and fodder grasses are grown in an area of 2.8, 2 and 2 ha, respectively with the available water from farm pond. The irrigation water was used to irrigate at critical stages in cotton (flowering and boll formation stage), paddy (panicle initiation stage) which has increased cotton yield by 19%, paddy yield by 7% and fodder crop yield by 12% more than the rainfed crops.

Farm pond and cotton and fodder crops grown with the supplemental irrigation in Khammam

In Chhachhamau village of Pratapgarh, land levelling was demonstrated with laser land leveller which has helped in water saving and increased yields of paddy. An area of 20.8 ha was levelled benefitting 52 farmers during the year. This has resulted in additional yield up to 3.86 q/ha and an additional net return of Rs. 4690/ ha with a B:C ratio of 2.6 as against 1.9 with conventional practice by farmers.

Laser land levelling of fields in Chhachhamau village of Pratapgarh, Uttar Pradesh

Direct seeding of rice technology in Dantewada, Chattisgarh

In Heeranar village of Dantewada, direct seeding of rice technology of short duration variety MTU 1010 was demonstrated in 4 ha involving 10 farmers. This resulted in average paddy grain yields of 3180 kg/ ha, with average gross returns of Rs. 40379/ha and an average net returns of Rs. 20818 /ha.

In Amwakhash village of Kushinagar, low yields of wheat due to terminal heat stress are a common problem. To overcome this problem, timely sowing of wheat variety HD-2967 with zero-till machine was demonstrated which reduced the cost of cultivation by Rs. 3452 and also increased the yield by 11.7q/ha. Zero-tillage machine has facilitated 10-15 days early sowing there by reducing the chances of exposure to terminal heat stress. So far, a total of 414 farmers have adopted this technology in an area of 305 hectares. The net return from this practice was 62926 Rs./ha with a B:C ratio of 3.99.

Zero till sowing of wheat and the wheat crop at Kushinagar, Uttar Pradesh

Water harvesting tank and well in tank cum well system, and vegetables grown from the harvested water at Port Blair

In Portmount village of Port Blair, 4 tank cum well systems were developed under TDC. The tanks are situated at higher slopes and wells are located in downhill within the recharge zone of tanks. The harvested seepage water from the tanks is stored in the wells which were used to grow vegetable crops. Composite fish culture with Rohu, catla, mirgal is also introduced in the tanks. These together resulted in gross returns of Rs. 5,35,300 as against the gross cost of cultivation of Rs. 1,58,500 resulting in a net profit of Rs. 3,76,800 and B:C of 3.38.

In Sarko village of Guna, moisture stress during long dry spells and intense storms are common. Broad bed and furrow (BBF) planting method in soybean has been demonstrated for *in-situ* moisture conservation and to provide drainage during heavy rainsin 8 hectares involving 20 farmers. This has resulted in net returns of Rs. 37450/ha as against Rs. 25200/ha from flatbed planting.

In village Belwa and Gunghara, Godda district demonstration of short duration paddy variety Heera (duration 75 days) and Sahbhagi (duration 120 days) in 21 ha area covering 94 farmers were taken up. The yield of Heera and Sahbhagi variety increased by 21% and 17% over the local. In Bhoimunda village of Jharsuguda, low yield in paddy due to moisture stress is a common problem. Drought tolerant rice variety Sahbhagidhan was demonstrated in an area of 8.5 ha involving 40 farmers of the village. This variety has yielded 34.7 per cent more grain than the farmers' practice . The net return from Sahbhagidhan variety was Rs. 21200/ha against Rs. 14600/ha as compared to the farmers' practice.

Demonstration of drought tolerant paddy varieties Sahbhagidhan and Naveendhan in Port Blair

In Portmount and Badmashpahad villages of Port blair drought tolerant paddy varieties Sahbhagidhan and Naveen dhan were demonstrated by TDC of NICRA in an area of 5 hectares each. The grain yields from Sahbhagidhan and Naveen dhan were 5428 and 3280 kg/ha, with B:C ratios of 2.02 and 1.55, respectively.

Demonstration of drought tolerant paddy variety Sahbhagidhan in Jharsuguda, Odisha

In Umchara village of Kaushambi, sodic soils with frequent droughts are common. Hence, salt tolerant paddy variety CSR-43 was demonstrated in an area of 4 hectares involving 10 farmers. This has resulted in 15% higher grain yield than local variety. The net return from CSR-43 was Rs. 35320 /ha with a BCR of 2.52 compared to local variety with net return of Rs. 28644/ ha and BCR of 2.32.

Salt tolerant paddy variety CSR-43 and farmers' practice at Kaushambi, Uttar Pradesh

In Nacharam village of Khammam, salinity tolerant paddy variety Siddi (WGL-44) was demonstrated in 20 hectares involving 50 farmers. Higher grain yield (64.31 kg/ha), net returns (48733 Rs./ha) and B:C ratio (1.91) were reported in Siddi than the traditional variety BPT-5204 (59.43 kg/ha, 36934 Rs./ha net returns and B:C ratio of 1.64

Salt tolerant paddy variety Siddi (WGL-44) plots at Khammam

Sirusuwada village of Srikakulam is frequently prone to floods. Hence, flood tolerant paddy varieties MTU-1061 and RGL-2537 were introduced by TDC of NICRA in an area of 26 hectares involving 36 farmers of the village which resulted in higher grain yield of 805 kg/ha over traditional varieties. The grain yield losses were reduced to the extent of 17 per cent. The BCR for MTU-1061 and RGL-2537 were 2.16 and 2.10 as compared to the local variety Swarna with 1.51.

Flood tolerant paddy varieties MTU-1061 and RGL-2537 in fields at Srikakulam, Andhra Pradesh

In Yagantipalle village of Kurnool, erratic rainfall, frequent drought conditions during crop growth stages and crop failures due to prolonged dry spells are common. To minimize the risk and bring stabilize farmers' income in the village, intercropping of foxtail millet and pigeonpea at 5:1 ratio was taken up which was quite successful and is spreading to other regions of the district.

Intercropping system of foxtail millet and pigeonpea at Khammam, Telangana

Gaddipally village of Nalgonda always reports low income due to erratic rainfall. Demonstration of Cotton (Bt) + pigeonpea (PRG-176) intercropping at row ratio of 6:1 has been demonstrated in an area of 5 hectares involving 10 farmers of the village to minimize the risk and to bring stability to farm income. An additional income of 12580 Rs./ha was realized by farmers compared to cotton sole crop. The B:C ratio of intercropping was 2.24 as against the sole cotton crop with 2.16.

Intercropping system of Cotton and pigeonpea at Nalgonda, Telangana

In Capari village of Jhabua, availability of green fodder is a main problem especially in lean periods. Promotion of azolla, fodder sorghum and berseem was taken up for augmentation of green fodder round the year. Azolla was demonstrated with 10 units, while fodder sorghum and berseem were demonstrated in 2 ha and 2.4 ha, involving 10, 10 and 25 farmers each, respectively. The average per day milk production has increased from 2.15 litres to 2.35 with azolla feeding and to 2.65 with the feeding of fodder sorghum and berseem thus enhancing the returns to the farmer.

Production of azolla, fodder sorghum and berseem at Jhabua, Madhya Pradesh

Composite fish farming with Catla: Rohu: Mrigal at 3:4:4 ratio were promoted to increase the farmers' income in Badmal village of Sonepur. A total 51 farmers were involved in growing fish in 3.2 hectares of area. The yield of fish has increased from 20 q/ha with local fish to 31 q/ha with composite fish farming. Net returns to the extent of Rs.18600/ha was realized by the fish farmers with a B:C ratio of 3.1.

Composite fish farming with Catla, Rohu and Mrugal at Sonepur, Odisha

To improve the farmers income in the rainfed conditions and to reduce the risk, integrated farming systems were demonstrated in all the locations. In sonara village of Datia, multiple enterprises such as field crops (soybean and mustard), vegetable crops (tomato and chilli), dairy, fishery, compost and biogas production units were taken up and integration of various enterprises were demonstrated for efficient use of resources. The new IFS model has increased the net income to Rs. 128382 from Rs. 61158 realized with the traditional practice (cultivating field crops and dairy together). The additional cost incurred was only Rs. 22591.

Vegetable crop (chilli), dairy, fishery, compost and biogas production units at Datia, MP

In the states of Punjab and Haryana, paddy straw burning is a problem and farmers generally burn their paddy crop residue in view of the short time available and for timely planting of wheat. As part of NICRA various available technologies like use of baler, slasher and spreader, using the straw as mulch for horticultural crops, livestock bedding material, etc were demonstrated to prevent paddy crop residue burning in the adopted villages and also for taking up of timely wheat planting. Zero till planting of wheat after the harvest of paddy in the standing residues of paddy was given enough stress. This has resulted in making a total of 26 villages including four NICRA villages in Punjab and two in Haryana residue burning free during the year 2017.

Zero till sowing with happy seeder in NICRA villages of Punjab and Haryana

The mitigation co-benefits of adaptation practices were assessed using EX-ANTE modeling framework during the year 2017-18. The extent of mitigation achieved due to implementation of resilient practices was assessed for the states of Bihar and Jharkhand. The resilient practices have contributed towards enhancing the carbon sink as well as reduction of green house gas emissions.

Trainings were organized on various aspects of climate change consisting of the global warming, human activities contributing to the global climate change, impacts on agricultural production systems, enhancing the adaptive capacity of the communities and skill up gradation. In addition, trainings were also imparted on various themes related to natural resource management, resilient cultivars and cropping systems, enhancing the productivity of livestock and fisheries including feed and fodder management, efficient nutrient management, resource conservation technology, farm implements and machinery in NICRA villages.

Technical program finalization workshop was organized at ICAR-CRIDA on 18 May 2017 to finalize the technical programme of the TDC of NICRA for the next three years (2017-2019). The meeting was chaired by Dr A K Singh, Deputy Director General (Agricultural Extension), ICAR and attended by the directors of all ATARIs. During the meeting, the technical programme of the TDC of NICRA for the next three years was discussed and finalized.

Zonal level review workshops were organized during April to June 2017 in all the zones of ATARI to discuss the progress of the programme during the year and also to finalize the programme for the next year (Table 3.10).

During the year, zonal monitoring committees (Table 3.11) were constituted to review the work done by KVKs and to make suggestions for making the programme more effective. As part of the ZMC four chairmen were identified for four regions of the country (North, East, West and South). About eight monitoring visits were being taken up since October 2017 and 19 KVKs were visited by the teams and suggestions were made.

Table 3.10: Annual workshops organized during 2017-18

Zone (No. of KVKs)	ATARI	Place of meeting	Date of meeting
I (13)	Ludhiana	ATARI Ludhiana, Punjab	August 18, 2017
II (7)	Jodhpur	ATARI Jodhpur, Rajasthan	July 5, 2017
III (13)	Kanpur	ATARI Kanpur, UP	July 1, 2017
IV (13)	Patna	KVK Coochbehar, WB	May 30-31, 2017
V (9)	Kolkata	KVK Coochbehar, WB	May 30-31, 2017
VI (9)	Guwahati	AAU Guwahati, Assam	July 10-11, 2017
VII (14)	Barapani	AAU Guwahati, Assam	July 10-11, 2017
VIII (13)	Pune	KVK Baramati, MH	July 3, 2017
IX (12)	Jabalpur	ATARI Jabalpur, MP	November 13-14, 2017
X (11)	Hyderabad	ATARI Hyderabad, Telangana	July 13, 2017
XI (7)	Bengaluru	ATARI Bengaluru, Karnataka	July 29, 2017

Table 3.11: Details of Zonal Monitoring Committee (ZMC) visits during 2017-18

S. No.	Name of the ATARI	Name of the KVK	Date visited
1	Kolkata	Kendrapara, Jharsuguda	October 31-November 01, 2017
2	Barapani	Ri-Bhoi and Imphal East	November 23-24, 2017
3	Hyderabad	Nalgonda and Khammam	December 12-13, 2017
4	Patna	Buxar, Jehanabad and Aurangabad	December 13-15, 2017
5	Jodhpur	Sirsa, Yamunangar	December 21-23, 2017
6	Bengaluru	Kalburgi (Gulbarga) and Gadag	February 26-28, 2018
7	Ludhiana	Ropar, Fatehgarh Sahib, Faridkot, Bathinda	February 1-2, 2018
8	Guwahati	Tirap and Dibrugarh	March 13-15, 2018

ZMC team interacting with communities at Kendrapara and Sirsa

4. Coordinated/ Network Projects

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

The All India Coordinated Research Project for Dryland Agriculture currently has a network of 19 main centres, 3 sub-centres, 8 Operational Research Project (ORP) centres and 8 voluntary centres (including ICAR-IGFRI, Jhansi, ICAR-IISWC Centre, Bellary and ICAR-CAZRI, Jodhpur) in diverse rainfed agro-ecologies and socio-economic settings of the country.

The project has a mandate to generate location specific simple rainfed technologies/practices through on station research in the thematic areas of rainwater management, cropping systems, nutrient management,

energy management, evaluation of drought tolerant varieties, alternate land use and farming systems. The resultant technologies are subsequently assessed on farmers' fields through ORP centres. Since 2011, the network centres are also undertaking demonstration of resilient practices in selected villages under National Innovations on Climate Resilient Agriculture (NICRA) project.

4.1.1. Salient findings

4.1.1.1. Rainwater management

- In semi-arid vertisols at Indore, among different land configuration treatments in soybean, 90 cm raised bed and furrow with 3 rows of soybean at 30 cm spacing with seed rate of 60 kg/ha (75% of recommended) recorded significantly higher seed yield of 1606 kg/ha compared to flatbed sowing at 45 cm row spacing + furrow opening after every 10 rows (1279 kg/ha).
- At Munger (new voluntary centre), in a study on *in-situ* moisture conservation practices in maize based cropping systems, maize-*rabi* crops sown on raised beds produced significantly higher maize equivalent yield (9982 kg/ha), net returns (Rs.119781/ha) and RWUE (11.44 kg/ha/mm) followed by ridge & furrow system (9464 kg/ha, Rs. 113569/ha and 10.85 kg/ha/mm, respectively).
- In semi-arid vertisols at Akola, the runoff causing rainfall in the catchment area of 4 ha of farm pond 2 was 301.3 mm with accumulation of 2014.8 m^3 runoff in the farm pond. The total runoff recorded was 50.54 mm, which was 16.8% of the runoff causing rainfall. Two protective irrigations of 50 mm each from harvested rainwater, through sprinklers, at pod initiation and pod filling stages recorded highest seed yield (1848 kg/ha), B:C ratio (1.87) and WUE (2.24 kg/ha/mm) compared to one protective irrigation of 50 mm at pod initiation stage (1399 kg/ha) and no irrigation (1247 kg/ha).
- In semi-arid vertisols at Parbhani, in an evaluation of minimizing evaporation was from the plastic tubs (0.8 m^2 surface area), application of cetyl alcohol @ 10-15 mg/m^2 every five days reduced the cumulative evaporation by 49 to 53% while neem and vegetable oil reduced evaporation to the extent of 24 to 28% compared to control. In semi-arid vertisols at Vijayapura, least evaporation was recorded with application of stearyl alcohol (41.97 cm) followed by silicon oil (46.3 cm) compared to control (81.07 cm).

4.1.1.2. Cropping systems

- Efficient inter-cropping systems with additive series at various centres enhanced system productivity viz. at Bengaluru, pigeonpea+cowpea (1:1) with 81% yield increase over base crop; at SK Nagar, castor+green gram (1:1) with 53%; at Rajkot centre, cotton+sesame (1:1) with 60%; at Akola, cotton+green gram (1:1) with 27% and at Faizabad, pigeonpea+ black gram (1:2) with 32% over base crop.

Castor + green gram inter-cropping system (1:1)

- In strip cropping systems, at Arjia, strip cropping of black gram (seed) in 2/3 area + maize (fodder) in 1/3 area gave 42% higher maize grain equivalent yield (4218 kg/ha) compared to sole maize (2979 kg/ha), with higher net returns (Rs. 57345/ha), B:C ratio (3.99) and RWUE (5.34 kg /ha/mm). At Ballowal Saunkhri, maize strip at a width of 4.8 m and cowpea strip with a width of 1.2 m higher maize equivalent yield (2252 kg/ha), LER (1.13), net returns (Rs. 8083/ha), and RWUE (6.01 kg/ha-mm) over sole maize (1928 kg/ha).
- At Darsi (new voluntary centre), in an evaluation of different cropping sequences, foxtail millet-cowpea sequence recorded the highest pigeonpea equivalent yield (5125 kg/ha) followed by pearl millet-cowpea sequence (4699 kg/ha) compared to other treatments.

Maize:cowpea strip cropping (4.8 m : 1.2 m)

4.1.1.3. Nutrient management

- In arid alfisols at Anantapuramu, in the PMT study in groundnut, application of 50% RDF along with FYM @ 4 t/ha recorded higher pod yield (844 kg/ha), closely followed by RDF (20-40-40 N, P_2O_5, K_2O kg/ha) (822 kg/ha). Application of 50% RDF (10:20:20 kg NP_2O_5, K_2O) along with FYM @ 4 t/ha recorded higher soil organic carbon stocks (13.45 t/ha) and microbial biomass carbon (1035µg/g) at surface soil depth. Higher soil available phosphorous (105 kg/ha) was observed in plots under 100% RDF + ZnSO4 @ 50 kg/ha. Higher net returns (Rs.17418/ha), B:C ratio of 2.21 and RWUE of 3.36 kg/ha/mm were recorded with application of 50% RDF + groundnut shells @ 4 t/ha compared to other treatments.
- In sub-humid inceptisols at Jagdalpur, application of 100% NPK (30:60:30 kg/ha)+lime @ 3 q/ha+ $MgSO_4$ @ 15 kg/ha+FYM 5 t/ha recorded higher groundnut pod yield (2053 kg/ha), net returns (Rs. 37694/ha) and RWUE (1.53 kg/ha-mm) compared to 100% NPK alone (1730 kg/ha). Further, agronomic efficiency of NPK (53.3, 26.6 and 53.3 kg grain/kg fertilizer nutrient applied) was found higher with application of 50% RDF+$ZnSO_4$@ 25 kg +FYM @ 5 t/ha in furrows compared to other treatments.
- In semi-arid vertisols at Arjia, foliar spray of soluble NPK (18:18:18) @ 2% at flower initiation and pod filling stages of blackgram produced higher seed yield (1407 kg/ha) compared to water spray (1089 kg/ha), with higher net returns (Rs. 74277/ha) and RWUE (1.60 kg/ha/mm).
- In sub-humid inceptisols at Faizabad, significantly higher grain yield of rice (2582 kg/ha) and straw yield (3235 kg/ha) were recorded with application of 100% RDF (60:40:30 kg NPK/ha)+2 foliar sprays of 0.5% kg $ZnSO_4$+0.5% $FeSO_4$+0.25% borax+1.0% sulphur compared to 100% RDF alone (1902 kg/ha).

4.1.1.4. Energy management

- In sub-humid inceptisols at Ballowal Saunkhri, 50% conventional tillage (CT) + interculture + chemical weed control recorded significantly highest maize grain grain yield (3896 kg/ha), net returns (Rs. 34512/ha), B:C ratio (2.08) and RWUE (7.81 kg/ha/mm) than other treatments. Application of 50% N through urea + 50% N through compost gave significantly highest yield (3779 kg/ha), net returns (Rs. 31170/ha) and RWUE (7.81 kg/ha-mm) compared to application of 100% N through compost. The energy use efficiency was highest (12.2) under 50% CT + interculture + chemical weed control.
- In semi-arid entisols at SK Nagar, the highest seed and stalk yield (424 and 656 kg/ha) of cluster bean, net returns (Rs.10108/ha) B:C ratio (1.73) and RWUE (0.58 kg/ha-mm) were recorded when sown with roto till drill compared to other treatments except strip till drill (370 kg/ha).
- In arid alfisols at Ananthapuramu, in a study on development and evaluation of cluster bean planter, higher seed yield (473 kg/ha), B:C ratio (1.05), RWUE (1.46 kg/ha-mm), higher field efficiency (2.5 hr/ha), higher output energy (11547.6 MJ/ha) and energy use efficiency (9.52) was recorded.

4.1.1.5. Evaluation of improved varieties

- The varieties/germplasm that performed better compared to local checks/popular varieties were: blackgram cv. KPU 129-104 (1439 kg/ha) at Arjia; chickpea cultivars BAUG-26 (1827 kg/ha) at Chianki, H 13-02 (2639 kg/ha) at Hisar and C-561 (2523 kg/ha) at Vijayapura; groundnut cv. MLTG-SB-15-7 (1037 kg/ha) at Anantapuramu; horse gram cv. VLG-42 (632 kg/ha) at Arjia; pigeonpea cv. BAC-1 (1885 kg/ha) at Biswanath Chariali; rice cv. HUR-3022 (2886 kg/ha) at Varanasi; taramira cv. TMLC-2 (911 kg/ha) at Ballowal Saunkhri.

Chickpea cv. BAUG-26

4.1.1.6. Alternate land use systems

- In sub-humid inceptisols at Ballowal Saunkhri, guava and amla yielded 27811 kg and 17214 kg/ha fruit, respectively in case of sole crops. However, in association with intercrops guava gave 32350 kg/ha fruit yield and amla gave 23556 kg/ha fruit yield. The yield of blackgram was 248 and 414 kg/ha, respectively in association with guava and amla plantation. The net returns from amla (Rs. 185869/ha) as well as guava (Rs. 560786/ha) based agri-horti systems were higher than sole cultivation of crops and fruit plants.
- In sub-humid inceptisols at Chianki, significantly highest aonla yield (1286 kg/ha) was recorded in aonla + blackgram system followed by aonla + sesame system (1143 kg/ha) compared to other treatments. Similarly, significantly highest aonla equivalent yield (1548 kg/ha) and B:C ratio (4.12) was recorded with aonla + blackgram system compared to other treatments.

Aonla with blackgram

- In semi-arid vertisols Parbhani, drumstick + green manuring (1:6) system recorded significantly higher system yield (13926 kg/ha), net returns (Rs. 108926/ha), B:C ratio (4.59) and RWUE (17.73 kg/ha-mm) and significantly lowest system production (8385 kg/ha) was recorded with drumstick + soybean (1:6) system.

4.1.2. Operational Research Project

These centres assess different rainfed technologies in adopted villages and give feedback to the main centres for refinement of the technologies as required.

4.1.2.1. Participatory Technology Development

- In Yerraguntlapalli village, Kurnool district, Andhra Pradesh (Anantapuramu centre), deep tillage with chisel plough improved groundnut pod yield (573 kg/ha) and net returns (Rs.1380/ha) compared to farmers' practice (512 kg/ha). Similarly, deep tillage with chisel plough improved pigeonpea seed yield (584 kg/ha) and net returns (Rs. 13015/ha) compared to farmers' practice (521 kg/ha and Rs. 11050/ha).

Deep tillage with chisel plough

- In Behdarya-Kothi village, Hoshairpur district, Punjab (Ballowal Saunkhri centre), napier bajra hybrid planted on the field bunds to conserve soil moisture during the rainy season gave 12% higher maize grain yield (2710 kg/ha) with higher net returns (Rs.16994/ha), B:C ratio (1.60) and RWUE (5.46 kg/ha/mm) compared to no vegetative barrier (2420 kg/ha).
- In Chappar Jogiyan village, Bhiwani district, Haryana (Hisar centre), strip cropping of pearl millet + mungbean (8:4) recorded higher pearl millet equivalent yield (2764 kg/ha), net returns (Rs. 17261/ha), B:C ratio (1.88) and RWUE (21.24 kg/ha-mm) compared to farmers' practice of sole pearl millet (1824 kg/ha).

- In Hingani village, Satara district, Maharashtra (Solapur centre), *in-situ* moisture conservation with compartmental bunding gave higher mean grain yield of *rabi* sorghum (1280 kg/ha), stover yield (3750 kg/ha), net returns (Rs. 13080/ha) and B:C ratio(1.99) compared to farmers' practice of no compartment bunding (570 kg/ha).

4.1.2.2. Technology upscaling

- In Newariya Village, Chittorgarh district, Rajasthan (Arjia centre), demonstration of improved moisture conservation practices viz. peripheral bunding, deep ploughing, tillage and sowing across the slope, soil mulching and ridging at 30 DAS in maize gave higher grain yield (2190 kg/ha), returns (Rs. 29250/ha) and B:C ratio (3.17) as compared to farmer's practice (1757 kg/ha).
- In Baichenahalli and Iraksandra villages, Tumkur district, Karnataka (Bengaluru centre), demonstration of opening of moisture conservation furrow between paired rows of pigeonpea in fingermillet + pigeonpea intercropping system (8:2) recorded higher fingermillet grain equivalent yield (823 kg/ha) and B:C ratio (0.95) as compared to farmers' practice (409 kg/ha and 0.49, respectively).
- In Gonda village, Garhwa district, Jharkhand (Chianki centre), demonstration of pigeonpea + okra intercropping (1:1) with improved variety of pigeonpea (Bahar) and okra (SG-597) gave higher pigeonpea equivalent yield (2561 kg/ha), B:C ratio (2.59) and RWUE (2.35 kg/ha-mm) compared to local varieties of pigeonpea and okra (1965 kg/ha).
- In Piploda Dwarakdheesh village, Ujjain district, Madhya Pradesh (Indore centre), demonstration of application of RDF (30 kg N + 60 kg P_2O_5/ha) + 30 kg S/ha resulted in significantly higher seed yield of soybean (2061 kg/ha), net returns (Rs. 59408/ha), B:C ratio (3.8) and RWUE (1.5 kg/ha/mm) compared to farmers practices of 50 kg DAP/ha alone (1530 kg/ha) and 50 kg DAP + 30 kg S/ha (1746 kg/ha).

4.1.3. AICRPDA-NICRA

During the first phase of the Technology Demonstration component of National Initiative on Climate Resilient Agriculture (NICRA), the AICRPDA-NICRA was undertaken at 23 centres. The on farm program was extended to 22 more adjoining villages to the existing 32 villages in 24 districts across 15 states and 2017-18 programme is being implemented in 54 villages. The interventions to cope with delayed onset of monsoon and seasonal drought (early, mid and terminal were demonstrated in more than 1000 farmers' fields in these villages during 2017-18.

4.1.3.1. Real-time contingency planning

Delayed onset of monsoon

- At Chikkamaranahalli village (Bengaluru rural district, Karnataka), during 2017, onset of monsoon was delayed by 9 days. Among the drought tolerant varieties of fingermillet demonstrated, long duration variety (MR-6) recorded higher grain yield (2610 kg/ha), net returns (Rs. 58989/ha) and B:C ratio (3.34) compared to medium duration var. GPU-28 (2520 kg/ha) and short duration var. GPU-48 (2490 kg/ha). Similarly, transplanted fingermillet (MR-6) recorded higher grain yield (2625 kg/ha), net returns (Rs. 29866/ha) and B:C ratio (2.12) as compared to direct sown fingermillet.

Transplanted fingermillet

- At Patameghpar village (Jamnagar district, Gujarat), during 2017, onset of monsoon was delayed by 24 days. Short duration groundnut var. GJG-9 gave 16% higher pod yield (2250 kg/ha), net returns (Rs. 71200/ha), B:C ratio (3.99) and RWUE (4.53 kg/ha-mm) as compared to var. GG-20. Similarly, seed cotton yield was increased by 13.8% with Bt. cotton

variety G.Cot. 8 BGII compared to different Bt. cotton research varieties grown by the farmer, with higher net returns (Rs. 78550/ha), B:C ratio (3.40) and RWUE (3.54 kg/ha-mm).

Early season drought

- At Vannedoddi village (Ananthapuramu district, Andhra Pradesh), to cope with dry spell of 21 days, supplemental irrigation (10 mm depth) from harvested rainwater in farm pond increased the pod yield by 13.3% in groundnut (1672 kg/ha) and 13.8 & 12.9% in castor varieties Haritha (692 kg/ha) and PCH-111 (634 kg/ha), respectively compared to rainfed crops with no supplemental irrigation.

Castor cv. PCH-111 *Castor cv. Haritha*

- At Chikkamaranahalli village (Bengaluru rural district, Karnataka), to cope with a dry spell of 20 days, *in-situ* moisture conservation with opening of conservation furrow between paired rows of pigeonpea in fingermillet (MR-6) + pigeonpea (BRG-2) intercropping (8:2) recorded 20.9% higher fingermillet equivalent yield (2483 kg/ha), net returns (Rs.52678/ha) and B:C ratio (2.89) compared to farmers practice of growing finger millet + *Akkadi* cropping.

Fingermillet + pigeonpea (8:2) with conservation furrow

Mid season drought

- At Balawas village (Hisar district, Haryana), *rabi* crops experienced a dry spell of 32 days. Weeding/ interculture with wheel hand hoe resulted in higher seed yield in mustard (1710 kg/ha) and chickpea (740 kg/ha) when compared with Kasola, a traditional implement (1585 and 620 kg/ha, respectively). Similarly, higher net returns (Rs. 48600 and 14060/ ha), B:C ratio (3.45 and1.76) and RWUE (61.5 and 26.6 kg/ha/mm) were also improved with wheel hand hoe over Kasola in mustard and chickpea.
- At Kavalagi village (Vijayapura district, Karnataka), a dry spell of 56 days occurred coinciding with vegetative growth and flowering stage of pigeonpea, chickpea and sorghum. Foliar spray of KNO_3 @ 0.5% gave 25.4, 25.6 and 19.8% higher yields in pigeonpea, chickpea and sorghum, respectively over farmers' practice. The improved practice also recorded higher net returns (Rs. 40713, 28843 and 17424/ha), B:C ratio (3.5., 3.4 and 2.8) and RWUE (2.22, 5.43 and 5.90 kg/ha/mm) compared to farmers' practice.

Terminal drought

- At Hardoiya village (Faizabad district, Uttar Pradesh), there was no rainfall from 7th September till maturity of crops. Foliar spray of 2% urea in paddy, maize, sorghum and pigeonpea improved yields by 14.3 to 42.4% compared to no foliar spray. Among the crops pigeonpea (NDA-1) recorded the highest net returns (Rs. 99450/ha) and B:C ratio (6.22) followed by maize (Naveen) with net returns of Rs. 15096/ha and B:C ratio of 1.75.
- At Patameghpar village (Jamnagar district, Gujarat), to cope with terminal drought, two irrigations each of 30 mm in alternate rows wee applied at square formation and boll development stage of cotton. Supplemental irrigation increased seed cotton yield by 30.6% (2628 kg/ha) with higher net returns (Rs. 99150/ha), B:C ratio (3.07) and RWUE (3.88 kg/ha-mm) compared to without supplemental irrigation. Similarly, yield of groundnut was increased by 22.0% with supplementary irrigation at pod formation stage and gave higher net returns (Rs. 86174/ha), B:C ratio (4.47) and RWUE (3.64 kg/ha-mm).

4.1.3.2. Preparedness

- At Achalpur village (Hoshiarpur district, Punjab), sowing of maize on ridges produced 11.7% higher grain yield (3646 kg/ha), net returns (Rs. 28971/

ha), B:C ratio (1.88) and RWUE (9.4kg/ha-mm) followed by bed sowing (3482 kg/ha) compared to farmers' practice of flat sowing (3263 kg/ha).

- At Chikkamaranahalli village (Bengaluru rural district, Karnataka), among different pulse based intercropping systems, pigeonpea (BRG-1) + cowpea (1:1) recorded higher pigeonpea equivalent yield (1221 kg/ha), net returns (Rs. 11151/ha) and B:C ratio (1.29) compared to sole pigeonpea (523 kg/ha).

Pigeonpea + cowpea intercropping system (1:1)

- At Balawas village (Hisar district, Haryana), chickpea cv. HC-1 a short duration variety, performed well under moisture stress conditions and recorded 10.1% higher seed yield (815 kg/ha), net returns (Rs. 17360/ha), B:C ratio (1.94) and RWUE (29.3 kg/ha-mm) compared to cv. C-235 a long duration variety.
- At Vannedoddi villages (Ananthapuramu district, Andhra Pradesh), sowing of groundnut with bullock drawn Ananta planter recorded higher pod yield (1667 kg/ha), net returns (Rs. 48793/ha), B:C ratio (2.74) and RWUE (3.39 kg/ha-mm) when compared to bullock drawn local seed drill (1535 kg/ha).

Sowing of groundnut using bullock drawn Ananta planter

4.1.4. Monitoring and evaluation

4.1.4.1. Technical Workshop of AICRPDA-NICRA

A Two day Technical Workshop of AICRPDA-NICRA was held at ICAR-CRIDA during 26-27 May, 2017, with the objective to review the overall progress of the centres and to develop technical programme for next phase of NICRA (2017-20). Dr S Bhaskar, ADG (AAF&CC), NRM Division, ICAR, Dr K Sammi Reddy, Director (Acting), ICAR-CRIDA, Dr G Ravindra Chary, Project Coordinator (AICRPDA), Dr M Prabhakar, PI (NICRA), Dr P Vijaya Kumar, PC (AICRPAM), Dr M Maheswari, Head, DCS, Heads of KVK and other sections along with scientists from CRIDA and scientists from 23 AICRPDA Centres participated.

Dr Bhaskar appreciated the contributions of AICRPDA centres in location-specific real time contingency technologies to cope with weather aberrations, their validation and implementation in farmers' fields. Dr Bhaskar suggested that the main challenge in rainfed farming is management of midseason drought, and suggested to develop/refine technologies for a) efficient utilization of farm pond water, b) foliar sprays, and c) soil management to cope with midseason drought. Dr K Sammi Reddy, Director, ICAR-CRIDA emphasized the need for focused work under AICRPDA-NICRA programme and also suggested to bring out experiences from real-time contingency plan implementation during 2011-17 and also publish the results in reputed journals. Dr M Prabhakar PI (NICRA) suggested to bring out flyers/short video films of successful technologies. Dr G Ravindra Chary, Project Coordinator (AICRPDA), while welcoming the participants, briefed about the aim of the workshop and presented the overall progress of AICRPDA-NICRA.

Dr S Bhaskar, ADG (AAF&CC) addressing the participants

4.1.4.2. XVI Working Group Meeting of AICRPDA

The XVI Working Group Meeting of AICRPDA was organized at AICRPDA centre, Jagdalpur, IGKV, Chhattisgarh during 1st to 5th February 2018. During the inaugural session, Shri Kedar Kashyap ji, Hon'ble Education Minister, Govt. of Chhattisgarh was the chief guest, Dr S K Patil, Hon'ble Vice Chancellor, IGKV presided and other dignitaries present were Shri Anoop Shrivastava, IAS, Secretary, Agriculture, Govt. of Chhattisgarh, Dr J C Katyal, Hon'ble Chairman, and members of VII QRT (CRIDA-AICRPDA-AICRPAM), Dr S Bhaskar, ADG (AAF&CC), NRM Division, ICAR, Dr M B Chetti, ADG (HRD), Education Division, ICAR & Governing Body Member, IGKV, other GB members of IGKV, Dr K Sammi Reddy, Acting Director, CRIDA, Dr G Ravindra Chary, Project Coordinator, AICRPDA, Dr P Vijaya Kumar, Project Coordinator, AICRPAM, scientists from CRIDA, PC Unit, AICRPDA, 19 main, 3 sub, 8 ORP and 5 voluntary centres of AICRPDA centes, 4 centres of AICRPAM, IGKV, AICRPs at Jagdalpur and KVKs in Bastar region, public representatives from Bastar region and district officials and importantly, the farmers including women farmers from Bastar region.

Shri Kedar Kashyap ji, in his address appreciated the efforts of AICRPDA centre, Jagdalpur in developing rainfed technologies, which are integrated and implemented through convergence of various national/state agriculture/rural /tribal development programmes in Bastar region of Chhattisgarh state. Shri Kashyap ji emphasized the need to enhance the livelihoods of the tribal farmers. Dr S K Patil, emphasized that AICRPDA is a unique project in addressing holistically the productivity, profitability and sustainability of rainfed agriculture in small farm holdings. Dr J C Katyal suggested to develop rainfed technologies considering the socioeconomic aspects of the small and marginal farmers. Dr Bhaskar suggested to strengthen agro-ecology specific rainfed integrated farming systems research for risk resilience and sustainability of rainfed agriculture. Dr K Sammi Reddy suggested for strengthening existing collaboration with other AICRPS for addressing operationalization of the real-time contingency plan implementation at microlevel and also suggested centes for soil test based fertilizer recommendation. Earlier, Dr G. Ravindra Chary, Project Coordinator, AICRPDA, briefed about the achievements of the project and purpose of the meeting.

Shri Kedar Kashyap ji, Hon'ble Education Minister, Govt. of Chhattisgarh, addressing the participants

Felicitation of best dryland farmers

On the occasion, Shri Kashyap ji, Hon'ble minister and dignitaries felicitated 13 best dryalnd farmers from various states for their efforts in adoption and popularizing the improved rainfed technologies, released 19 publications brought out by PC unit, AICRPDA and AICRPDA centre. Shri Kedar Kashyap ji inaugurated an exhibition highlighting the doable technologies/practices from AICRPDA centre, Jagdalpur, other AICRPs in IGKV, and KVKs in Bastar region for the benefit of rainfed farmers from various states and other stakeholders involved in rainfed agriculture research and development.

The VII QRT and scientists visited on-farm interventions in Tahkapal village, Bastar district adopted by AICRPDA centre, Jagdalpur and interacted with the farmers.

Dr J C Katyal, Chairman, Dr S Bhaskar, ADG (AAF&CC), members of VII QRT and AICRPDA scientists visited Tahkapal village, Bastar district and interacted with farmers

4.1.4.3. VII QRT CRIDA-AICRPDA-AICRPAM Review Meetings

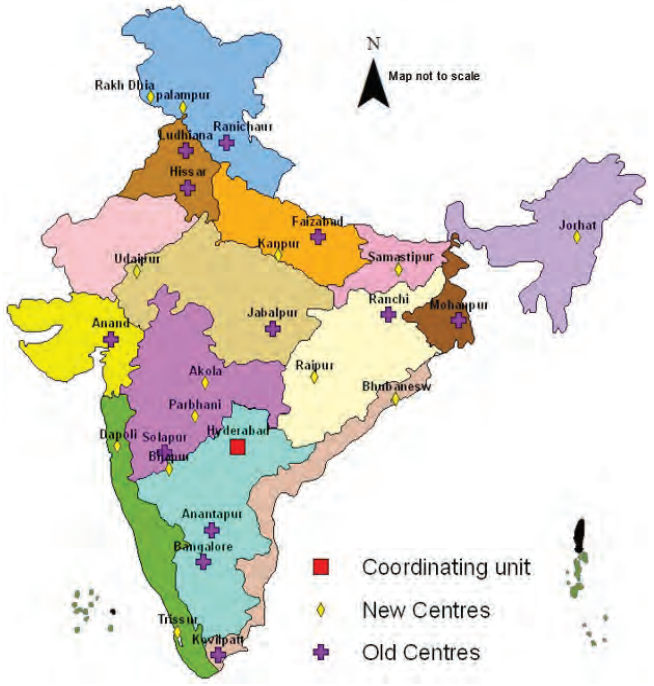
Four main centres, two sub centres and one ORP AICRPDA viz. Jagdalpur, Varanasi, Faizabad, Agra, Rewa, and Indore (main centre & ORP) were reviewed by VII QRT at AICRPDA Centre, Jagdalpur, Chhattisgarh on February 2nd, 2018.

VII QRT Review Meeting at Jagdalpur and at Junagadh

The VII QRT reviewed AICRPDA centres Rakh Dhiansar, SK Nagar, Rajkot, main and ORP centres at Ballowal Saunkhri, Arjia and Hisar at JAU, Junagadh on March 13th, 2018.

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

The salient research achievements of various AICRPAM centers during *kharif* 2017 and *rabi* 2017-18 seasons are summarized under the following five themes *viz.* Agroclimatic characterization, crop weather relationships, crop growth modeling, weather effects on pests and diseases and agromet advisory services.



4.2.1. Salient findings

4.2.1.1. Agro-climatic Characterization

- Higher variablity of seasonality index in monsoon rainfall indicates relative lack of reliability both in timing and quantum of rainfall in the state of Gujarat.
- There is no trend regarding amount of rainfall, number of rainy days and occurrence of extreme rain events in more than 90% taluks of Vidarbha region of Maharashtra.
- Analysis of 2000-2014 data indicates that there is more than 85% probability for drought in Chikkalallapur, Aland and Jewagi taluks in Kalaburagi district and Shivahatti taluk in Gadag district of Karnataka for drought in a year.
- Study of long term data (1985-2015) indicate that Faizabad located in the Eastern Plain Zone of Uttar Pradesh experiences on an average 5 days of heat wave and 3 days of cold wave per year. The extreme minimum temperature is also on a decreasing trend.
- In Haryana, regarding occurrence of extreme events, there is a decreasing trends for extreme minimum temperature and rainfall events indicating enhanced wetting and warming conditions over the entire state.
- Correction functions for temperature (using Leander & Buishand method and difference method) and rainfall (using modified difference method and difference method) was done for PRECIS simulated downscaled data (1961-1990) with the actual observatory data to remove bias for various met stations of Punjab.
- Four climatic types of West Bengal state viz. dry sub-humid, moist sub-humid, humid and per-humid dry sub-humid zone having MAI values ranging from 20 to 80. The dry sub-humid climate covers around 50% of the area especially the central part of West Bengal.
- Demarcation of rice and wheat productivity zones were delineated for Chhattisgarh state was undertaken. Areas where scope exists to either increase acreage or productivity were identified.
- Assured Rainfall at 25, 50 and 75 per cent probability levels were estimated for Bihar. At 50 per cent probability level, the longest water availability period of 22 weeks was observed in Kishanganj as against the shortest period of 13 weeks in Arwal district.
- In Kerala, a significant increasing trend was observed in the number of hot days for two districts viz. Thiruananthapuram and Wayand during SWM season and in all four districts during NEM season. In general *El Niño* is positively influencing the NEM rainfall over Kerala.
- Trends of different rainfall spells (1970-2014) in 32 districts of Rajasthan indicates that longest spell of >10 mm rainfall has significant decreasing trend at Jalore district only whereas the trend in other districts was not significant. A significant decreasing trend was observed in Karauli and Nagaur districts for rainfall >25 mm and in Jalore for rainfall >100 mm.

4.2.1.2. Crop Weather Relationship

During *Kharif*

Rice

- At Faizabad, July 5th sown crop (among growing environments) and cv Sarjoo-52 (among cultivars) recorded the highest radiation use efficiency (2.5 and 2.8 g MJ^{-1}, respectively) which was reflected in the grain yield (4.07 and 3.94 t ha^{-1}, respectively).
- Among different growing environments, rice transplanted on 6th July recorded the highest grain yield, HUE and 1000 grain weight which can be attributed to the highest accumulated rainfall it received during the season (617.2 mm), compared to other growing environments at Kanpur.
- Study on effect of different levels of shade imposed during different stages of rice at Ludhiana revealed that number of days taken from tillering to flag leaf emergence was shortened by eight days for PR-122 and by 6 days for PR-123 when shade was imposed during 15-45 days after transplanting. But the crop duration increased by 2-4 days and 4-6 days when crop was subjected to shade during 45-75 DAT and 75-105 DAT, respectively.
- Study of relationship between accumulated intercepted PAR and biomass of rice cultivars at Mohanpur revealed that for cv Nayanmani, the highest RUE value (3.213 gm MJ^{-1}) was observed when crop was transplanted on 16th July, which could be due to higher biomass with less accumulated intercepted PAR in the initial phase of crop growth.
- At Samastipur, the normal (15th June) sown crop recorded the highest yield due to favorable temperature prevailing during 50% flowering to maturity stage and lower percentage of unfilled grains per panicle. The percentage of unfilled grains/ panicle increased and yield decreased as the sowing was delayed beyond 15th June due to increased rainfall and drop in maximum and minimum temperatures during 50% ear head to maturity stage.
- Correlation studies between grain yield of paddy cultivar Jyothi and phenophase-wise weather parameters at Thrissur indicated that grain yield had significant negative correlation with Tmax throughout the crop growth and it was highest during flowering to physiological maturity.

Maize

- Study on relationship between periodic dry matter and accumulated photosynthetically active radiation (APAR) at Jammu revealed a linear relationship with high coefficient of determination (R^2=0.95). The conversion efficiency of absorbed PAR to the dry matter was estimated as 1.17 g MJ^{-1}.

Pearl millet

- The relationship between consumptive use of moisture (CUM) and grain yield studied at Solapur indicated a linear relationship and a consumptive use of moisture (CUM) of 362 mm was found to be optimum for achieving higher grain yield.

Finger millet

- Crop-weather relationship studies conducted at Ranichauri showed that early sown crop (6th June) accumulated highest GDD till maturity due to longer duration (131 days), compared to crop sown during 18th and 26th June.

Soybean

- Crop water use, water productivity and seed yield were highest in crop sown during 26 SMW, followed by crop sown during 27 SMW at Akola. Sowing of soybean beyond 5th July causes drastic reduction in yield as well as water productivity. Among the cultivars, JS-335 recorded highest water productivity, crop water use and yield.
- Study on correlation between phenophase-wise weather parameters and seed yield at Parbhani revealed that rainfall showed significant positive correlation with seed yield during emergence to seedling stage, seedling to branching stages and all the three stages from pod development to maturity, for all the four cultivars (MAUS-158, MAUS-71, MAUS-81 and JS-335). But, maximum temperature showed significant negative correlation with seed yield during seedling to branching stage and branching to flowering stage and during pod development to full seed stage.

- Relationship between seed yield and absorbed PAR of three cultivars (JS-20-29, JS-20-34 and JS-97-52) was studied at Jabalpur, which indicated that an APAR about 200 MJ m^{-2} was found to be optimum for achieving higher seed yield in soybean at Jabalpur.

Sunflower

- Crop weather relationship studies in sunflower undertaken during *kharif* 2012-16 at Solapur revealed that there was a linear relationship between CUM and grain yield and the correlation was also high (R^2 = 0.89). An average seasonal maximum temperature of 32.5 ^{0}C and minimum temperature of 22 ^{0}C were found to be optimum for achieving higher yield at Solapur.

Groundnut

- Simulation of average weekly soil moisture at three depths (0-15, 15-30 and 30-45 cm) using FAO-CROPWAT model at Anand showed that model could simulate the average weekly soil moisture satisfactorily in case of crop sown on 19 July. In case of 4th July sown crop, model has overestimated the soil moisture in majority of weeks.
- Crop-weather relationship studies conducted at Anantapuramu showed that water use efficiency was higher in crops provided with protective irrigation, compared to rainfed groundnut. Highest WUE was recorded for crop sown during first fortnight of August for K6, Kadiri Harithandra and Dharani, whereas for Anantha, crop sown during 2nd fortnight of July recorded highest WUE.

Cotton

- Light extinction coefficients were developed for three cotton cultivars/hybrids at Akola (0.13 for AKH-081, 0.18 for AKA-7 and 0.10 for Balwan), based on the relation between fraction of itercepted PAR and LAI.
- Correlation studies between seed cotton yield and phenophase-wise weather parameters at Parbhani showed that seed cotton yield was significantly and positively associated with maximum temperature during emergence to seeding, flowering to boll setting (P_5) and boll bursting to first picking (P_7) for all the three hybrids (Ajit 155, Rasi 2 and Mallika). Yield showed significant negative correlation with rainfall during square formation to flowering for all the three hybrids.

During *Rabi*

Wheat

- The highest grain yield was recorded for crop sown on 15th Nov (3.38 t ha^{-1}) and it gradually decreased with subsequent sowings at Raipur, which may be attributed to higher minimum temperature (+1.2 ^{0}C) experienced by the crop sown on 15 Dec during reproductive stage, compared to crop sown on 15th Nov.
- Crop sown on 15th Nov recorded highest grain yield of 2.9 t ha^{-1} and the yield decreased gradually as the sowing got delayed at Samastipur. The lowest grain yield of 1.82 t ha^{-1} was recorded in crop sown on 25 Dec, which may due to higher average maximum temperature experienced (4 and 3 ^{0}C higher temperature during vegetative and reproductive stages, respectively), compared to 15th Nov sown crop, 25th Dec sown crop experienced.
- Study on effect of mean temperature during reproductive phase of wheat on grain yield at Udaipur indicated that there was a gradual reduction in yield as the mean temperature increased during reproductive stage of crop. The magnitude of yield reduction from low temperature regime to high temperature was highest in HI 1544 (1762 kg ha^{-1}), followed by Raj-4037 (1673 kg ha^{-1}) and MP-1203 (1403 kg ha^{-1}).
- Correlation study between grain yield and phenophase-wise weather parameters in wheat at Anand revealed that maximum temperature during booting showed significant negative (P=0.05) relation with grain yield.
- Study on the effect of growing environments and wheat cultivars on crop phenology at Palampur showed that main difference was noticed in time taken during tillering to heading and heading to 50% grain filling stages of cv. HPW-349 took 120, 117 and 104 days to complete heading when sown on 25th Oct, 25th Nov and 25th Dec 2017, respectively.

Rabi Sorghum

- Study on relationship between consumptive use of moisture (CUM) and grain yield of *rabi* sorghum at Solapur indicated that a CUM of 240 mm was found to be optimum for getting higher grain yield.

Chickpea

- Study on relationship between consumptive use of moisture (CUM) and grain yield of chickpea at Solapur revealed that CUM of 250mm was found to be optimum for getting higher seed yield.

Potato

- Tuber weight, tuber and haulm yield and harvest index were higher at Hisar (135.8 g/tuber, 30132.7 kg/ha, 43305.1 kg/ha and 70.0%, respectively) in crop planted on second fortnight of November compared to other dates, which may be due to comparatively higher average maximum temperature during reproductive stages of crop sown during first and second fortnights of December.

Perennial crops

Guava

- Crop-weather relationship studies conducted in a 11-year old guava orchard at Hisar (cv. Hisar Safeda) indicated that trees fruiting in rainy season had highest thermal use efficiency (TUE), water and radiation use efficiencies, followed by those fruiting in spring and winter seasons.

Pepper

- Correlation studies between weather parameters during different phenophases and plant growth traits in pepper at Thrissur showed that rainfall had highly significant (P=0.01) positive correlation and Tmax has significant negative correlation with number of leaves produced for all the cultivars (Panniyur 1 to 8). Maximum temperature has significant negative correlation with internodal length of cv. Panniyur- 3, 4, 6 and 8.

4.2.1.3. Crop growth simulation modeling

During *Kharif*

Soybean

- At Akola, simulation of yield of soybean cv. JS335 by providing daily irrigation of 50 mm in DSSAT model fetched better yields in under dry spell conditions across all sowing environments. Late sown soybean crop (29 SMW) got benefitted by almost 15% than the crop sown earlier with similar irrigation application during dry spell.
- Genetic coefficients were developed for rice at Jorhat and Thrissur; and for soybean at Jabalpur.

Maize

- At Ludhiana, under future climate scenarios there will be a decline in maize grain yield by the end of 21 century in the range of -55.6 to -83.2 kg/ha under A1B scenario followed by -54.5 to -80.1 kg/ha under A2 and -42.6 to -59.2 kg/ha under B2 scenarios.

During *Rabi*

Wheat

- With a likely rise in temperature by 3.0 ^{0}C from normal at Ludhiana, wheat crop will be most susceptible in the central zone with a yield reduction by 10.2%. However, the Northern hills zone was least susceptible with increase in yield by 3.5 - 5.8% depending on the crop phase at which temperature rise occurred.
- A multilocational study on increase in temperature and its impact on wheat crop using DSSAT model revealed that in all the zones, barring Northern hills zone the temperature during first fortnight of February was most critical to wheat productivity. However, in Northern hills zone, second fortnight of March was most critical.
- At Ranchi, the simulated wheat yields showed a likely decline under both ECHAM 5 and MK 3.5 projected climate change scenarios. The reduction in yield may be attributed to shortening of crop duration.

4.2.1.4. Weather effects on pests and diseases

During *Kharif*

Cotton

- Correlation study between weather parameters and leaf hopper and white fly infestation in cotton at Hisar indicated that increase in maximum temperature had negative influence on leaf hooper and white fly infestation while minimum temperature had positive effect.

- Ludhiana centre has developed a decision support system (DSS) for predicting whitefly infestation in cotton for different locations of Punjab.

Rice

- Effect of delayed sowing on stem borer infestation in rice at Kanpur showed that timely planted rice crop is less susceptible to stem borer infestation than that of delayed planting due to lower diurnal temperature range and higher cumulative rainfall received during 28-41 SMW in timely planted crop than in delayed planting.
- The analysis of rice blast disease incidence and weather showed that lower maximum and minimum temperature coupled with high rainfall and cloudiness during the 25th July - 5th August favoured the blast disease incidence in rice at Palampur.

During *Rabi*

Wheat

- Weather based statistical models for the prediction of incidence of karnal bunt disease in wheat for Karnal, Hisar, Rewari and Sirsa districts of Haryana were developed using historical data.

Mustard

- Study on weather influence on aphid infestation in mustard at Mohanpur revealed that diurnal temperature range had stronger influence on aphid infestation than either maximum temperature or minimum temperature.

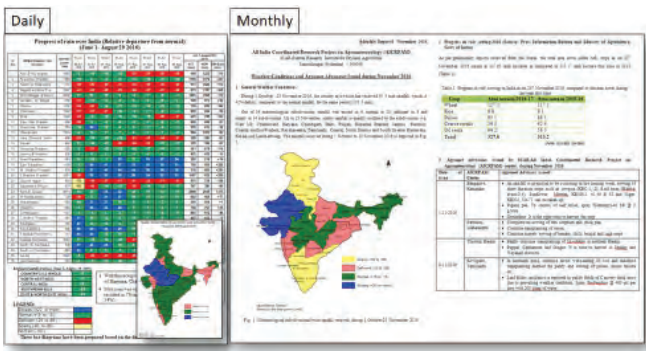
Chickpea

- Correlation study relating weather parameters and pod borer in different chickpea species indicated that gram pod borer infestation in *Kabuli* species of chickpea was less congenial to weather conditions compared to the infestation in desi chickpea species.

4.2.1.5. Agromet Advisory Services

Agriculture in India depends on the seasonal rainfall which should be timely otherwise hampers its production, which in turn has many-fold effects on the economy of the country. On the other hand extreme events like heavy unseasonal rainfall, floods, droughts, heat and cold waves, frost and hail storms are causing considerable damage to the field and horticultural crops. At this juncture, there is need to provide good weather forecast based crop and region specific agro advisories,which can help the planners and farmers to take timely action on the field and management front. A timely Agromet advisory can save inputs (seeds, fertilizers, plant protection chemicals etc) as well as the crop (especially at maturity stage). Agromet Advisory Service (AAS) is a part of extension Agrometeorology and it is defined as "All Agrometeorological and agro-climatological information that can be directly applied to improve and/or protect the livelihood of farmers". AICRPAM with the help of its cooperating centers across the country is involved in issuing AAS bulletins twice in a week, in vernacular languages. The dynamic web portal "Crop weather outlook" hosted by AICRPAM-CRIDA daily and every week updates the weather, crop information and Agromet advisories of the 25 states where the AICRPAM centers located in.

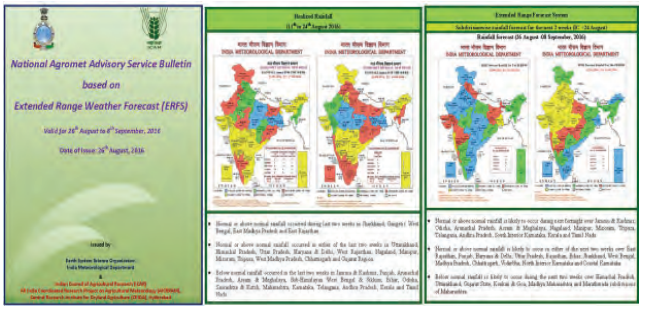
Apart from this, the coordinating unit at CRIDA plays a major role in issuing daily, weekly and "NITIAYOG" monthly bulletins on status of monsoon, progress in *kharif* sowing and AAS for deficit/excess rainfall areas of the country during southwest monsoon. All this information is dynamically uploaded in the crop weather outlook website hosted by AICRPAM from ICAR-CRIDA.



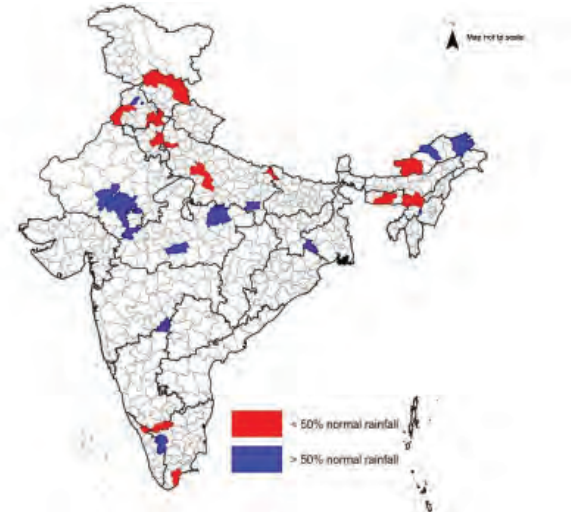
The information flow on Agromet advisories start from the forecast issued by South Asian Climate Outlook Forum (SASCOF) issues consensus outlook during April of every year on the ensuing southwest monsoon. Though the spatial resolution of the forecast is less, it gives a broad idea about the general performance of the monsoon and probable regions of the country where rainfall will be excess, normal and deficit.

Project coordinating unit of AICRPAM has overlaid the state and district boundaries on the SASCOF's forecast map to generate state and district specific information. This information on district wise and state-wise forecast of rainfall during 2017 southwest monsoon was shared with state government authorities during interface meeting on preparedness for monsoon 2017. At the AICRPAM unit level daily bulletins explaining the monsoon and rainfall progress at met sub division level were prepared, based on the data provided by India Meteorological Department (IMD) from June 1 to September 30, 2017.

Weekly weather and crop bulletins on status of monsoon, progress in *kharif* sowing and Agromet advisories for deficit/excess rainfall areas of the country were prepared with inputs from cooperating centers of AICRPAM. Further, weekly 'National Agromet Advisory Services' (NAAS) bulletins were prepared in collaboration with IMD. This bulletin provides realized weekly weather conditions over last week and Extended Range Weather Forecast (ERFS) for next two weeks. AICRPAM provides the Agromet advisories prepared for major crops for coming week by getting the information from AICRPAM centers across the country during *kharif* season and reported to officials of ICAR, Ministry of Agriculture and Farmers' Welfare and other stakeholders across the country.



Apart from this, AICRPAM had also provided weekly bulletins on 'Status of monsoon, progress in *kharif* sowing and Agromet advisories for excess/deficit rainfall districts'. Districts which received 50% excess and deficit rainfall were identified on weekly basis for prioritizing areas to implement crop contingency plans.



4.2.2. Trainings/Workshops/Meetings

4.2.2.1. AICRPAM-NICRA Annual Review meeting

The annual review meeting of AICRPAM-NICRA was conducted at Dr BSKKV, Dapoli during 22-23 May, 2017.

4.2.2.2. Meeting on Automation of Agromet Advisory Services

A meeting was held at ICAR-CRIDA, Hyderabad on 3rd August 2017 with IMD officials for automation of Agromet Advisory Services in the country and linking with crop weather calendars and contingency action plan.

4.2.2.3. AICRPAM Annual Working Group meeting

AICRPAM Annual Working Group meeting was held during Nov 27-29, 2017 at SKUAST, Jammu.

4.2.2.4. ICAR-Sponsored Training program for Technical Officers

AICRPAM has organized ICAR-sponsored training program on 'Agromet data collection, analysis and database management' for ICAR technical staff at CRIDA during Dec 11-23rd, 2017. Twelve participants from various ICAR institutes attended the training.

4.2.2.5. Output Oriented Capacity Enhancement Program for 'Development of Dynamic Crop Weather Calendar'

AICRPAM has organized 'Output Oriented Capacity Enhancement Program for 'Development of Dynamic Crop Weather Calendar' at JNKVV, Jabalpur during Feb 21-28, 2018.

Capacity building programme of AICRPAM at Jabalpur

5. Krishi Vigyan Kendra - Ranga Reddy District

Krishi Vigyan Kendra (KVK) of CRIDA was established in 1976 to cater to the needs of the farming community of Ranga Reddy district. The major objectives of KVK is transferring the technologies related to rainfed farming through On Farm Testing (OFTs), Front Line Demonstrations (FLDs), Trainings and Extension activities. Emphasis has to be given on need based and skill oriented training programmes for practicing farmers and farm women by the principles of 'Learning by doing' and 'Teaching by doing'. The farmers, farm women and rural youth in Ranga Reddy district are being benefited by the KVK activities and trainings since its inception. For the period 2017-18, following activities were accomplished.

5.1. On Farm Testing (OFT)

The KVK under Technology Assessment and Refinement has assessed 17 technologies (115 trials on Varietal, ICM, horticulture and livestock management) in the KVK adopted villages during *kharif* and *rabi*, 2017-18. The technology-wise results of OFTs are as follows.

5.1.1. Agronomy and Horticulture:

Technologies	No. of Trials	Yield (kg/ha)		Net returns (Rs.)/ha	B:C Ratio
		Farmers Practice	Improved Practice		
Assessment of Sorghum high yielding variety CSV -31	5	850	1350	5650	1.33
Assessment of Castor high yielding variety Pragathi (PCS 262) with timely management of Botrytis	5	680	945	16937	1.91
Adoption of soil test based fertigation technique for high productivity in cucurbits (Bottle gourd)	5	28300	39700	304500	4.29
Assessment of Improved chrysanthemum variety (Marigold) for high productivity	5	3700	6200	65800	2.6
Assessment of improved Tube rose variety, Hyderabad single	5	2250	4830	390500	5.22
Drumstick as intercrop in chrysanthemum for high net returns	5	4.6	8.3	161700	3.87
Evaluation of Multipurpose Plastic Mulch sheet laying machine (Tomato, Bottle gourd and Musk melon)	5	• Cost savings Rs. 4100/- compared to farmers practice per acre • Labour and time saving (two hours) per ac • Yield enhancement due to mulching and • Farmers net income increased to Rs.1,57,960/-			
Use of Alternate Wetting and Drying method for Paddy to save irrigation water	6	• Increase in yield : 10 – 30% • Decrease in the no. of irrigations : 1/3rd of total • Reduced water use : 33 – 60%			
Efficient use of water through micro sprinklers for vegetables	4	Irrigation water use efficiency enhanced by 70 -80%			
CRIDA Developed BBF with drip pipe manually laying (Bottle gourd)	5	• Yield enhancement to 20 t/ha • Net income increased to Rs. 95960/-			

5.1.2. Animal Science:

S. No.	Animal/ Species	Name of the technology	Thematic Area	No. of farmers/ trials	Farmers Practice	Demo	Results
1	Cattle	Efficacy of coated vitamins and chelated minerals on reproductive problems in dairy animals	Nutrition manage-ment	10	Natural grazing with dry paddy straw	Natural grazing + Complete balanced ration with supple-mentation of coated vitamins, chelated minerals (Gar-bhamin) Dosage: 1 bolus daily till desired effects or 14 days Janova – 3 capsule for 2 days	Animals shown estrous signs in time and attained good conception rate.

2	Cattle	Feeding of area specific mineral mixtures for improved productivity of dairy animals	Nutrition management	24	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 35% and 45%. Revenue through sale of milk increase 35%.
3	Buffaloes	Assessment of multi-cut fodder sorghum CSV-33-MF	Fodder management	10	Local fodder -Bojonnalu	Demonstrated 1 kg of fodder sorghum CSV- 33 MF per 0.25 acres	31.4% more yield of green fodder reported in lean period. More tillers, quick regeneration, moderately tolerant to drought conditions.
4	Sheep and goat	Integrated farming system model for sheep and goat farmers	Doubling farmers income-IFS module	5	Small ruminants grazing in barren lands with poor nutritive fodder resources	Phase – I provided the high protein leguminous hedge lucerne saplings @ 200 per farmer (1000 saplings) Phase –II Watershed areas Under NREGA (4000 saplings) provided	9.1% more yield of green fodder reported in lean period. More tillers, quick regeneration, moderately tolerant to drought conditions.

5.1.3. Home Science:

S. No.	Title of the OFT	Observations recorded
1	Drudgery reduction with Sapling transplanter	No. of farmers : 5 50% reduction in time and 40% reduction in expenditure on labour
2	Multi grain atta with horse gram	No. of farm families : 10 In comparison with rice diet, jowar roti and multi grain atta with horse gram was able to supply superior nutrients like, protein, calcium, phosphorous, minerals, fibres and vit A.
3	Cotton picking machine	No of farmers : 5 50% reduction in time and 50% reduction in labour expenditure

5.2. Front Line Demonstrations (FLDs)

FLDs (269 demonstrations) on 19 technologies were conducted in different disciplines covering field crops, vegetables, fruit crops, livestock, farm mechanization, soil water conservation and drudgery reduction during 2017-18. The technology-wise results of FLDs are as follows.

5.2.1. Agronomy and Horticulture:

Crop	Technology	Demos	Yield (kg/ha)		% Increase
			Farmers Practice	Improved Practice	
Kharif					
Red gram	Cluster FLD on Red gram Variety PRG 176	25 (10 ha)	630	888	40.95
Tomato	Use of vegetable special for higher flower and fruit set in vegetables	10 (4ha)	25500	28300	10.2
Rabi					
Bengal gram (Chickpea)	Cluster FLD on Bengalgram Variety Nandyala Senega – 1 (NBeG-3)	25 (10ha)	1350	1650	22.22
Guava	Control of fruit fly in guava through mass trapping with fruit fly traps	10 (4ha)	12100	14800	10.4
Red gram & Maize	Demonstration of CRIDA Six Row Planter for different crops	25 (10ha)	• Saving in seed by 20% • Saving in fertilizer by 15-20% • Increased productivity by 20-40% • Enhanced cropping intensity by 5-22% • Increase in gross income and return of the farmers by 20-40%		
All crops	Demonstration of Rotavator for field, seedbed preparation	6 (7ha)	• Primary and secondary application possible with the rotavator • Field capacity (ha/hr) : 0.43 • Field efficiency (%) : 79 • Fuel consumption (lit/hr) : 3.2 • Speed of operation (km/hr) : 3.6		
Tomato, Cotton & Mango	Demonstration of Mechanical weeders in different crops	5 (7 ha)	• Power weeder • Weeding coverage time 2-3 hr • Cost around Rs.1000 • Saving of cost Rs. 2000 per acre • Saving of time 6 hrs per acre		
Maize & Black gram	Demonstration of maize sheller without core broken and clean threshing.	5 (18ha)	• Labour and time saves (per ac saves 8 labor and time 7 hrs) • Easy to operate (tractor PTO operation) • Output of Sheller 3000-3500 kg per hour (30-35 q/hr) • Saves 8 to 10 labour per hr or per acre amounting to Rs. 2000/-		

5.2.2. Animal Science:

Crop/Animal /Species	Component (Intervention)	No. of farmers	Area (acre)	Yield		% Increase over control
				Farmers practice	Demo	
Buffaloes	Demonstration of teat cup (SAAF kit) and California mastitis kit (CMT) kit for early detection of mastitis	8	-	Lack of knowledge on mastitis, indiscriminate use dosage of various antibiotics, severe economics loss in terms of productivity	Screening of dairy cattle CMT kit and prophylactic usage of SAAF kit for prevention of recurrence of mastitis and created awareness on mastitis	Prevented the economic losses to farmers by creating awareness campaign and effectively adopted prophylactic measures
Sheep and goat	Demonstration of mineral licks for grazing sheep and goat	18	-	Small ruminants depend on poor nutrients agricultural byproducts and no supplementation of minerals	Provided concentrated balanced ration with supplementation of mineral in the form of salt licks	24.1% higher body weight was achieved
Calves	Management of parasitic infestation in calves mortality	21	-	No proper control of ecto and endo parasitic leads to severe calves mortality	Internal parasite control -Fentas plus -Orally@1ml/ 3 kg b.wt. provided Ecto parasite control- Butox – 2ml / 1litre used, Advised Hygienic sanitation measures	100% reduction of parasitic load after booster dose of 21 days period with broad spectrum anti-helminthics
Perennial fodder	Demonstration of perennial Hybrid Napier RBN-13 (Phule Jaywant) fodder	125	0.25 acres each farmer	Local varieties 300 t/ha	RBN-13 413 t/ha	More farmers adopted perennial fodder to their livestock, got 27.3% more green fodder yield
Fodder conservation	Demonstration of silage bags for fodder conservation	03	-	Severe shortage of fodder during lean period	Conservation of surplus fodder in new innovative method - silage bags	Farmers are more benefitted by conserving surplus green fodder in silage bags utilizing in lean season got 21% additional increase of milk yield
Multicut sorghum	Demonstration of multicult fodder sorghum Co-FS-29	25	0.25	Single cut sorghum low yield of 70t/ha	6-7 cuts of more tillers, quick regeneration, moderately tolerant to drought, green fodder yield of 180 t/ha	61.1% more green fodder yield reported

5.2.3. Home Science:

S. No.	Title of the FLD	Observations recorded
1	Maize shellers	• No. of farm women: 5 • 50% reduction in time and • 40% reduction in expenditure on labour
2	Improved sickles	• No. of farm women : 10 • 60% drudgery reduction • 20% savings in time • Safety increased
3	Cotton knitted hand gloves	• No. of farm women: 20 • Drudgery reduction, • Safety increased
4	Dryland weeders	• No. of farm women: 6 • 80% reduction in time and • 80% reduction in labour expenditure
5	Nutrition garden	• No. of farm families : 20 • Money saved and • Consumption of vegetables increased there by more consumption of nutrients
6	Harvesting bag	• No of farm families :10 • 40% reduction in drudgery while harvesting of vegetables

Assessment of Castor variety Pragathi (PCS 262)

Training on Soil health management and soil health card distribution

Assessment of Improved chrysanthemum varieties for high productivity

Control of fruit fly in guava through mass trapping with fruit fly traps

OFT- Area specific mineral mixtures

Technology week with veterinary theme

Mulching sheet laying machine demonstration in farmer fieldscrop

Six Row Planter demonstration in KVK adopted village

Drudgery reduction-dryland weeder machine in farmer fields crop

Director-CRIDA addressing farm women on women in Agriculture day 2017

5.3. Seed Hub Programme

Under the "Creation of seed hubs for increasing indigenous production of pulses in India" programme sanctioned by Department of Agriculture and Cooperation, Ministry of Agriculture and Farmers' Welfare, to KVK-Ranga Reddy, CRIDA, produced the foundation and breeders seed of red gram and horse gram to the tune of 110.9 q during 2016-17. An amount of Rs. 8,58,938.00 was obtained through sales to the Telangana State Seeds Development Corporation Limited (TSSDC), Hyderabad and farmers. During 2017-18, 19.5 q of red gram seed (Var: PRG176) and 5 q of horse gram (Var: CRHG-04) were produced in the Hayathnagar Research Farm (HRF) and certification was obtained from Telangana State Seed Certification Agency (TSSCA) and the seed is for sale for the year 2018-19.

5.4. Training Programmes

The Krishi Vigyan Kendra organized 115 need based and skill oriented training programmes on various aspects of improved technologies to 3005 clientele farmers, farm women, rural youth and field level extension workers.

Discipline	No. of Courses	Total No. of Participants		Total
		Male	Female	
Crop Production	4	85	15	100
Plant Protection	4	105	15	120
Home Science	27	-	1200	1200
Veterinary Science	18	155	30	185
Agricultural Engineering	24	535	185	720
Horticulture	38	610	70	680
Total	**115**	**1490**	**1515**	**3005**

5.5. Extension activities by KVK during 2017-18

Activity	No. of activities	No. of farmers
Field diagnostic visits	38	103
Animal Health camps	1	1588 (animals)
Field days	3	158
Radio talks / TV shows	8	-
Agro-advisory services through mobile contacts and SMS	3550	22500
Exhibitions	4	
Exposure visits	2	60
Lectures delivered as resource persons	29	1800
News paper coverage	15	--
World Soil Health day (05.12.2017)	1	188
Agricultural Women's Day (15th October, 2017)	1	385
Mothers Milk Week Celebrations (1-7th August 2017)	1	120
National Nutrition Week (2-6th September 2017)	2	450

5.6. TV/Radio talks/shows

Date	Topic	Source
April 1, 2017	Management practices in fruit crops and marketing	AIR, Nampally
April 13, 2017	Live programme on Good agricultural practices in Fruit crops and marketing strategies	DD Yadagiri, Ramanthapur
June 30, 2017	Post-harvest management in Mango	AIR, Nampalli
August, 2017	Agricultural Implements for small and marginal farmers	AIR, Nampally
August 23, 2017	Income generation through sheep	AIR, Nampally
September 27, 2017	Management practices in vegetables	AIR, Namaplly
October 8, 2017	Good Horticultural practices in Vegetable crops	AIR, Nampally
November 04, 2017	Silage makings in bags	AIR, Nampally

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

Scientist	Topic	Period	Venue
G. Sri Krishna	Annual Action plan meeting	May 16-17, 2017	IIOR, Rajendranagar
G. Sri Krishna	ZREAC meeting	July 26, 2017	PJTSAU, Rajendranagar
S.M. Vidya Sekhar	Zonal Workshop on Cluster FLDs on Pulses and Oilseeds	August 16-17, 2017	ATARI, Zone-X, Hyderabad
S. Vijayakumar	National Symposium on Pulses for Nutritional Security and Agricultural Sustainability	December 2-4, 2017	Hyderabad
G. Sri Krishna	International Workshop on Integrated management of Root lesion nematodes	December 11, 2017	NIPHM, Rajendranagar
S.M. Vidya Sekhar	Review meeting of Seed Hubs	January, 2018	ATARI, Zone-X, Hyderabad

G. Sri Krishna D. Sudheer	Innovative Agricultural Interventions for Doubling the Farmers Income in India	February 19-23, 2018	Dept. of Agril. Ext. and rural sociology, AC & RI, Madurai, Chennai
G. Sri Krishna	Workshop on developing training modules for Krishimitra	February 27, 2018	MANAGE, Hyderabad
G. Sri Krishna	DLCC meeting of DAATTC	March 12, 2018	Rajendranagar, Hyderabad
G. Sri Krishna	Krishi Unnathi Mela	March 15-20, 2018	IARI, New Delhi
S.M. Vidya Sekhar	National Conference of KVKs	March 17-18, 2018	IARI, New Delhi

5.8. Special Events organized by KVK, CRIDA

5.8.1. World soil Day

World Soil Day was organized on December 5th, 2017 in one of the KVK adopted villages, Nagireddipalli, Nawabpet Mandal. Hon'ble MLA Sh K Yadaiah, Chevella Assembly Constituency participated in the programme along with other local representatives, government officials, NGOs and 188 farmers and Farm women. Hon'ble MLA distributed soil health cards to 300 farmers from 4 villages. Pledge for Soil day was also taken. Exhibits on soil testing kit, biofertilzers, fodder was also arranged."

5.8.2. Group meeting for Mango growers association on 'Measures to improve flowering, fruiting and management practices for high productivity in mango'

KVK-CRIDA in collaboration with Sri Vigneswara Fruit & Vegetable growing farmers' Association, Dandumylaram, Ibrahipatnam mandal organized one day group meeting on 14th December, 2017 on mango to educate and import good management practices for flower initiation, fruit set, plant protection measures in mango for high productivity. Around 125 farmers actively participated in this programme and got field level awareness in mango cultivation.

Hon'ble MLA Shri K. Yadaiah distributing soil health cards on 'World Soil Health Day

5.8.3. One day workshop on sustainable intensification and diversification in horticulture and livestock entrepreneurs

One day workshop on Sustainable intensification and diversification in horticulture and livestock entrepreneurs was conducted at KVK-CRIDA, Ranga Reddy District on 4 January, 2018. About 48 Farmers were attended in the programme. Dr Y.G. Prasad, Director, ATARI, Zone X emphasized the importance of the Agriculture and allied activities like horticulture and livestock management in entrepreneurs mode to doubling the farm income by 2020 with cost reduction technologies and improved management practices. KVK Team lead by Dr V. Maruthi, Head KVK explained the technologies and approaches for doubling the farmers income.

5.8.4. Exposure cum knowledge sharing visit to Chittoor, Kurnool and Kadapa districts

Exposure cum awareness visit organized to the selected farmers (25 members) of Ranga Reddy district from 22-26 January, 2018 on cultivation practices in horticulture crops under different climatic and soil conditions and livestock management. Farmers got ample experience with the following technologies, Institutions and progressive farmers during the visit. Dr Dhanalaxmi and Dr Krishnamurthy from KVK explained about technologies demonstrated at KVK related to crops. KVK-Banganapalle, Kurnool visit has created awareness on integrated farming system model. Livestock Research station, Mahanandhi was helpful in creating awareness for fodder cafeteria. Farmers also visited Center of Excellency, Kuppam and got exposure about high-tech nurseries, poly tunnels/walking tunnels, shade net houses, automated fertigation schedules, etc.

5.8.5. Skill development training program on "Farm Pond Construction and Lining" organized for rural youth from different district of Telangana State

A skill development training program was organized by CRIDA-KVK in association with Dept. of Horticulture, Govt. of Telangana for rural youth and farmers on "Farm Pond Construction and Lining" during June 2 to 16, 2017 and 20 Feb to 27 March, 2018. 520 rural youths were trained from 24 districts from Telangana. The trainees were imparted with skills of location of farm pond based on the slope direction, marking for the farm pond, construction procedure with machinery, calculation of farm pond capacity for different catchment areas, inlet and outlet structures along with silt trap, etc. The trainees were also exposed to the field visit of farm pond technology at GRF and HRF.

Dr K Srinivas Reddy, Principal Scientist (SWCE) and Er S Vijaya Kumar, SMS (Agricultural Engineering) for the skill development program stressed the need for water resource development through farm ponds and efficient utilization for enhancing the water productivity at farm level for enhancing the farmer's income through crop diversification and multiple use of water in rainfed areas. Dr V Maruthi, Head, KVK spoke on the crop management practices under farm ponds for efficient utilization of water resources in rainfed areas.

6. Training and Capacity Building

6.1. Participation in Trainings

Name	Title	Duration	Venue
G Nirmala P K Pankaj	National training programme on Results based Monitoring and evaluation in Agriculture development	June 19-21, 2017	MANAGE, Hyderabad
G R Rao	Training programme on emotional intelligence at Workplace for Scientists/ Technologists	December 11-15, 2017	Centre for Organization Development (COD), Hyderabad
Anshida Beevi CN	Training Programme on Good Practices in Extension Research	December 11-16, 2017	ICAR-NAARM, Hyderabad
B Sanjeeva Reddy	Developing Training Modules for Krishi Mitras	February 26-28, 2018	MANAGE, Hyderabad

6.2. Deputation to other Organization

Dr G Rajeshwar Rao has taken over the charge of Director, Tropical Forest Research Institute, Jabalpur under ICFRE, MoFE & CC, GOI since Febrauary 22, 2018 on deputation.

6.3. Deputation outside India

Name	Title	Duration	Venue
DBV Ramana	Recent Advances in Animal Nutrition (RAAN) Conference	October 23-31, 2017	School of Environmental and Rural Science, University of New England, Armidale, New South Wales, Australia
S Desai	DAAD Alumni International Seminar on Steigerung der Ernährungssicherungdurch Precision Agriculture - food security increase by precision agriculture	November 6-13, 2017	Göttingen, Germany
S Desai	Agrotechnica 2017	November 14-19, 2017	Hannover, Germany

6.4. Undergraduate and Post graduate research and Training

Scientist	Student	Degree	Discipline	Institute/University
M Srinivasa Rao	D Manimanjari	Ph.D.	Zoology	Osmania University, Hyderabad
	T Divya Bharati	Ph.D.	Agril. Entomology	ANGRAU, Bapatla
	D Mounika	Ph.D.	Agril. Entomology	ANGRAU, Bapatla
	K Deekshitha	Ph.D.	Agril. Entomology	ANGRAU, Bapatla
	D V Sravan Kumar	Ph.D.	Agril. Entomology	ANGRAU, Bapatla
R V Adake	C Yellaswami	M. Tech.	Farm Machinery & Power	IGKV, Raipur
	Karengula Gopi	M. Tech.	Farm Machinery & Power	IGKV, Raipur
V Maruthi P K Pankaj	16 Students	PGDBM (Agri)	Rural experience in the KVK adopted villages (10 days)	MANAGE, Hyderabad
V Maruthi	Rachana Ambati	M. Sc.	Horticulture	SKLTSHU, Rajendranagar
B Sanjeeva Reddy	04 Students	B. Tech.	Agriculture Engineering	CAE, ANGRAU, Guntur
	Bakka Raj Kiran	Ph.D.	Farm Machinery & Power Engineering	ANGRAU, Guntur
	Chintha Sravan Kumar	Ph.D.	Farm Machinery & Power Engineering	UAS-R, Raichur

DBV Ramana	Santhoshini Chinta	M.V.Sc.	Veterinary & A.H. extension	PVNRTSUVAFS, Rajendhranagar
	J Razia Sultana	Ph.D.	Livestock Production & Management	PVNRTSUVAFS, Rajendranagar
	Prashanth Sarthy	M.Sc.	Biotechnology	Andhra Loyola College, Vijayawada
	Y Geetha	M.Sc.	Biotechnology	Andhra Loyola College, Vijayawada
	M Hema Priya	M.Sc.	Biotechnology	Andhra Loyola College, Vijayawada
K L Sharma	D Suma Chandrika	Ph.D.	Environmental Sciences	JNTU, Hyderabad
K Nagasree	T Archana	Ph.D.	Agril. Extension	PJTSAU, Hyderabad
M Vanaja	Y Anitha	Ph.D.	Genetics	OU, Hyderabad
	Sowmya	Ph.D.	Genetics	OU, Hyderabad
	Ira Khan	Ph.D.	Botany	OU, Hyderabad
	P Vagheera	Ph.D.	Environmental Science	OU, Hyderabad
	Satyavathi	Ph.D.	Environmental Science	OU, Hyderabad
S K Yadav	Yogesh Kumar Tiwari	Ph.D.	Biochemistry	JNTU, Hyderabad
R Rejani	Geethu Krishnan	M.Tech	Soil & Water Engineering	PJTSAU, Rajendranagar
Prabhat Kumar Pankaj	N. Venkata Raju	Ph.D.	Biotechnology	Vignan's University, Guntur, Andhra Pradesh
	Perikala Bhagyasri	M.Sc.	Biotechnology	Andhra Loyola college, Vijayawada
	Goriparthi Nikhilesh	M.Sc.	Biotechnology	Andhra Loyola college, Vijayawada
	A R Jagan Mohan Rao	M.Sc.	Biotechnology	Andhra Loyola college, Vijayawada
	Kola Mounika	M.Sc.	Biotechnology	Andhra Loyola college, Vijayawada
I Srinivas	G Kartik	M.Tech.	FMP	CAE, ANGRAU, Bapatla
	Rashmi Bengale	Ph.D.	FMP	IGAU, Raipur
	Ramya	M.Tech.	FMP	Vignan University, Guntur
B K Rao	M Abishek K Siva Ch Sudheer	B. Tech.	Agri. Eng. (4m in-plant training)	CAE, ANGRAU, Bapatla
	J Sri hari	M.Tech.	SWCE	PJTSAU, Hyderabad
	B Ramya	M.Tech.	SWCE	PJTSAU, Hyderabad

6.5. Higher studies

Scientist	Supervisor	Degree	Discipline	Institute/University
Sumanta Kundu	Ch Srinivasa Rao	Ph.D.	Agronomy	Institute of Agricultural Science, University of Calcutta
G Venkatesh	B Venkateswarlu	Ph.D.	Environmental Science	Jawaharlal Nehru Technological University, Hyderabad

6.6. Human Resource Development (HRD) Achievements

S. No.	Category	No. of trainings undergone
1	Scientist	9
2	Technical	2
3	Administrative and Finance	3
4	Skilled Support Staff	0

7. Women in Agriculture

KVK-CRIDA, R.R. District is actively involved in promoting the technologies, trainings and activities which can empower women. This year also KVK was involved in many such activities, like training programmes, exposure visits, FLDs for farm women for skill development and income enhancement.

7.1. Training Programmes for Farm Women

Total No. of Programmes conducted	**:**	**15**
Total No. of Women Trained	:	594
Duration of the training (days)	:	1-30
Venue	:	On campus /0ff campus

S. No.	Date	Title of the Programme	Village	No. of Participants	Beneficiaries
1.	June 2, 2017	Vermicompost, vegetable cultivation	Mekaguda	42	Farm Women
2.	June 17-18, 2017	Method demos on candle making & nutritious recipes	99 Rapid Action Force, Hyderabad	210	Families of soldiers, Family welfare centre, RAF 99
3.	June 24, 2017	Improved Charkha for wool	Rayaprolu	23	Farmers and farm women
4.	August 30, 2017	Nutrition awareness –method demo on use of Multi grain and Moringa leaves	Gummadivelli	30	Farm women
5.	October 25, 2017	Method demo-nutrition awareness-Moringa leaves	Gummadivelli	22	Farm women
6.	November 10, 2017	Method demo-fruit preservation, amla preservation, multi grain atta	Gummadivelli	24	Farm women

7.	November 13, 2017	Method demo-amla preservation, multi grain atta	Nerrapally	20	Farm women
8.	November 17, 2017	Method demo-fruit preservation, multi grain atta	Kolanguda	10	Farm women, pregnant and lactating mothers
9.	December 29, 2017	Demonstration on solar cooker	Gummadivelli	18	Farm women
10.	December 30, 2017	Income generating activity-vaseline making	Gummadivelli	15	Farm women
11.	Jan 22-27, 2018	Bakery-NIMSME	Gummadivelli	60	Farm women
12.	Jan 29-Feb 2, 2018	Bakery-NIMSME	Kolanguda	30	Farm women
13.	Feb 3-8, 2018	Bakery-NIMSME	Begumpeta	30	Farm women
14.	Feb 9-14, 2018	Bakery-NIMSME	Gunegal	30	Farm women
15.	Feb 15-19, 2018	Bakery-NIMSME	Ythanda	30	Farm women
		Total		**594**	

7.2. Vocational Training Programmes for Rural Youth

Total no of Vocational Training Programmes : 10

No. of Rural youth trained : 300

Duration of the training (days) : 1-90

Venue : On/Off campus

S. No.	Date	Title of the training programme	Villages	No of the trainees	Beneficiaries
1	March, April, 17	Basic Tailoring	Yellamma Thanda	26	Rural youth
2	April, May, 17	Basic Tailoring	kolanguda	30	Rural youth
3	April, May, 17	Basic Tailoring	Gummadi velli	31	Rural youth
4	April, May, 17	Basic Tailoring	Nakkagutta thanda	30	Rural youth
5	April, 17	Banjara Embroidery	Kolanguda	30	Rural youth
6	June, 17	Advanced training on Fashion Technology	Gummadivelli	30	Rural youth
7	August, Sept, 17	Basic tailoring	Gummadivelli	30	Rural youth
8	Jan 22-March 15, 2018	Maggam works ESDP-COWE	Gummadivelli	33	Farm women
9	Jan 29-April 29, 2018	Tailoring-Jayalakshmi Foundation	Begumpet	30	Farm women & school drop outs
10	Jan 30-April 30, 2018	Tailoring- COWE	Gunegal	30	Farm women & school drop outs
	Total			**300**	

7.3. Training programmes for Extension Functionaries

S. No.	Date	Title of the training programme	Village	No of the trainees	Trainees
1	June 13, 2017	Training on prevention of Anaemia	Ibrahimpatnam	160	Anganwadi teachers
2	March 20, 2018	Method demo on nutritious recipes	Aarutla	150	Anganwadi teachers and mothers
	Total			310	

7.4. Events for Farm Women

S. No.	Date	Title of the training programme	Village	No of the trainees	Trainees
1	August 9, 2017	Mother`s milk week celebrations	Ibrahimpatnam	120	Extension functionaries
2	September 6, 2017	National Nutrition Week	Nerrapally	250	Farm women, Extension functionaries
3	September 7, 2017	National Nutrition Week	Gummadivelli	200	Farm women, Extension functionaries
4	October 15, 2017	Women in Agriculture day	Gmguda, Gummadivelli, Yellammathanda, Tallapalli, Keshavapalli, Chandanavelli, Narrepally, Peddashapur, Ethebarpalle	250	Farm women

7.4.1. National Women Farmers' Day (Mahila Kisan Divas)

National Women Farmers' Day (Mahila Kisan Divas) was organized by Krishi Vigyan Kendra, CRIDA on 15.10.2017 at Hayathnagar Research Farm with the participation of women farmers from Ranga Reddy district. Dr V Maruthi, Head & Principal Scientist, KVK welcomed the Chief guests, Resource persons and briefed the importance of the day and women's role in agriculture. The resource persons Dr K Uma Maheswari, Head, PGRC, PJTSAU in her lecture informed the women farmers about the health, nutrition, diet, nutritive value of millets and discussed about the problems faced by women in farm activities. Dr Sarah Kamala, Professor, AICRP (H.Sc.) in her lecture discussed the issues related to drudgery reduction technologies for farm women, income generation through small scale household recipes, farm women's role and problems in agriculture. Dr K Sammi Reddy, Director (Acting), ICAR-CRIDA, Chief guest addressed the women farmers' about the KVK role in women empowerment, drudgery management of rural women, nutritional aspects. Dr Y G Prasad, Director, ATARI, guest of honour in his address sought the farmers to utilize the services of KVK by women farmers related to nutrition garden, drudgery equipment, trainings on farm and non-farm activities.

One of the progressive women farmers, Smt. Rama Devi from Ranga Reddy District addressed the women farmers on farming, sharing of responsibilities of both home and farm front, health, education of children and to utilize the drudgery reduction technologies developed by PJTSAU for ease of farming activities.

About 250 farm women from Gmguda, Yellammathanda, Tallapally, Eithwarpally, Narrepally, Gummadivelly, Chandanvalli, Thimmareddypally of Ranga Reddy District and Vikarabad district participated in the programme. Women groups from Gaddamallaiahguda, Tallapally, Yellammathanda displayed fabric works, candles, food recipes as a apart of income generation activities of farm women. Exhibitions were organized on farm machinery, livestock medicines, feed mixtures, bio-products, micro irrigation, fodder cafeteria, books and literature on agriculture.

8. Awards and Recognition

A **Copyright** was bagged for the web enabled software namely 'Unreaped yield potentials in major rainfed crops and scope for bridging yield gaps - A decision support system' (Citation: 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. 2018) (available at http://www.crida.in:8129/).

AICRPDA centre, Anantapuramu received **ICAR-Vasantrao Naik Award for Outstanding Research Application in Dry Land Farming Systems** for 2016 on the occasion of ICAR Foundation day and award ceremony on July 16, 2017 at NASC, New Delhi.

Dr P Vijaya Kumar has been elected as **Chairman** of Hyderabad Chapter of Association of Agrometeorologists. He has also been selected as one of the **editors** of Journal of Agriculture and Environment for International Development.

Dr G Rajeshwar Rao and **Dr DBV Ramana** has been selected for **Fellow of Indian Society of Agro-forestry (ISAF)**, Jhansi. Dr Rao was also nominated as member, IMC of ICAR-CAZRI, Jodhpur.

Dr Konda Sreenivas Reddy was conferred **Indian Water Resources Society Fellowship** for his professional contribution in the field of water resources on February 18, 2018.

Dr S Desai has been inducted as **member, Scientific Panel** on "Contaminants in Food Chain" of the Food Safety Standards Authority of India, Ministry of Health and Family Welfare, Government of India for a period of 2017-2019. He has also been inducted as **member, Local Project Advisory Committee** of the DST funded project "Agricultural Research and Development Infrastructure in Select Indian States (AP and Telangana)".

Dr K L Sharma was conferred **Bharat Jyoti Purskar 2017** The Best Citizen Publishing House the World's most leading biographical Specialists.

Dr G Nirmala was nominated for **member of IMC** of ATARI (Zone X), Hyderabad for two years from 2017 to 2019.

Dr M Vanaja was nominated as **member of Board of Studies** of Botany (UG), under the Faculty of Science, Osmania University, Hyderabad and Telangana University, Nizamabad.

Dr M Srinivasa Rao was honored with **Fellow of Plant Protection Association of India (FPPAI)** for his contribution in the field of crop protection. He further received Reviewer Excellence Award from Agriculture Research Communication Centre (ARCC), Karnal in order of contribution in reviewing the journals Legume Research and Indian Journal of Agricultural Research.

Dr N N Reddy was selected as **expert member** for evaluation of Ph.D. and M.Sc. theses of different universities (KLTSHU, Hyderabad; Dr YSRHU, West Godavari and PDKV, Akola).

Dr I Srinivas was conferred as a **member of State level expert committee** for Farm mechanization in Telangana and Andhra Pradesh states.

Dr B Sanjeev Reddy has been selected for **ISAE Best Paper Reviewer Award** for the year 2017 for excellent work as reviewer of articles in Farm Machinery and Power on the occasion of 52nd ISAE Convention, January 8-10th, 2018.

Dr DBV Ramana acted as **member of selection committee** for selection of faulty (Assistant/Associate/Professors)

and also for awarding promotion/benefits under CAS to teachers of SVVU, Tirupati, Andhra Pradesh, MPKV, Rahuri, Maharastra and PVNRTVU, Hyderabad, Telangana. He further acted as external examiner for MVSc and PhD students of SVVU, Tirupati.

Dr DBV Ramana and **Dr PK Pankaj** developed CO-4 **organic fodder production** plot at HRF and got conversion certification for the 5th successive year from APEDA. Further, the team received **organic conversion certificate for the sheep** from APEDA along with NRC on Meat.

Dr K Ravi Shankar received the **Young Scientist Award-2017** from Indian Society of Extension Education, New Delhi at the ISEE National Seminar on **"Doubling Farmers' Income and Farm Production through Skill Development and Technology Application"** organized by Department of Extension Education, Bihar Agricultural University, Sabour and Indian Society of Extension Education, New Delhi at Sabour, Bihar during November 28-30, 2017.

Dr B Krishna Rao received Indian Association of Soil and Water Conservationists (IASWC)-**Gold Medal** for the year 2017, for significant contributions in soil and water conservation and rainwater management.

Dr B Krishna Rao received **best poster presentation award** during conference on Farmers First for conserving soil and water resources (FFCSWR-2018) during February 1-3, 2018.

Dr K V Rao and **Dr R Rejani** was conferred **best paper award** for the paper "Spatial and temporal variation of C–factor and soil erosion in a semi-arid watershed: A case study in Mahabubnagar District" as Co-author in International Journal of Agricultural Science and Research 2017, 7(5): 175-188.

Dr Prabhat Kumar Pankaj was conferred **Editorial board membership** of the Asian Journal of Dairy and Food Research and SVU-International Journal of Veterinary Sciences (SVU- IJVS) from South Valley University, Egypt (eISSN: 2535-1877, pISSN: 2535-1826). He was also conferred **Editorial Excellence Award** for contribution in editorial activities of the Asian Journal of Dairy and Food Research, ARCC Journals, Karnal, India. Further, Dr Pankaj was conferred "Certificate of Recognition" for valuable contribution in service of scientific community as Reviewer and **Member of Scientific Advisory Board** of International Journal of Livestock Research **(**eISSN 2277-1964) in

year 2016-17.

Dr R Nagarjuna Kumar was awarded with the **Best PhD thesis award** during the National conference on Technological Challenges in Social, Environmental and Agricultural Reforms held at ICAR-IIRR, Hyderabad during September 09-10, 2017.

Dr R Nagarjuna Kumar was awarded the **Best Paper Presentation Award** for the paper "Mobile Applications: Shaping the future of agricultural extension and advisory services" presented during the National conference on Technological Challenges in Social, Environmental and Agricultural Reforms organized at ICAR-IIRR, Hyderabad during September 09-10, 2017. (Citation : Nagarjuna Kumar, R., Rama Rao, C.A., Raju, B.M.K., Josily Samuel, Nirmala, G., Sailaja, B., Sammi Reddy, K. 2017).

Dr Sumanta Kundu received **best poster award** for presenting poster entitled "Increasing agronomic productivity and mitigating climate change through conservation agriculture in semi arid tropics" in the International Seminar on Global Climate Change: Implications for Agriculture and Water Sectors from December 14-16, 2017 at Aurangabad, Maharashtra, India.

Ms Pushpanjali bagged **best oral presenter award** for "Land Resource Inventory for Crop Planning in Semi-Arid Climate of Central India Using Geo Spatial technologies: A case Study" in the National conference on technological challenges in social, environmental and Agricultural reforms.

Ms. V. Visha Kumari received **best oral presentation award** for the paper "Fodder based cropping system to alleviate fodder scarcity in rainfed areas" at National conference on Technological Challenges in Social, Environmental and Agricultural Reforms held at ICAR-IIRR, Hyderabad during September 09-10, 2017.

Ms Pushpanjali and **Visha Kumari V** received **best research paper award** for the year 2017 in conference on "Farmers First for Conserving Soil and Water Resources in Western Region" being organized by the IASWC, ICAR-IISWC, Dehradun during 1-3, Feb 2018 at AAU, Anand, Gujarat as co-author of the research paper (Deka, B., Sankar, G.R., Dutta, M., Baruah, T.C., Pushpanjali, Visha Kumari, V and Mishra, P.K. 2017. Assessment of fertility potential for the soils of Northern Brahmaputra valley zone using principal component analysis. *Indian Journal of Soil Conservation*, 45(1): 1-11.).

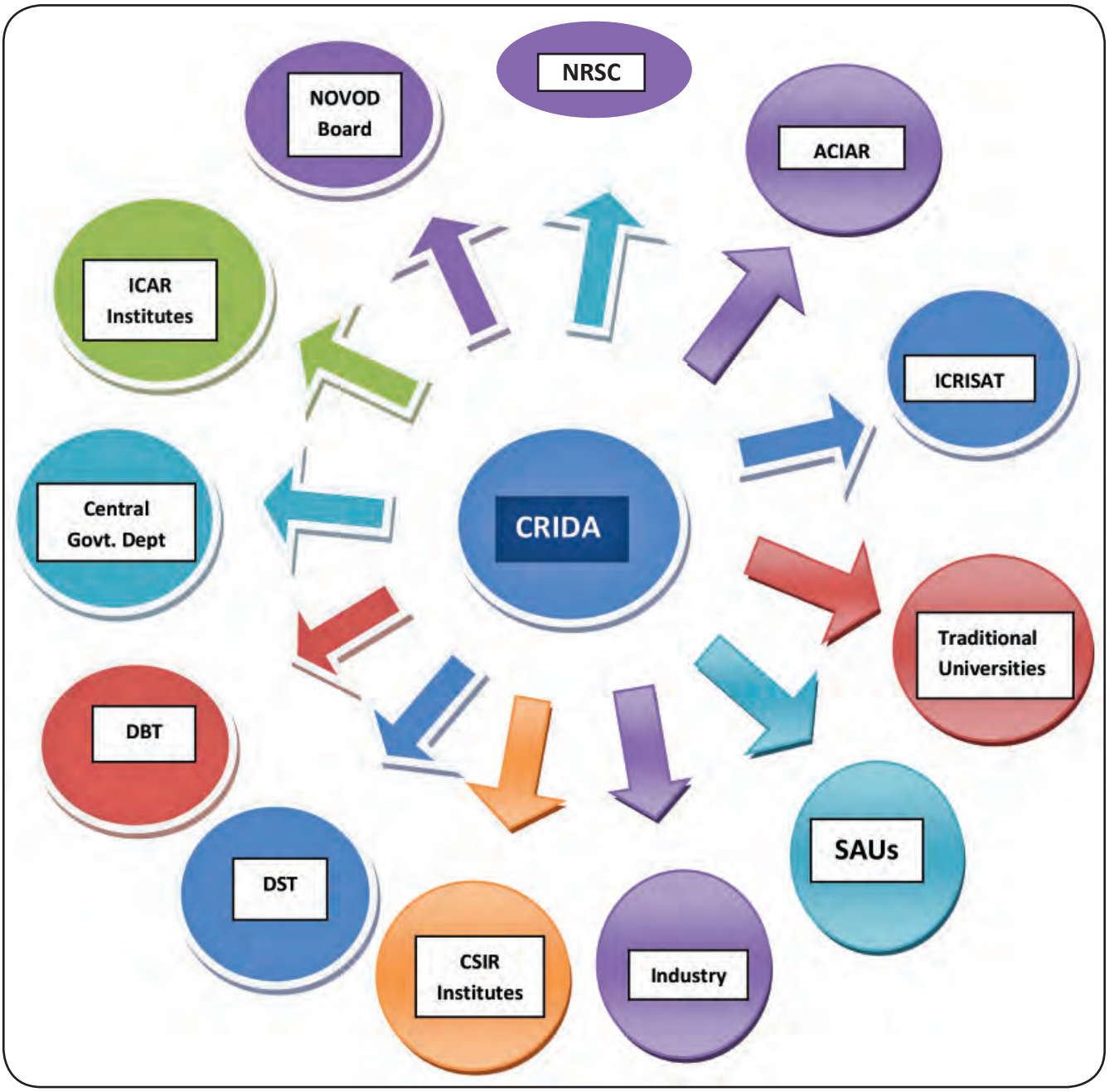
Dr M Manjunath was conferred Certificate of **Outstanding Contribution in Reviewing** in recognition of contributions made to the quality of the journal 'Plant Science' (Elsevier).

Dr Anshida Beevi CN received **best oral presentation award** for the paper entitled "A Comparative Study on Job Satisfaction of Women Extension Personnel" at National Conference on Technological Challenges in Social, Environmental and Agricultural Reforms held at ICAR-IIRR, Hyderabad on September 9, 2017.

9. Linkages and Collaborations

Memorandum of agreement between ICAR-CRIDA and M/s-Avanti Bufa Ltd.

ICAR-CRIDA continually endeavors to explore new linkages with stakeholders while renewing and strengthening old ones. ICAR-CRIDA promotes action oriented research in public-private partnership mode through consortium approach. It has strong collaboration with ICRISAT, ILRI, IWMI, Prof. Jayashankar Telangana State Agricultural University (PJTSAU) and other SAUs, JNTU, Osmania University and other Universities and 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 CSIR, DBT, DST, NOVOD Board, Govt. of Telangana, etc. ICAR-CRIDA also takes up consultancy programme for specific tasks from different institutes/organizations. ICAR-CRIDA takes inputs from IMD and NCMRWF and generates value added outputs for the benefit of the rainfed farmers.


NRSC
NOVOD Board
ACIAR
ICAR Institutes
ICRISAT
Central Govt. Dept
CRIDA
Traditional Universities
DBT
SAUs
DST
CSIR Institutes
Industry

10. Publications

Release of Book by Shri G S Shekhawat, Hon'ble Union Minister of State for Agriculture and Farmers' Welfare

10.1. Research papers

Abdul Khadar, B., Prabhuraj, A., Srinivasa Rao, M., Naganagoud, A., Srinivas, A.G. and Beladhari, R.V. 2018. Biochemical and developmental response of gram caterpillar *Helicoverpa armigera* (Hubner) to elevated CO_2 conditions. *J. Agromet*. 20(1): 80-84.

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11. Ongoing Projects 2017-2018

S. No.	Institute Code No.	Title of the Project	Investigators	Year of Start-Close
		DRM		
1.	RM/LU/13	Conservation tillage farming strategies and crop residue management for soil health improvement and higher crop productivity in sorghum – black gram system in rainfed Alfisol	**K.L. Sharma** Ch. Srinivasa Rao, K. Srinivas G. Pratibha, K. Sammi Reddy S.S. Balloli, B. Sanjeeva Reddy	2013-2020
2.	RM/RM/08	Effect of biochar amendment on soil properties and growth of crops	**G. Venkatesh** Ch. Srinivasa Rao K.A. Gopinath K. Sammi Reddy G.R. Rao, G. Pratibha B. Sanjeeva Reddy	2009-2018
3.	EF053 (CRP-CA)	Development and validation of Conservation Agriculture (CA) practices for rainfed production systems of India	**K. Sammi Reddy** K.L. Sharma, G. Ravindra Chary G. Pratibha, J.V.N.S. Prasad Sumanta Kundu B. Sanjeeva Reddy I. Srinivas, K.A. Gopinath	2015-2018
4.	RM/NM/06	Impact of Conservation Agriculture Practices on Soil Physical Properties in Maize-Pigeonpea crop rotation under Rainfed Alfisols	**Ashok Kumar Indoria** Ch. Srinivasa Rao G. Pratiba, K. Sammi Reddy	2012-2018
5.	EF057 (Extramural)	Soil Quality Assessment and Developing Indices for Major Soil and Production Regions of India	**Ashok Kumar Indoria** K. Srinivas, K.L. Sharma Ch. Srinivasa Rao K. Sammi Reddy Kaushalya Ramachandran Pushpanjali	2016-2018
6.	EF054 (CRP-Water)	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	2015-2018
7.	EF040 (ACIAR)	Impact of meso-scale watershed development in Andhra Pradesh (India) and comparative catchments in Australia -castor system	**K.V. Rao**	2011-2018

S. No.	Institute Code No.	Title of the Project	Investigators	Year of Start-Close
8.	RM/RM/04	Soil and crop management strategies for resource conservation, weed control and carbon sequestration in pigeonpea	**G. Pratibha** K.V. Rao, K. Srinivas I. Srinivas, M. Srinivasa Rao K.L. Sharma Arun Kumar Shanker	2008-2018
9.	RM/RM/09	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	2009-2018
10.	EF055 (CRP-FM&PF)	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	2015-2018
11.	RM/RM/24	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 V. Visha Kumari R.V. Adake, R. Rejani G. Venkatesh, A.K. Indoria D.B.V. Ramana, G. Nirmala Josily Samuel, Anshida Beevi C.N. Jagriti Rohit, Boini Narsimlu	2015-2022
12.	RM/RM/23	Impact of grass strip on soil carbon sequestration and soil physical properties in cropped field under semi-arid environment.	**Pushpanjali** K.L. Sharma, G. Pratibha K. Srinivas, P.K. Pankaj A.K. Indoria, R. Rejani Josily samuel	2015-2019
13.	RM/RM/22	Zeolite characterization and its application effect on enhancing water and nutrient use efficiency in rainfed crops.	**V. Girija Veni** Sumantha Kundu Pushpanjali, K. Sammi Reddy Ch. Srinivasa Rao	2014-2018
		DCS		
14.	CS/CP/31	Chlorophyllfluorescence induction kinetics and photosystem II dynamics in Pearl millet (*Pennisetum gluacum L.*) under water deficit and heat stress	**Arun Kumar Shanker** M. Maheswari, S.K. Yadav M. Vanaja, B. Sarkar M. Prabhakar N. Jyothi Lakshmi A.K. Indoria	2016-2019
15.	EF046 (CROPSAP)	Crop Pest Surveillance and Advisory project (CROPSAP) 2011-12 in Maharashtra	**M. Prabhakar** Commissioner, State Department of Agriculture, Maharashtra A.V.M. Subba Rao	2011-2018

S. No.	Institute Code No.	Title of the Project	Investigators	Year of Start-Close
16.	EF058 (DST)	Hyperspectral Remote Sensing for Crop Condition Assessment in Dryland Crops	**M. Prabhakar** K.A. Gopinath N. Ravi Kumar	2016-2019
17.	CS/CP/34	Exploiting the potential of cropping systems as a climate resilient adaptive strategy for managing drought in rainfed agriculture	**V. Maruthi** B. Sanjeeva Reddy K.S. Reddy, K. Srinivas P.K. Pankaj, M. Vanaja B.M.K. Raju, V. Visha Kumari M. Maheswari	2016-2020
18.	CS/PP/33	Plant growth promoting rhizobacteria and chitosan mediated biotic and abiotic stress tolerance in rainfed crops	**S. Desai** N. Jyothi Lakshmi Pushpanjali A.G.K. Reddy	2016-2018
19.	CS/CP/27	Genetic improvement in cluster bean for dryland agriculture	**K. Salini** A.G.K. Reddy N. Jyothi Lakshmi S.K. Yadav, V. Maruthi K. Sreedevi Shankar Basudeb Sarkar	2013-2018
20.	CS/FN/01	Biofortification for improved nutritional traits in selective dryland crops grown under rainfed conditions	**K. Sreedevi Shankar** K. Srinivas, M. Vanaja S.K. Yadav, V. Visha Kumari	2014-2019
21.	CS/CP/29	Development of mapping population and genetic enhancement for drought tolerance in maize	**Basudeb Sarkar** M. Maheswari K. Salini, S.K. Yadav N. Jyothi Lakshi V. Visha Kumari	2014-2019
22.	CS/CP/30	Development of Resilient Fodder-based Cropping System for Resource Conservation and Profitability in Rainfed Areas.	**V. Visha Kumari** S.S. Balloli, K. Srinivas V. Maruthi, M. Prabhakar D.B.V. Ramana, Manoranjan Kumar M. Osman, A.K. Indoria G. Ravindra Chary, M. Manjunath	2015-2019
23.	CS/CP/32	Genotypic Variability For Yield And Nutritional Quality Attributesin Horsegram Under Abiotic Stresses	**Basudeb Sarkar** S. K. Yadav, A.K. Shanker M. Vanaja, M. Maheswari V. Girija Veni, K. Sreedevi Shankar A.K. Indoria, V. Maruthi	2016-2019

S. No.	Institute Code No.	Title of the Project	Investigators	Year of Start-Close
		SDA		
24.	D&A/AS/02	Unreaped yield rainfed crops potentials of major	**B.M.K. Raju** C.A. Rama Rao K.V. Rao, A.V.M. Subba Rao M. Osman, Josily Samuel R. Nagarjuna Kumar	2011-2018
		TOT		
25.	EF059 (Farmer FIRST)	Farmers' Centric Natural Resource Development for Socio-economic Empowerment in Rainfed Areas of Southern Telangana Region	**G. Nirmala** K Sammi Reddy B Krishna Rao V Visha Kumari, V Maruthi K A Gopinath, C A Rama Rao B Sanjeev Reddy, P K Pankaj K Ravi Shankar, AGK Reddy K Nagasree, Josiley Samuel Jagriti Rohit, R Nagarjuna Kumar Anshida Beevi CN	2016-2018
26.	TOT/LM/06	Development of Inventory of Technologies for Livestock Production for counteracting seasonal stress in rainfed areas	**Prabhat Kumar Pankaj** D.B.V. Ramana K. Ravi Shankar Ravi Dupdal, G. Nirmala	2012-2018
		AICRPAM		
27.	AGMET/05	Inter-comparison of DSSAT, Infocrop and APSIM crop simulation models for climate change impact assessment in Sorghum	**Sarath Chandran M. A.** Visha Kumari V. P. Vijaya Kumar A.V.M. Subba Rao N. Jyothi Lakshmi B.M.K. Raju, S.S. Balloli Rajkumar Dhakar	2016-2020

Ongoing Projects under NICRA (2017-18)

S. No.	Institute Code No.	Title of the Project	Investigators	Year of Start-Close
1.	NICRA/01	Knowledge Management for Climate Resilient Agriculture (NICRA)	**K. Nagasree** N. Ravi Kumar, C.A. Rama Rao K. Ravi Shankar, Jagriti Rohit Anshida Beevi C.N.	2012-2020
2.	NICRA/02	Assessing vulnerability to Climate Change	**C.A. Rama Rao** B.M.K. Raju, K.V. Rao A.V.M. Subba Rao Kaushalya Ramachandran K. Nagasri, K. Ravi Shankar Josily Samuel, Ravi Dupdal R Nagarjuna Kumar	2011-2020

S. No.	Institute Code No.	Title of the Project	Investigators	Year of Start-Close
3.	NICRA/03	Potential of organic crop production as a climate change mitigation and adaptation strategy in rainfed agriculture	**K.A. Gopinath** J.V.N.S. Prasad, G. Venkatesh Ch. Srinivasa Rao, S.K. Yadav	2011-2020
4.	NICRA/06	Development of SCADA based rainfall simulation facility and precision type Lysimeter with open top climate chambers for assessing the impact of climate change to resource loss and soil water balance for rainfed crops	**K. Srinivas Reddy** Manoranjan Kumar M. Vanaja	2012-2020
5.	NICRA/08	Development of weather index based insurance module for selected crops and other agricultural sectors	**P. Vijaya Kumar** M. Osman, B.M.K. Raju A.V.M. Subba Rao	2012-2020
6.	NICRA/12	Study of Satellite-derived NDVI variations to assess agricultural vulnerability in rainfed regions due to climate change	**Kaushalya Ramachandran** C.A. Rama Rao B.M.K. Raju A.V.M. Subba Rao K. Nagasri, K. Ravi Shankar D.B.V. Ramana	2012-2019
7.	NICRA/13	Pest and disease dynamics under climate change scenario	**M. Srinivasa Rao** S. Desai, M. Prabhakar A.V.M. Subba Rao	2012-2020
8.	NICRA/14	Quantitative assessment of potential positive impacts of long ter conservation agricultural practices on climatically resilient soil parameters in rainfed Alfisol	**K.L. Sharma** K. Srinivas Ch. Srinivasa Rao Pushpanjali	2012-2020
9.	NICRA/15	Computational genome analysis and in vivovalidation of genes and transcription factors involved in Abiotic Stress in Maize	**Arun Kumar Shanker** M. Maheswari N. Ravi Kumar N. Jyothi Lakshmi S.K. Yadav	2012-2020
10.	NICRA/16	Demonstration of appropriate practices and technologies in farmers' fields (NICRA-TDC)	**M. Osman** J.V.N.S. Prasad I. Srinivas, D.B.V. Ramana K. Nagasree, R. Rejani A.V.M. Subba Rao	2012-2020
11.	NICRA/17	Biochar amendment for improving the performance of maize in drylands – climatechangeadaptation and mitigation strategy	**G. Venkatesh** J.V.N.S. Prasad Ch. Srinivasa Rao K.A. Gopinath G. Ravindra Chary A.K. Shanker, N.S. Raju	2011-2020

S. No.	Institute Code No.	Title of the Project	Investigators	Year of Start-Close
12.	NICRA/18	Adaptive management of small ruminants under grazing conditions to climate change	**D.B.V. Ramana** N. Ravi Kumar P.K. Pankaj	2012-2020
13.	NICRA/19	Impact of elevated CO_2 and high temperature on nutrient quality of dryland crops	**K. Sreedevi Shankar** M. Vanaja	2012-2020
14.	NICRA/20	Assessing the plant root adaptive plasticity in the stressed environments of moisture deficits and excess in rainfed agriculture-Maize	**V. Maruthi** K. Srinivas K. Srinivas Reddy M. Maheswari N. Ravi Kumar	2012-2020
15.	NICRA/21	Role of bio-fuel crops in rural energy supply and GHG mitigation	**G. Rajeswara Rao** J.V.N.S. Prasad I. Srinivas, S.S. Balloli	2012-2018
16.	NICRA/22	Scope for enhanced adaptation strategies for climate resilience in horticultural crops through improved management practices	**N.N. Reddy** B.M.K. Raju P. Vijaya Kumar A.G.K. Reddy	2012-2020
17.	NICRA/24	Conservation Agriculture (CA) for productivity enhancement and mitigating GHG emissions in maize-horse gram system in Alfisols of semi-arid tropics	**Sumanta Kundu** Ch. Srinivasa Rao V. Girija Veni	2012-2020
18.	NICRA/25	Soil Carbon Sequestration strategies for improving soil health, productivity enhancement, enhancing nutrient use efficiency and reducing GHG emissions in rainfed production systems of India	**Sumanta Kundu** V. Girija Veni Raj Kumar Dhakar	2012-2020
19.	NICRA/26	Development of strategies for improved agromet advisories at micro level and their dissemination	**P. Vijaya Kumar** S.K. Bal, **A**.V.M. Subba Rao Raj Kumar Dhakar Sarath Chandran, S.K. Bal	2012-2020
20.	NICRA/27	Genetic enhancement of pigeonpea germplasm for moisture stress tolerance	**K. Salini** N. Jyothi Lakshmi M. Vanaja, M. Maheswari Basudeb Sarkar	2012-2020
21.	NICRA/28	Transpiration efficiency and water use variations in maize	**N. Jyothi Lakshmi** M. Maheswari M. Vanaja, S.K. Yadav A.K. Shanker, K. Salini	2012-2020

S. No.	Institute Code No.	Title of the Project	Investigators	Year of Start-Close
22.	NICRA/30	Mitigation of Climate Change through conservation agriculture in rainfed regions of India	**G. Pratibha** K.V. Rao I. Srinivas	2012-2020
23.	NICRA/31	Productivity of rainfed crops under enhanced carbon dioxide and its interaction with water deficit and elevated temperature	**M. Vanaja** M. Maheswari, S.K. Yadav N. Jyothi Lakshmi K. Sreedevi Shankar	2012-2020
24.	NICRA/32	National Initiative on climate Resilient Agriculture – Subproject on Phenotyping	**M. Maheswari** M. Vanaja, S.K. Yadav N. Jyothi Lakshmi N. Ravi Kumar A.K. Shanker K. Salini, V. Maruthi K. Sreedevi Shankar Basudeb Sarkar	2012-2020
25.	NICRA/33	Physiological and metabolic indices for heat tolerance in maize	**S.K. Yadav** M. Maheswari N. Jyothi Lakshmi M. Vanaja, A.K. Shanker	2010-2020
26.	NICRA/35	Quantification of Green house gas emissions from rainfed systems	**J.V.N.S. Prasad** Ch. Srinivasa Rao K. Srinivas	2013-2018
27.	NICRA/36	Runoff potential availability in rainfed areas in different agro ecological regions of India for rainwater harvesting under changing climatic scenarios.	**R. Rejani** K.V. Rao G. Ravindra Chary K.A. Gopinath K. Sammi Reddy, M. Osman	2015-2020

12. Meetings of IMC, IRC, QRT and RAC

Members of RAC with Scientists of ICAR-CRIDA

12.1. Institute Research Committee (IRC)

IRC meeting was conducted during 1st, 2nd and 4th April, 2017 under the chairmanship of Dr Ch. Srinivasa Rao, Director, ICAR-CRIDA and was attended by project coordinators, heads of the divisions/ sections/units and scientists. In his opening remarks, the Chairman, IRC suggested all the PIs to select a theme pertaining to the mandate of the Institute and apply for external funding projects. He further informed the house about the cut in the budget and suggested to workout modalities for meeting the maintenance cost of new state of art facilities created under NICRA. Once again, stress was laid on good quality publications having high impact factor which serves as one of the indicators of performance. The progresses of the ongoing projects under all the divisions were reviewed and suggestions were given. The new project proposals were also discussed.

Monitoring of Projects during IRC meeting

12.2. Field Institute Research Council (IRC)

Field IRC meeting for 2017-18 was held on 21st September, 2017 at Gunegal research farm (GRF) and 27th September, 2017 at Hayathnagar research farm (HRF) under the chairmanship of Dr K Sammi Reddy, Director (Acting). The chairman IRC, Dr K Sammi Reddy, Director (Acting), Project coordinators, Heads of Divisions/Sections and scientists visited various experiments and discussed thoroughly on various treatment effects. Various suggestions like displaying of the experimental and treatment boards at the experimental site, periodical monitoring of soil moisture in CA related experiments, correlation of rainfall amount, rainy days and crop were made in Field IRC.


Dr K. Sammi Reddy, Director (Acting) alongwith all scientists visited various experimental plots during Field IRC

12.3. Mid-Term Institute Research Council (IRC)

Mid-term IRC was conducted on January 18 and 23, 2018. The meeting was chaired by Dr K. Sammi Reddy, Director (Acting), ICAR-CRIDA and was attended by Project Coordinators and all Heads of Divisions/Sections/Units and Scientists.

Dr M. Osman, Principal Scientist and Member Secretary IRC welcomed the Director, Project Coordinators, Heads and all the Scientists to the Mid-IRC. Dr Osman informed the house that the Institute is conducting mid-IRC since 2012 as a mid-course correction earlier this tradition was not there and adhering to the Council's guidelines scrupulously apart from field IRC. A suggestion was made to explore external funding by writing good research proposals. Further, he made a request to all the scientists to submit their RPPs on time to avoid any remarks as these are subjected to audit by external agencies. All the RPP-IIIs will now be assessed by the technical committee constituted for this purpose to look into the accomplishment of objectives as envisaged.

Dr K. Sammi Reddy, Director (Acting) and Chairman of IRC reviewed the status of RPPs and advised to adhere to the guidelines and submit them within the given timeframe. New projects need to consider the expectations of RAC, QRT and ICAR, so as to tune the research for development of our clientele. Other expectation of the Council like publications in high rated journals to be given high priority and at the same time scientists are advised to participate actively in various seminars/symposia, etc.

On-going projects progress was discussed on the second day, i.e. 23rd January 2018. All the PIs made brief presentation for the on-going projects and also brought to the notice few constraints in achieving the objectives.

12.4. Research Advisory Committee (RAC)

The XXVI meeting of the Research Advisory Committee of the institute was held during 11-12 January 2018 at ICAR-CRIDA, Hyderabad. The composition of present RAC is as follows:

1. Dr Panjab Singh, Ex Director General, ICAR and President, Foundation for Advancement of Agriculture and Rural Development (FAARD), Varanasi, UP - Chairman

2. Dr S.R. Singh, Former Director, Institute of Agricultural Sciences, BHU, Member

3. Dr A. Subba Rao, Ex Director, IISS, Bhopal, Member

4. Dr P.K. Mahapatra, Ex Dean, College of Agriculture, OUAT, Member

5. Dr Kamalesh Kumar Singh, Head, Agromet, India Meteorological Department, Member

6. Dr Rajeswari S. Raina, Professor & Head, Dept. of International Relations & Governance Studies, Shiv Nadar University, UP, Member

7. Dr S Bhaskar, ADG (Agron. AF & CC), ICAR, Krishi Bhawan, New Delhi, Member

8. Dr K Sammi Reddy, Director (Acting), ICAR-CRIDA, Hyderabad, Member

9. Dr C A Rama Rao, Head, Section of Design & Analysis, ICAR-CRIDA, Hyderabad, Member Secretary alongwith Heads and PCs of the Institute.

The committee reviewed the progress of research at CRIDA during the previous one year. Some of the recommendations that emerged out of the deliberations include strengthening of basic sciences research, identification of high biomass producing species to meet fodder needs, greater emphasis on minimization of seepage and evaporation losses and assessment of ecosystem services in watershed development programmes. They also suggested to communicate the positive outcomes emanating from NICRA to the development programmes being implemented by state and central governments.

RAC meeting in progress

Visit of RAC to NICRA facilities

12.5. Quinquennial Review Team (QRT)

VII Quinquennial Review Team of the Institute constituted for the review of period 2011-12 to 2017-18, under the Chairmanship of Dr J.C. Katyal, Ex-VC, HAU, Hisar & Former DDG (Education), ICAR. Three meetings of QRT already conducted during December, 2017 - April, 2018 (Jagdalpur February 1 to 2, 2018, Junagarh March 12 to 13 and Jorhat April 21 to 22, 2018) and next meeting is scheduled during June 18 to 19, 2018, in Bangalore. The following is the composition of present QRT team:

1. Dr J.C. Katyal, Former Director, NAARM and Ex-Vice-Chancellor, HAU, A-104, Park View City, Sector 49, Sohna Road, Gurgoan (Haryana) - Chairman

2. Dr V.M. Mayande, Former Vice-Chancellor, PKDV, Flat No. B- 504, Mont Vert, Baner-Pashon Link Road, Pashan, Pune, Member

3. Dr A. M. Shekh, Former Vice-chancellor, AAU, 9-10 Kirti Park Society, Opposite Royal Plaza, 100 Feet Road, Anand, Gujarat, Member

4. Dr S.D. Gorantiwar, Professor & Head, Department of Irrigation and Drainage Engineering, MPKV, Rahuri, Distt. Ahmednagar, Maharashtra, Member

5. Dr Rajendra Prasad, Principal Scientist, ICAR-IASRI, Library Avenue, Pusa, New Delhi, Member

6. Dr V.S. Korikanthimath, Ex- Director, ICAR-CCARI, Goa, Member

7. Dr Mohammed Osman, Head, PME, ICAR-CRIDA, Hyderabad, Member Secretary.

QRT meeting in progress

QRT members interacting with scientists of ICAR-CRIDA

A two-day QRT meeting was organized at ICAR-CRIDA, Hyderabad during 20-21st December, 2017 under the Chairmanship of Dr J C Katyal. Dr K Sammi Reddy, in his welcome address briefed the members about historical background of the institute, organizational structure, achievements in brief, budget and few constraints like manpower and replacement of vehicles. The QRT members appreciated the efforts of ICAR- CRIDA and recommended inter-divisional approach for carrying out research. An interaction session was also organized with the scientists of the institute.

QRT visit to NICRA facility

QRT visit to workshop at HRF

12.6. Institute Management Committee (IMC)

IMC meeting in progress

47th meeting of Institute Management Committee was conducted on 22nd January, 2018. The following is the composition of present IMC team:

1. Dr K Sammi Reddy, Director (Acting), ICAR-CRIDA, Hyderabad - Chairman

2. Professor M S Nataraju, University of Agricultural Science, Bengaluru, Member

3. Professor T V K Singh, Dean/Director (Extension), PJTSAU, Rajendranagar, Hyderabad, Member

4. Shri D D Verma, Comptroller, ICAR-NAARM, Hyderabad, Member

5. Dr (Smt.) K Surekha, Principal Scientist, ICAR-IIRR, Rajendranagar, Hyderabad, Member

6. Dr G Ravindra Chary, Project Coordinator, AICRPDA, ICAR-CRIDA, Hyderabad, Member

7. Dr Jagadish Rane, Head, ICAR-NIASM, Baramati, Pune, Member.

8. Agricultural Commissioner, Telangana state, Hyderabad, Member.

The research activities, institute budget utilization and other important activities of the institute were discussed during the meeting.

13. Participation of Staff in Conferences, Meetings, Workshops, Seminars and Symposia

Scientist	Program name	Duration	Venue
S Desai	Company visit for MoU	April 13, 2017	M/s Avanti Bufa Pvt Ltd, Zaheerabad
PK Pankaj K Ravi Shankar Jagriti Rohit Dhimate Ashish	Krishi Kalyan Mela	April 13-19, 2017	Motihari, Bihar
Jagriti Rohit	National Conference on revisiting Agricultural Extension Strategies for Enhancing Food and Nutritional Security, Sustainable livelihood and Resilience to Climate Change	April 22-24, 2017	PJTSAU, Hyderabad
V Girija Veni Josily Samuel	Training workshop on Integrating Systems Modeling Tools as Support for Decision Making for Scaling Up Climate Resilient Agriculture	May 3-5, 2017	ICRISAT, Hyderabad
P Vijaya Kumar	International Conference on Climate Change and Adaptation: Empowering small holders and ensuring food security	May 11, 2017	Chennai
R Nagarjuna K	Conference on sustainable development goals: Indian preparedness and roll of Agricultural organized by TAAS, IFPRI and ICAR	May 11-12, 2017	NASC, New Delhi
K V Rao	Interface Meeting with State Govt of Karnataka on *Kharif* Preparedness	May 11-12, 2017	Bengaluru
R Nagarjuna Kumar PK Pankaj	Scientific Advisory Committee (SAC) meeting of CRIDA-KVK, Ranga Reddy District	May 12, 2017	CRIDA-KVK, R.R. District
K V Rao S Desai	Updation of Contingency Plans for Chhattisgarh	May 16-18, 2017	IGKV, Raipur
K Sammi Reddy C A Rama Rao K Nagasree	Technical Programme finalization workshop (2017-2020) of Technology Demonstration Component of NICRA	May 18, 2017	ICAR-CRIDA, Hyderabad
K Sammi Reddy P Vijaya Kumar AVM Subba Rao Sarath Chandran MA	AICRPAM-NICRA Annual Workshop	May 22-23, 2017	Dr BSKKV, Dapoli
K Sammi Reddy C A Rama Rao KA Gopinath K Nagasree Boini Narsimlu	Two day Technical Workshop of AICRPDA-NICRA	May 26-27, 2017	ICAR-CRIDA, Hyderabad

Scientist	Program name	Duration	Venue
K V Rao	Interface Meeting with State Govt of Andhra Pradesh on *Kharif* Preparedness	May 26-28, 2017	Guntur, Andhra Pradesh
K Sammi Reddy DBV Ramana	NICRA Technical Programme finalization workshop	May 27, 2017	NAAS, New Delhi
K Nagasree R Nagarjuna Kumar	ISDA General Body Meeting	May 27, 2017	ICAR-CRIDA, Hyderabad
K V Rao	Interface Meeting with State Govt of Maharashtra on *Kharif* Preparedness	June 1-2, 2017	Pune, Maharashtra
K V Rao	Interface meeting on Agriculture Contingencies for the state of West Bengal	June 6, 2017	Kolkata
P K Pankaj	Regional Coordination Committee meeting of Forage Research Stations	June 6, 2017	Regional Fodder Station, Hyderabad
K Nagasree	Training on IPM to Vegetable farmers	June 7, 2017	Devanoniguda
K V Rao	Workshop on Policy Dialogue on Drought Management at ICAR-RCER-Patna	June 7-8, 2017	ICAR-RCER, Patna
P Vijaya Kumar	Brainstorming session on Pre-project preparatory work related to Andhra Pradesh drought mitigation project	June 9-10, 2017	ICAR-CRIDA, Hyderabad
K V Rao	Interface Meeting with State Govt of Rajasthan on *Kharif* Preparedness	June 15-17, 2017	Jaipur, Rajasthan
C A Rama Rao	Consultation Workshop on Developing a common framework for vulnerability and risk assessment in the India Himalayan Region	June 19, 2017	Indian Institute of Science, Bangalore
G Nirmala P K Pankaj	National training programme on Results based Monitoring and Evaluation in Agriculture Development	June 19-21, 2017	MANAGE, Hyderabad
K V Rao	Workshop on Drought Research and Management by NRM Division, ICAR	June 21, 2017	New Delhi
K L Sharma	Training Programme on Implementation of soil health card scheme	June 27 - 29, 2017	MANAGE, Hyderabad
K Sammi Reddy K V Rao	Capacity building program for Line Depts on Development of Drought Proofing Action Plans-Karnataka	June 29, 2017	Bengaluru
K Sammi Reddy P Vijaya Kumar	Workshop on the project Drought management in Odisha and presented proposed workplan of the project	July 7, 2017	Bhubaneswar
P Vijaya Kumar K Nagasree	Stakeholders consultation on Global Technology Watch Group (GTWG) – Sustainable Agriculture Workshop 2nd Meeting	July 13, 2017	ICAR-NAARM, Hyderabad
C A Rama Rao	Zonal Review and Progress Workshop for KVKs of Andhra Pradesh, Telangana and Maharashtra	July 13, 2017	ICAR-CRIDA, Hyderabad
S S Balloli	First Brain-Storming Workshop on National Soil Management Policy	July 20-21, 2017	NIAEM, Hyderabad

Scientist	Program name	Duration	Venue
V Maruthi	Annual Zonal Workshop of KVKs under ATARI V	July 23-25, 2017	YCMOU, Nashik
K V Rao	Capacity building program for Line Depts on Development of Drought Proofing Action Plans – A.P.	July 26, 207	Tirupati
P Vijaya Kumar	Meeting on Revision of Agro-climatic classification in the country in respect of observed Climate Change	August 1, 2017	IMD, Pune
K V Rao K A Gopinath	*Karif* 2017 Agriculture Scenario Assessment and Contingency Plan Preparation for Rayalaseema, Prakasam and Nellore districts of Andhra Pradesh	August 1, 2017	ARS, Anantapur
V Visha Kumari	Training Programme on Developing Winning Research Proposals in Agricultural Research	August 1- 5, 2017	ICAR-NAARM, Hyderabad
K Sammi Reddy K V Rao B M K Raju K A Gopinath V Visha Kumari	Interaction meeting on *Kharif* 2017 agriculture Scenario Assessment and Contingency Plan Preparation for Telangana	August 8, 2017	ICAR-CRIDA, Hyderabad
A K Indoria	INDO-US Workshop on Security of Dual Use Agrochemicals (Improving security at vulnerable locations in the agrochemical supply chain)	August 8, 2017	CSIR-IICT, Hyderabad
S Desai	Vigilance Review Meeting of the Southern Zone Institutes of ICAR	August 23-25, 2017	ICAR-NIANP, Bengaluru
K Nagasree	Exposure Visit to Horticultural Exhibition	August 30, 2017	Peoples Plaza, Hyderabad
K A Gopinath	National group meeting of AICRP on Forage Crops	September 5, 2017	UAS, Bengaluru
A G K Reddy	International Symposium on Horticulture: Priorities & Emerging Trends	September 5-8, 2017	IISC, Benguluru
CA Rama Rao	Review Meeting of NMSA funded projects	September 8, 2017	ICAR-CRIDA, Hyderabad
K A Gopinath G Venkatesh R Nagarjuna K Pushpanjali V Visha Kumari Anshida Beevi	National conference on Technological Challenges in Social, Environmental and Agricultural Reforms	September 09-10, 2017	ICAR-IIRR, Rajendranagar, Hyderabad
K Sammi Reddy	Delivered lecture in Summer School on Recent Advances in Abiotic Stress Management in Climate Smart Agriculture	September 15, 2017	ICAR-NIASM, Baramati, Maharashtra
K V Rao G R Chary DBV Ramana R Rejani	Meetings for reviewing the Drought Proofing Action Plans for Karnataka	September 16, 2017	Karnataka State Natural Disaster Monitoring Centre (KSNDMC), Bangalore
K V Rao	National Conference on Agriculture-*Rabi* Campaign	September 19-20, 2017	New Delhi

Scientist	Program name	Duration	Venue
K Sammi Reddy	Attended World Bank aided Project meeting on Climate Resilient Agriculture (POCRA) ad to give inputs regarding the effective dissemination	September 22-23, 2017	World Trade Centre, Mumbai, Maharashtra
S Desai DBV Ramana	Interface meeting for preparedness for *rabi* 2017 for Madhya Pradesh	September 23-25, 2017	Vindhyachal Bhavan, Bhopal
Ashish S Dhimate	International workshop on Advanced Farm Mechanization	September 25-29, 2017	NIRD&PR, Hyderabad
S Desai S S Balloli P K Pankaj	Workshop on mid-term evaluation and updation of District Agriculture Contingency Plans (DACPS) of Madhya Pradesh	October 04-05, 2017	RVSKVV, Indore, M.P.
V Girija Veni	National seminar on Zeolite and allied mineral deposits of India	October 6-7, 2017	G.S. Science College, Belagavi, Karnataka
C A Rama Rao	Workshop on Green Revolution in Eastern India: Constraints, opportunities and way forward	October 9-10, 2017	NASC, New Delhi
G Nirmala P K Pankaj A G K Reddy	National Training Workshop on Methodological framework for implementation of FFP program	October 10-13, 2017	TNAUVAS, Chennai
C A Rama Rao	77th Annual Conference of the Indian Society of Agricultural Economics	October 12-14, 2017	CGPS, CAU, Umiam, Barapani
G Ravindra Chary	Finalization of Action Plan for 24 Drought Prone Districts under Pilot Implementation of interventions for most vulnerable Drought Prone-Districts by National Rainfed Area Authority (NRAA)	October 13, 2017	NAAS complex, New Delhi
S Desai	Updation of District Agricultural Contingency Plans for Himachal Pradesh	October 20-23, 2017	CSKHPKVV, Palampur, H.P.
R Nagarjuna Kumar	International Conference on Agriculture and Veterinary Sciences	October 23-25, 2017	PJST Agriculture University, Hyderabad
K Salini	Awareness day on germplasm exchange and phyto-sanitary issues	October 27, 2017	ICAR-NBPGR-Research Station, Hyderabad
K V Rao	Capacity building program for Line Depts on Development of Drought Proofing Action Plans- Rajasthan	October 30, 2017	Jaipur
DBV Ramana	XVI Convocation cum Scientific Convention of NAVS (I)	November 4-5, 2017	SVVU, Tirupati
V Visha Kumari	Interface meeting on updating of contingency plan for *kharif* and *rabi* in Maharashtra	November 6-8, 2017	Dr PDKV, Akola
K Sammi Reddy	Chaired the Thematic Session-5 on Climate Resilient Agriculture in the 3rd World Congress on Disaster Management	November 7, 2017	Visakhapatnam, Andhra Pradesh
CA Rama Rao	Silver Jubilee Conference of Agricultural Economics Research Association (India). Doubling farmers income : Options & Strategies	November 7-9, 2017	NAARM, Hyderabad

Scientist	Program name	Duration	Venue
P K Pankaj	Presented a lead paper in National Seminar on Small Ruminants: National scope on upscaling production to products value addition and their safety	November 9-10, 2017	ICAR-Central Institute for Research on Goats, Makhdoom, Mathura
K V Rao R Rejani A G K Reddy	Meetings for reviewing the Drought proofing action plans for Karnataka	November 10, 2017	Horticulture University, Bagalkot
CA Rama Rao	Planning Workshop on Research Impact Assessment	November 13, 2017	NIAP, New Delhi
DBV Ramana	Impact of environmental changes on ruminants	November 13-14, 2017	CIRAD, France
V Maruthi	National workshop on Seed Hub	November 24, 2017	ICAR-IIPR, Kanpur
K Sammi Reddy P Vijaya Kumar S K Bal AVM Subba Rao	Annual workshop of AICRPAM	November 27-29, 2017	SKUAST, Jammu
K Ravi Shankar Anshida Beevi CN	ISEE National Seminar on Doubling Farmers Income and Farm Production through Skill Development and Technology Application	November 28-30, 2017	Bihar Agricultural University, Sabour
S S Balloli B K Rao	Workshop on Mid Term Evaluation of District Agricultural Contingency Plans	December 1, 2017	Biswanth Agricultural College, Assam
K V Rao	Regional Workshop on Building Drought Resilience in Agriculture: Partnerships and Outreach and the Training Programme on Earth Observation Based Tools for Drought Monitoring	December 3-9, 2017	Bangkok, Thailand
K Sammi Reddy G Nirmala K Nagasree P K Pankaj	World Soil Day celebrations	December 5, 2017	Rakamcharla village, Pudur Mandal
K Sammi Reddy M Vanaja	Attended Interactive Seminar on the foresight – Agrimonde – Terre : 2050 The Indian Perspective	December 7-9, 2017	NASC, New Delhi
K Sreedevi Shankar	26th Indian Convention of Food Scientists and Technologists ICFOST 2017 Food & Nutrition Challenges: Role of Food Science and Technology	December 7-11, 2017	CSIR-IICT, Hyderabad
K Sammi Reddy	Delivered a keynote address in International Groundwater Conference	December 11, 2017	New Delhi
K Ravi Shankar	Training Programme on Good Practices in Extension Research	December 11-16, 2017	ICAR-NAARM, Hyderabad
K Nagasree	National level Workshop on ICTs in Agriculture	December 12-13, 2017	MANAGE, Hyderabad
DBV Ramana S K Bal	Zonal Monitoring Committee Visit	December 13-15, 2017	KVKs of Buxar, Jehanabad and Aurangabad in Bihar

Scientist	Program name	Duration	Venue
CA Rama Rao S Desai M Srinivasa Rao A K Indoria V Girija Veni	International Seminar on Global Climatic Change: Implication for agriculture and water sectors organized by VNMKV, Parbhani and others	December 14-16, 2017	WALMI, Aurangabad
Md Osman P K Pankaj	Workshop on Mid Term Evaluation and updation of District Agricultural Contingency Plans for Assam	December, 15, 2017	AAU, Jorhat, Assam
S Desai	National workshop on Innovative strategies for the management of plant disease under Climate Change Scenario	December 18-21, 2017	ICAR-IARI, New Delhi
G Nirmala K Ravi Shankar AGK Reddy	National Conference of Farmers FIRST	December 22-23, 2017	ICAR-NAARM, Hyderabad
G R Rao JVNS Prasad G Venkatesh	Consultative workshop on selection of agro-forestry modules and tree species for Northern Telangana	January 3, 2018	Hyderabad
DBV Ramana	IARD 50th Anniversary Celebrations	January 6, 2018	Hyderabad
K S Reddy	52nd Annual Convention of ISAE and National Symposium on Doubling the Farmers Income through Technological Interventions	January 8-10, 2018	AAU, Anand
K Nagasree	*Kharif* Review and *Rabi* Progress workshop of NICRA KVKs 2017-18 of ICAR-ATARI, Zone-X	January 10-11, 2018	KVK, Chittoor (Tirupati)
S S Balloli P K Pankaj	Workshop on Mid Term Evaluation and updation of District Agricultural Contingency Plans for Assam	January 11, 2018	SCS College of Agriculture, AAU, Dhubri, Assam
Kaushalya Ramachandran	National Initiative for Revitalizing Indian Rivers for Sustainable Agricultural Development through Buffer Zone Afforestation	January 18, 2018	Geospatial World Forum (GWF-2018), HICC, Hyderabad
S Desai P K Pankaj	Workshop on mid-term evaluation and updation of District Agriculture Contingency Plans (DACPS) for Andhra Pradesh	January 22-24, 2018	Ongole, Tirupati and Anantapuramu, A.P.
DBV Ramana	Review meeting on District Action Plans for Drought Proofing	January 28, 2018	Vikas Soudha, Bengaluru
K V Rao	Review Meeting of External Aided Projects	January 31, 2018	New Delhi
K Sammi Reddy CA Rama Rao K A Gopinath B M K Raju	XVI Working Group Meeting of AICRPDA	February 1-5, 2018	AICRPDA Centre, IGKV, Jagdalpur, Chhattisgarh
K S Reddy	National Conference on Engineering Interventions for Doubling the Income of Small and Marginal Farmers by 2022	February 2-3, 2018	Engineers Bhavan, IE, Delhi

Scientist	Program name	Duration	Venue
DBV Ramana	Action plan meeting on development of action plans for drought proofing of Rajasthan	February 7-9, 2018	Ajmer, Nagore and Churu districts of Rajasthan
K S Reddy	Annual Review Workshop on NICRA projects	February 8-9, 2018	ICAR-NIASM, Baramati
M Vanaja	Review of Crop Sciences & Modeling technical programme of NICRA project	February 12, 2018	NASC, New Delhi
K Nagasree	National Workshop on Agricultural Extension: Time to change	February 14, 2018	MANAGE, Hyderabad
K Sammi Reddy M Prabhakar P K Pankaj	Review meeting on finalization of Technical Programme of NICRA Partner Institutes under Livestock	February 16, 2018	ICAR-NDRI, Karnal
K S Reddy	International conference on Sustainable Technologies for Intelligent Water Management	February 16-19, 2018	IIT, Roorkee
C A Rama Rao	Working Committee Meeting on Scaling up Climate-Smart Agriculture in Telangana state	February 19, 2018	EPTRI, Hyderabad
M Srinivasa Rao	National Agronomy Congress on Redesigning Agronomy for Nature Conservation and Economic empowerment	February 20-22, 2018	G.B. Pant university of Agriculture and Technology India
S Desai	National Seminar on Futuristic Agriculture	February 21-22, 2018	ANGRAU, Tirupati, A.P.
K Ravi Shankar	Annual Review workshop of Farmers First Project	February 21-22, 2018	ICAR-IARI, New Delhi
P Vijaya Kumar SK Bal AVM Subba Rao Rajkumar Dhakar Sarath Chandran MA	Output oriented capacity enhancement program on Development of dynamic crop weather calendar	February 21-28, 2018	JNKVV, Jabalpur
S Desai	National Seminar on Indian Veterinary Leadership to Promote National and International Collaboration, Coalitions and Linkages for Global Competitiveness in Animal Health and Production, Research and Education	February 23-24, 2018	SVVU, Tirupati, A.P.
DBV Ramana	Review meeting on District Action Plans for Drought Proofing	February 24, 2018	Kurnool
K S Reddy	National Conference on Digital and Engineering Technologies for Precision Agriculture and Value Addition	February 26-27, 2018	CAE, Bapatla
M Vanaja	Review the functioning of CTGC facility at IIHR, Bengaluru	February 27, 2018	ICAR-IIHR, Bengaluru
M Prabhakar P K Pankaj	Review meeting on finalization of Technical Programme of NICRA Partner Institutes under Fisheries	March 1-2, 2018	ICAR-CMFRI, Kochi, Kerala

Scientist	Program name	Duration	Venue
K V Rao S Desai	Updation of District Agricultural Contingency Plans for Tamil Nadu	March 04-06, 2018	TNAU, Coimbatore, Tamil Nadu
Md Osman P K Pankaj	Meeting for mid-term evaluation and updation of District Agriculture Contingency Plans (DACPS)	March 7, 2018	JNKVV, Jabalpur
Jagriti Rohit	National Conference on Technological Empowerment of Women (Nominated by ICAR)	March 8-9, 2018	Vigyan Bhawan, New Delhi
A K Indoria	CRP-CA Review/ Technical Program finalization meeting	March 12, 2018	KAB II, Pusa, New Delhi
K Nagasree	Field day cum Demonstration	March 13, 2018	Devanoniguda & Rakamcharla village, Pudur
CA Rama Rao K V Rao	Regional Workshop cum Training on Drought Monitoring – Constraints and Opportunities organized by IWMI and CRIDA	March 14, 2018	ICAR-CRIDA, Hyderabad
K V Rao	Training on Drought Monitoring through Earth Observation Tools	March 15 -16, 2018	ICAR-CRIDA, Hyderabad
All Scientists of ICAR-CRIDA	Farmers Scientists Interface	March 17, 2018	ICAR-CRIDA, Hyderabad
I Srinivas R V Adake B Sanjeeva Reddy	Annual Review Workshop on CRP Farm Machinery and Precision Farming	March 20, 2018	NASC, New Delhi
G Nirmala K Ravi Shankar	National Review workshop on Farmers FIRST programme	March 21-22, 2018	NASC complex, New Delhi
I Srinivas	Annual workshop on CRP-FMPF	March 22, 2018	NASC complex, New Delhi
K S Reddy	Annual Review workshop on Agri Consortia Research Platform on Water	March 23, 2018	KAB-II, IARI, New Delhi
K Sammi Reddy S S Balloli	National Conference on Bhumi Suposhan – Approaches and practices to enrich soil for sustainable agriculture	March 24-25, 2018	CSIR-IICT, Hyderabad
R Nagarjuna Kumar N S Raju	User's Training Workshop on Geospatial Applications in Data Enrichment of ICAR-KRISHI Geoportal	March 26-27, 2018	ICAR-NBSS&LUP, Nagpur
All Scientists of ICAR-CRIDA	Interactive Workshop between Hon'ble Vice President of India, Sri M. Venkaiah Naidu and Researchers of ICAR Institutes located at Hyderabad	March 31, 2018	ICAR-IIRR, Hyderabad

14. Workshops, Seminars, Trainings and other Activities Organized by the Institute

A drumhead of programmes organized throughout the year by ICAR-CRIDA is as follows:

Programme	Period	Venue
Scientific Advisory Committee meeting of KVK-Ranga Reddy, CRIDA	May 21, 2017	KVK- RR District, CRIDA, Hyderabad
AICRPAM-NICRA Annual Workshop	May 22-23, 2017	Dr BSKKV, Dapoli
IMD training for Met -II grade officers	July 24-25, 2017	IMD, Pune
Meeting on Automation of Agromet Advisory Services	August 3, 2017	ICAR-CRIDA, Hyderabad
ICAR-CRIDA and MANAGE collaborative training programme on "Extension Strategies for Promotion of Climate Smart Livelihood Opportunities"	September 12-14, 2017	MANAGE, Hyderabad
Training programme on "Efficient Watershed Management in Rainfed Agriculture" sponsored by Watershed Development Department, Govt. of Karnataka	September 19-23, 2017	ICAR-CRIDA, Hyderabad
Model Training Course (MTC) on "Participatory Natural Resource Management for Sustainable Agricultural Productivity in Rainfed areas" sponsored by DOE, New Delhi	October 04-11, 2017	ICAR-CRIDA, Hyderabad
Training programme on "Farm Mechanization for Tribal Farmers"	October 27, 2017	Yellammathanda R.R. District
ICAR short course on "Monitoring, Evaluation, and Impact Assessment of Rainfed Technologies and Development Programmes"	November 1-10, 2017	ICAR-CRIDA, Hyderabad
Professional Attachment Training to ARS Scientist from ICAR-NRRI, Cuttack, Odisha	November 20, 2017 to February 20, 2018	ICAR-CRIDA, Hyderabad
Annual Workshop of AICRPAM	November 27-29, 2017	SKUAST, Jammu
Telangana State Department (PMKYS & WEC) sponsored training programme on "Farm Mechanization and Production System Improvement in Agriculture"	December 7-8, 2017	ICAR-CRIDA, Hyderabad
ICAR-sponsored training program on "Agromet Data Collection, Analysis and Database Management" for technical officers	December 11-23, 2017	ICAR-CRIDA, Hyderabad

International training on "Strategies for Enhancement of Farmers Income in Dryland Agriculture" under the program Feed the Future - India Triangular Training (FTF-ITT)	January 16-31, 2018.	ICAR-CRIDA, Hyderabad
International Training programme on Rainwater management for climate resilient agriculture in drylands under India Africa Summit	February 15 to March 7, 2018	ICAR-CRIDA, Hyderabad
Output oriented capacity enhancement program on "Development of Dynamic Crop Weather Calendar"	February 21-28, 2018	JNKVV, Jabalpur
Action Learning Programme on "Farm Mechanization for Small Farm holdings"	March 21-22, 2018	ICAR-CRIDA, Hyderabad
Interface workshop on Machinery manufacturers, R&D and Line Department officers interfacing workshop	March 24, 2018	ICAR-CRIDA, Hyderabad

14.1. An overview of Activities organised

14.1.1. ICAR-CRIDA Foundation Day

ICAR - CRIDA celebrated its 33rd Foundation Day on 12th April, 2017. Dr David Bergvinson, Director General, ICRISAT has graced the occasion as Chief Guest. Dr Ch. Srinivasa Rao, Director, CRIDA while welcoming the invitees appreciated the efforts of all the staff members of the Institute and also predecessors of the Institute who brought laurels and recognition to the organization. Dr Bergvinson appreciated the contributions of CRIDA to the rainfed farming community as well as climate change research. He opined that translating science to profitable adoption, integrating IT in agricultural research with ample use of spatial data and crop modelling for future climate could play a vital role in national agricultural productivity enhancement programs to meet food security challenges. On this occasion, 18 farm innovators from six states were honoured for achieving sustainable productivity through their novel innovations in agriculture and allied enterprises. The staff in administrative & accounts, technical and supporting categories were recognized for their significant contributions to the organization and felicitated.

14.1.2. International Yoga Day

The 3rd International Yoga Day was celebrated in ICAR-CRIDA on 21st June, 2017. To initiate staff and research scholars in yoga practices, the Isha Foundation sent volunteers to teach Upa Yoga, a subset of yoga designed by Sadhguru Jaggi Vasudev. Over 124 staff members of CRIDA actively participated in the event. The Upa Yoga postures are devised to give health, success, peace, wellbeing, joy, inner exploration and love. The seven sets of practices devised for increasing agility, strength in limbs, correction of posture of spinal cord, lumbar region, etc., were demonstrated to the participants.

14.1.3. Independence Day Celebration

The 71st Independence Day was celebrated on 15th August, 2017 with pride, patriotic zeal and gratitude towards the sacrifices of our freedom fighters. The Director hoisted the flag and addressed the staff of CRIDA. On this occasion Director distributed cash awards (CCS & CCRC) to the X class toppers of CRIDA staff children and motivated the staff with his message to work with dedication and boost institute's growth.

14.1.4. Sadbhavana Diwas

Sadbhavana Diwas was observed by ICAR-CRIDA on 18th August, 2017. Accordingly, a pledge taking ceremony was held on this occasion.

14.1.5. Hindi Fortnight Celebration

The Hindi Fortnight was organized from 1st to 14th September, 2017. On this occasion Hindi noting & drafting, Hindi-English technical, terminology, Hindi competitions were organized. Winners were awarded cash prizes on the concluding day.

14.1.6. Swachhta Hi Seva

Swachhta Hi Seva was organized at ICAR-CRIDA during 14th September to 2nd October, 2017. The inaugural day started with oath by all the staff and various activities were carried out under Swachhta Hi Seva. All the staff participated in the event for cleanliness in office premises and residential quarters. Trees were planted in KVK adopted village, HRF, GRF, CRIDA main office and residential complex. Samagra Swachhata Diwas Sharamadann was celebrated in KVK adopted village.

14.1.7. Training program on Efficient Watershed Management in Rainfed Agriculture

ICAR-CRIDA organized Watershed Development Department, Government of Karnataka Sponsored training program on Efficient Watershed Management in Rainfed Agriculture from September 19-23, 2017 at ICAR-CRIDA. Fifteen participants from the line department have participated in the event.

14.1.8. South Zone Sports Meet

ICAR-CRIDA contingent participated in ICAR South Zone Sports Meet held at ICAR-Sugarcane Breeding Institute, Coimbatore, Tamil Nadu from 9th to 13th October, 2017. Mr. Mukund, Technical Assistant secured 2nd place in 1500 meters cycle race.

14.1.9. Vanamahostavam

CRIDA Cultural and Recreation Club organized Vana Mahostavam at Hayathnagar Research Farm of the Institute on 28th October, 2017. All the CRIDA staff members actively participated in the cultural activities. The events generated great enthusiasm and unity among staff.

14.1.10. Vigilance Awareness Week

Vigilance Awareness Week was observed from 30th October to 4th November, 2017. Dr K Sammi Reddy, Director (Acting) in his address emphasized the importance of vigilance week and suggested all the staff to be vigilance week and suggested all the staff to be vigilant in day to day office activities. As part of vigilance awareness week Shri B Viswanath, Deputy Chief Vigilance Officer, South Central Railway delivered the lecture on My Vision : Corruption Free India on 2nd November, 2017.

14.1.11. ICAR Sponsored Short course on Tools on Monitoring, Evaluation and Impact Assessment of Rainfed Technologies and Development Programmes

ICAR Sponsored Short course on Tools on Monitoring, Evaluation and Impact Assessment of Rainfed Technologies and Development Programmes has been organized at ICAR-CRIDA, Hyderabad from 01-10 November 2017. Dr Y G Prasad, Director, ATARI Zone X was the Guest of Honour for the inaugural session. He addressed the participants about importance of Tools on Monitoring, Evaluation and Impact Assessment of Rainfed Technologies. Dr K Sammi Reddy, Director (Acting), ICAR-CRIDA highlighted the importance of the short course, and also highlighted significance of M&E for impact assessment of rainfed technologies in context of doubling farmers' income. Dr G Nirmala, Principal Scientist and Course Director briefed the objectives of the short course. The participants were from seven different disciplines of agronomy, horticulture, agricultural extension, agricultural economics, agriculture engineering, veterinary science, and agricultural statistics, etc. and represented 12 states across India. During the ten days of short course, the participants familiarized with topics like concepts and principles of M & E, results based management, theory of change, protocols for organic livestock interventions, impact assessment of KVK, IWDP and agricultural development programmes. For the valedictory program Dr R N Chatterjee, Director, ICAR-Directorate on Poultry Research, Hyderabad was the chief guest.

14.1.12. National Agriculture Education Day celebrations

ICAR-CRIDA celebrated National Agriculture Education Day on 3rd December, 2017 to mark 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. ICAR-CRIDA Celebrated National Agricultural Education Day by

organizing Essay writing competitions for Class VIII & IX students and Painting competitions for Class VI & VII students. Total 36 students from 12 different Kendria Vidyalaya Schools located in Hyderabad and Secunderabad participated in the competitions. Each school was represented by a three-member team.

Later students were taken to CRIDA Gallery on rainfed technologies, climate research facilities like Open Top Chambers. Dr R Nagarjuna Kumar, Scientist, welcomed the students, teachers, parents of the students, CRIDA staff and briefed about the celebrations of Nation Agriculture Education day.

The students from KV-AFS-Begumbet, KV-Kanchanbagh and KV1-AFA-Dundigal have won the 1st, 2nd, 3rd prizes respectively in Essay writing competition. The students from KV1-Uppal, KV-AFS-Begumpet, KV-Bowenpally have won the 1st, 2nd, 3rd prizes respectively in painting competition. Two Consolation prizes were given each in Essay writing and painting competition. To encourage the students, participation certificates were also given to all the participated students.

Dr K Sammi Reddy, Director (Acting), ICAR-CRIDA congratulated all students for their participation and especially those who won prizes. He appreciated the interest shown by the students and encouraged them to participate in many more competitions of this nature. Prizes and certificates were distributed to the winners in Essay writing and Painting competitions. In his address, he advised the students to choose agriculture science as a career option and also said that agriculture as a discipline which has huge opportunities and awareness of this has to be created through such science based programmes.

14.1.13. World Soil Day

ICAR-CRIDA celebrated World Soil Day on 5th December, 2017 at Rakamcharla village, Pudur Mandal, Vikarabad district under the Chairmanship of Dr K Sammi Reddy, Director (Acting), ICAR-CRIDA, Hyderabad. Around 200 farmers attended the Soil Health Card distribution program from the villages of Pudur cluster, Vikarabad district. Dr G Nirmala, Principal Scientist & Head, TOT and PI, FFP welcomed the participants and explained the objectives of the program organized on the occasion of World Soil Day. Shri Ram Mohan, Agricultural Officer from the Agriculture department oriented the farmers about soil testing facility, procedure of soil sample collection and analysis and usage of recommendations for higher crop yields. Sri Pentaiah, Village Sarpanch thanked for the CRIDA efforts in preparation and distribution of soil health cards and requested similar cooperation and support in future also. CRIDA scientists and extension functionaries from Agriculture department and Horticulture department interacted with the farmers. Farmer representatives shared their experience with the fellow farmers on the Soil Health Cards and its usage for nutrient management. 140 Soil Health Cards were distributed with the crop related recommendations to the farmers of Rakamcharla, Tirumalapur and

Devanoniguda villages of Pudur cluster under Farmers' First Project. Dr K Sammi Reddy, Director (Acting), ICAR-CRIDA explained the usage of Soil Health Cards and its interpretation for effective nutrient management in the field crops for sustainable crop yields. On this occasion farm literature on "Soil Health Cards", "Soil and Water Conservation measures" and "Nursery raising through portrays" were released by the dignitaries. Dr K Sammi Reddy along with CRIDA scientists reviewed the progress of Farmers FIRST project during the field visit.

14.1.14. International training on Strategies for Enhancement of Farmers Income in Dryland Agriculture

USAID and Ministry of External Affairs (MEA), India identified countries among those involved in GOI-supported development programs defined as Feed the Future-India Triangular Training Program (FTF-ITT). The MANAGE, Hyderabad is implementing this program in collaboration with various Subject Matter Institutions. Accordingly, the MANAGE, identified Central Research Institute for Dryland Agriculture (ICAR-CRIDA) as a potential institute to impart training on one of the important theme of "Strategies for Enhancement of Farmers Income in Dryland Agriculture". ICAR-CRIDA organized 15-days international training program (January 16-30, 2018) for 22 international executives representing seven African and three Asian countries. The international training was conducted in accordance with standard operating procedure for implementation of FTF-ITT as devised by the funding agencies.

The main aim of this training program was to enhance the human resources which in turn could assist in ambitious goal to achieve the food and livelihood security to the billions living in the rural and backward setups with following specific objectives:

- Generating economic growth and raising incomes of various Dryland agriculture based farm enterprises
- Scaling existing, proven technologies to benefit more people living in thematic area
- Increasing resilience of vulnerable communities and household practicing dryland agriculture

The training program was inaugurated by Shri Chhabilendra Roul, Special secretary (DARE) and Secretary (ICAR) in the gracious presence of Mrs. V Usha Rani, IAS, Director General, MANAGE, Dr K Sammi Reddy, Director (Acting), ICAR-CRIDA and Directors of various ICAR institutes located in Hyderabad. Participants were formally introduced to Special secretary (DARE) and Secretary (ICAR), Director General (MANAGE), Director (CRIDA), Directors of different ICAR Institutes and Scientists (in-house faculty) of CRIDA.

14.1.15. International Training Program on Rainwater Management for Climate Resilient Agriculture in Drylands

International Training Program on Rainwater Management for Climate Resilient Agriculture in Drylands was organized from 15th February-7th March, 2018 at ICAR-CRIDA, Hyderabad. This program was organized under India–Africa forum Summit-III and sponsored by Ministry of External Affairs. The executives from Nigeria, Ethiopia and Malawi participated in this training program.

Dr Anthony Whitbread, Research Program Director for Innovation Systems for the Drylands (ISD), ICRISAT, Hyderabad was the chief guest for valedictory function. Dr Whitbread mentioned the ICRISAT programmes in African Countries and he also emphasized the Agribusiness opportunities in African Countries.

Dr K Sammi Reddy, Director (Acting) briefed the various rain water management technologies developed by ICAR-CRIDA. He stressed on the point that as most of the participating countries have similar problems what India has, these technologies would very well fit in their countries for enhancing land and water productivity in their respective countries. Dr B Krishna Rao, Programme Coordinator, presented brief report about the training.

In this training broad areas covered were *in-situ* rainwater conservation, *ex-situ* rainwater harvesting and management, modern tools/ techniques/ models for rainwater management, crops/ agroforestry/ livestock/ fisheries management techniques for higher water productivity and socio-economic/ livelihood/ impact aspects of rainwater management.

Exposure and field visits to ICRISAT, ICAR institutes, WALAMTARI, Telangana State centre of excellence on Horticulture, Fisheries, progressive farmers' fields etc were made. A compendium of training material was also released. The trainee executives from African countries expressed that this training imparted very good knowledge, skills and information on rainwater management for climate resilient agriculture in drylands and got confident for successful replication of various rainwater management technologies in African countries.

14.1.16. One day workshop on Drought Monitoring Systems: Constraints and Opportunities

A workshop on Drought Monitoring Systems: Constraints and Opportunities was organized on 14th March 2018 by ICAR-CRIDA in collaboration with International Water Management Institute (IWMI). The workshop has been organized as part of ICAR-IWMI collaboration work plan.

The focus of the workshop was to understand the prevailing drought monitoring systems across

different states for monitoring meteorological, agriculture droughts etc. and the use of the remote sensing information for in-season monitoring of agriculture droughts and the methods being followed for integration of various information sources etc.

The workshop has been attended by Dr S K Choudhary, ADG (SWM), NRM Division, ICAR, Dr K Sammi Reddy, Director (Acting), ICAR-CRIDA and Dr A K Sikka, India Representative, IWMI, Experts from IWMI, representatives of States from Andhra Pradesh, Telangana, Karnataka and Tamil Nadu, Scientists from CRIDA, IARI, CAZRI, Central Government agencies (MNCFC, ISRO & IMD) and scientists from State Agriculture Universities (ANGRAU & PJTSAU).

Major recommendation of the workshop was to popularize the available drought monitoring products among various stakeholders particularly the line departments for initiating the drought contingency measures. Data availability and sharing, improving the available products with collaboration, validation of various products across project sites were also discussed.

14.1.17. Farmer – Scientist Interface and Web telecast of Krishi Unnati Mela

A Farmers – Scientists interface meeting was held at ICAR - CRIDA, Hyderabad on 17th March, 2018 at 10.00 AM. About 1000 farmers, scientists, technical officers and other officials participated in the meeting. All participants watched the live telecast of Krishi Unnati Mela.

Honourable Prime Minister inaugurated the Krishi Unnati Mela and Biennial National Conference of KVKs on 17th March 2018 at the campus of ICAR-Indian Agricultural Research Institute (IARI), New Delhi. He visited the exhibition stalls of Krishi Unnati Mela and interacted with the scientific personnel and appreciated the various technologies namely, apiculture, white shrimps farming, agri-waste management etc., Hon'ble Minister of Agriculture and Farmers Welfare, Sri Radha Mohan Singh ji in his welcome remarks acknowledged and appreciated the initiatives of Hon'ble Prime Minister in the welfare of farmers by enhancing the agriculture budget. Later, Hon'ble Prime Minister laid the foundation stone for 25 KVKs across the country in addition to the existing 688 KVKs. Out of new 25 KVK's, two KVKs at Adilabad and Medak of Telangana and one at Visakhapatnam of Andhra Pradesh are proposed. He also inaugurated the e-portal for organic farming namely jaivikhethi.com. He also felicitated the best performing states with respect to agriculture production, outstanding KVK for their technological interventions and the progressive farmers for their productivity.

At the outset he welcomed all the farmers, scientists and extension personnel who were present at the occasion and others viewing the web telecast across the nation. He mentioned that the awardees farmers would be inspiration to all farmers of the country who can also reap the higher productivity. He emphasized that farmers of the country are facing the new threats and challenges and to resolve these, a new holistic approach is required with an aim to achieve Doubling of Farmers' income by 2022. In this direction, more than 11 crore soil health cards have been distributed to improve the soil health and in turn offer the reduced chemical fertilizer use. He explained about the benefits of Pradhan Mantri Fasal Bima Yojana (PMFBY) which has enabled the farmers with lower premium and higher claim. Under Prime Minister Krishi Sinchai Yojana (PMKSY) several incomplete and pending irrigation projects have been successfully completed by investing 80,000 crore rupees. He emphasized for strengthening farmer market supply chain system and introduction of operation green system in which Tomato-Onion-

Potato (TOP) farmers would be benefited more.

Government of India is committed to fix the MSP to one and half times the cost of cultivation including land revenue and lease and family labour cost. The Government is strengthening the Farmer-Producer-Organization (FPOs) which will give value addition processing, marketing and also get income tax benefits in the lines of cooperatives. He urged the farmers to start organic farming by taking the inputs from e-portal for organic farming namely jaivikhethi.com. A total of 22,000 gramin haats to be upgraded and link to eNAM and APMC. He also described about the importance of apiculture, rearing of honey bees which have key role in the crop pollination and supply the honey. It can trigger the "Sweet Revolution" and has tremendous scope after Green, Blue and White revolutions as it offers addition income. Introduction of solar farming by utilizing the solar energy in crop production especially in the lift irrigation replacing the diesel pumps. More than 2.75 lakh solar pumps are now in use. He enumerated the new scheme "Gobar-Dhan Yojana" to use cow dung for producing gobar biogas, which is very cost effective and practical.

After this event, Farmer Scientist Interface was held under Chairmanship of Dr K Sammi Reddy, Director, ICAR-CRIDA. Sri Satyanarayana, Petroleum Conservation Research Association (PCRA), Sri N Gallaya, Surpanch, Narepally village and Sri M Babu, Surpanch, Gummadivalli village of RR district were present in the meeting. Sri Satyanarayana, opined that use of petroleum products should be optimised the alleviate the effects of environmental pollution. Use of biodiesel can be promoted to reduce the load on petroleum products. Sri N Gallaya, Surpanch, appreciated the efforts of CRIDA in Swachh Bharat Mission which was implemented in the village wherein the planting of several tress species was done as a part of afforestation. Sri M Babu, Surpanch, acknowledged the technological interventions of KVK, CRIDA in farm machinery component. At the end Director, ICAR-CRIDA explained the several ways to reach the objective of doubling the farmers income as emphasized by the Hon'ble Prime Minister.

14.1.18. Two day farmers' training on Action Learning Programme on farm Mechanization for Small Farm Holdings

The programme was held on 21-22nd March 2018 under project CRP-Farm Mechanization and Precision Farming. About 80 farmers from 8 districts of Telangana state attended the residential training. Training included the lectures on small farm mechanization, establishment of custom hiring centres, repair and maintenance of the machinery, etc. Hands on training was given on all the improved machinery which included land preparation equipments, Precision planter, Raised bed planter, zero till planter, Biomass shredder, Precision planter cum herbicide applicator, Power weeders, etc. All the farmers operated the implements on their own and learned the techniques involved in raised bed making, row based adjustment in sowing, usage of correct metering plate, inter-row weeding without less drudgery, etc.

14.1.19. Farm Machinery Industry Meet

An Industry meet was organized at CRIDA on 24th March 2018 to create the awareness regarding the improved implements developed by the ICAR institutions. Shri L Kishan Rao, Chairman, Telangana Agro Industry Development Corporation inaugurated the meet and addressed the gathering. Representatives from 45 industries attended the meeting and expressed their concern over present practices. Representatives from CIAE, Bhopal, IARI, New Delhi, Professor Jayashankar Agril. University, CRIDA presented their technologies which are commercialized and also under the commercialization status.

14.1.20. Inauguration of Climate Change Research Complex at ICAR-CRIDA, Hyderabad by Dr Trilochan Mohapatra, Secretary, DARE and Director General, ICAR

Dr Trilochan Mohapatra, Secretary, DARE and Director General, ICAR inaugurated the Climate Change Research Complex at Hayathnagar Research Farm, ICAR-CRIDA on 25.3.2018. The complex houses has three major state-of-the-art facilities *viz.*, Free Air Temperature Elevation (FATE) system, Carbon dioxide and Temperature Gradient Chambers (CTGC) and Supervisory Control and Data Acquisition (SCADA) based Automatic Rainfall Simulator and Lysimeter.

The Free Air Temperature Elevation (FATE) system is a research facility with elevated temperature conditions over ambient and intended to conduct various experiments controlling other parameters such as CO_2 enrichment and moisture deficit stress in intact ecosystems. The facility creates artificially induced high temperature through arrays of infrared heaters in open field conditions with uniformity of the thermal radiation and canopy temperature across the plot.

CTGC, a CO_2 Temperature Gradient Chamber, is a facility designed for measuring the impacts of elevated CO_2 and temperature which are vital parameters of climate change. The chamber is with field like environment with higher CO_2 and warming conditions concurrently which influence the crop growth and insect pests. This facility simulates the future climate change scenario conditions with both CO_2 enrichment and warming conditions.

SCADA based Rainfall Simulation Facility and Precision type Lysimeters with open top climate chambers for studying the Climate Change Impacts on Resource losses and Soil water balance. This can be used for quantification of runoff and soil erosion losses due to different levels of rainfall intensity and data generated can be used for modeling prediction in different climate change scenarios.

The concerned scientists of facilities explained about relevance technical and scientific issues of these facilities to Hon'ble DG who was accompanied by Dr S Bhaskar, ADG (AAF&CC), Dr K Sammi Reddy, Director (Actg.), ICAR-CRIDA. The event was graced by Dr B Venkateswarlu, VC, VNMKV, Parbhani; Dr V Praveen Rao, VC, PJTSAU, Hyderabad; Dr Y S Ramakrishna, Former Director, CRIDA, and Member, NICRA Expert Committee and Directors of local ICAR institutes in Hyderabad.

14.1.21. Contingency Preparedness Meetings

ICAR-CRIDA along with Department of Agriculture, Co-operation & Farmers Welfare and Department of Agriculture of respective states organized contingency preparedness meetings in the various states to operationalize district contingency plans for *kharif* 2017. The meetings were attended by State Agriculture Department officials, other line department functionaries, state agricultural universities,Program Coordinators of KVKs, representatives of local ICAR Institutes, AICRPDA, AICRPAM centers, farmers, press and media.

Details of State wise Interface Meetings

S. No.	State	Place	Organised on
1.	Karnataka	Vikas Soudha, Bengaluru	May 11, 2017
2.	Andhra Pradesh	ANGRAU, Lam, Guntur.	May 27, 2017
3.	Maharashtra	Department of Agriculture, Government of Maharashtra, Pune	June 2, 2017
4.	West Bengal,	Nabanna, Department of Agriculture, Government of West Bengal, Kolkata	June 6, 2017
5.	Rajasthan	Pant Krishi Bhavan, Jaipur	June 16, 2017

Karnataka

An interface meeting on enhancing the preparedness for agriculture contingencies in *kharif* 2017 for Karnataka was organized at Vikas Soudha, Bengaluru on May 11, 2017. Shri M Maheswara Rao, Secretary, Department of Agriculture, Government of Karnataka stressed on preparation of contingency action plans for each district by the respective district level officials and impressed upon the officials to intervene during the drought periods with various inputs and for plans for supplemental irrigation. Dr KV Rao, ICAR-CRIDA informed the status of monsoon and stressed upon the need for contingency preparation in view of expected below normal and above normal rainfall which, if not prepared well, leading to problems of drought and seasonal water logging in the state and advocated the measures for of preparedness and real-time contingency measures.

Andhra Pradesh

An interface meeting on enhancing preparedness for agriculture contingencies in Andhra Pradesh for kharif 2017 was jointly organized at ANGRAU, Lam, Guntur on May 27, 2017. Dr KV Rao, ICAR-

CRIDA informed purpose of the contingency interface meeting and region wise monsoon forecast for the state of Andhra Pradesh. Shri B Rajasekhar, Special Chief Secretary, Department of Agriculture, Govt. of Andhra Pradesh and Vice Chancellor, ANGRAU, while appreciating efforts to ICAR-CRIDA in conducting these interface meetings, requested the field level officials to gear up in view of the forecast to reduce agricultural distress in sensitive districts. Dr M Hari Jawaharlal, Special Commissioner, Department of Agriculture, Government of Andhra Pradesh emphasized on convergence of the programs including allied sectors of agriculture for ensuring livelihoods security. Ms. A Neeraja, Joint Secretary (RKVY), Government of India requested the State Government to send feedback along with necessary support from Ministry of Agriculture & Farmers' Welfare, Government of India.

Maharashtra

An interface meeting on enhanced preparedness for agriculture contingencies in Maharashtra for *kharif* 2017 was jointly organized at Pune on June 2, 2017. Dr S L Jadhav, Director (Extension), Government of Maharashtra, informed the status of *kharif* and *rabi* seasons in the state and the growth rates realized during the year 2016-17. Dr Shakeel Ahammed, Joint Secretary (MIDH), Government of India advised the officials to make necessary efforts to meet any contingencies through management practices during the season.

West Bengal

An interface meeting for enhancing the preparedness of agriculture contingencies in *kharif* 2017 for West Bengal was jointly organized at Nabanna, Department of Agriculture, Government of West Bengal, Kolkata on June 6, 2017. Dr KV Rao, ICAR-CRIDA presented the purpose of meeting as well as weather forecast analysis of West Bengal and emphasized the need for adequate preparedness for any contingent situation which may arise due to above normal rainfall. Dr RK Singh, Joint Director, Agriculture has proposed various contingency measures for *kharif* 2017 including development of small community seed bed in villages affected bydrought/floods in a contingency situation.

Shri Sanjeev Chopra, ACS, Deportment of Agriculture, Government of West Bengal appraised the satisfaction about the preparedness to tackle with contingent situation and advised the department officials to be prepared to meet agriculture contingencies. Shri Pradip Majumdar, Advisor to the Government of West Bengal advocated all JDAs of different divisions of the state to have a contingency plan in place and execute them in an effective manner so that farmers are least affected in case of drought/floods.

Rajasthan

An interface meeting on enhanced preparedness for agriculture contingencies in during *kharif* 2017 for Rajasthan was organized at Pant Krishi Bhavan, Jaipur on June 16, 2017. The meeting was Chaired by Sri Suresh Gautam, Additional Director and Dr P S Rathore, Vice Chancellor, SKNAU, Jobner. The meeting was attended by Dr Balraj Singh, Dr G L Keshava, Vice Chancellors and Directors (Res) and Director (Extn.) of other agriculture universities in Rajasthan, representatives of ICAR institutes, officials from Department of Agriculture KVKs. Dr KV Rao, ICAR-CRIDA informed the status of monsoon and stressed upon the need for adequate preparedness for any contingent situation which may arise due to below normal rainfall. Shri S K Hudda, Joint Director while presenting the agriculture situation during 2016 and agriculture plan for 2017, urged the department officials to modify agriculture plans and to prepare the contingency plans based on the forecast made for the *kharif* season.

14.1.22. Thematic Technical Program Finalization Meetings of NICRA Partner Institutes

The Technical Program Finalization Meetings of NICRA Partner Institutes for various thematic areas were organized. Detailed discussions were held and experts gave the suitable suggestions for the programme finalization. During workshop the annual progress was reviewed and future road map was discussed.

Details of the Technical Program Finalization Meetings of NICRA Partner Institutes

Sl. No.	Themes	Place	Date
1.	Crop Sciences Division	IIPR, Kanpur	May 11, 2017
2.	Technology Demonstration Component	ICAR-CRIDA, Hyderabad	May 18, 2017
3.	AICRPAM-NICRA	Dr BSKKV, Dapoli	May 22-23, 2017
4.	Fisheries and Animal Sciences	NASC, New Delhi	May 27, 2017
5.	NRM	KAB-II, New Delhi	June 8, 2017
6.	Horticultural Sciences Division	ICAR-IIVR, Varanasi	June 17, 2017

14.1.22.1. Technical Program Finalization Meeting - Crop Sciences Division

One day meeting was organized to discuss and finalize Technical Programme of NICRA Partner Institutes under the division of Crop Sciences on May 11, 2017 at ICAR-IIPR, Kanpur. The meeting was chaired by Dr N P Singh, Director, IIPR, Kanpur and co-chaired by Dr K Sammi Reddy, Director (Acting), CRIDA, Hyderabad. Dr N P Singh in his welcome address suggested formulating technical programme considering the reduced budget allocation for NICRA. He also advised to avoid duplication of work and the need for coordinated efforts between the partner institutes for effective outputs. Dr K Sammi Reddy, Director (Acting), CRIDA in his opening remarks emphasized the need to bring out tangible outputs from strategic research partner institutes which can be tested under Technology Demonstration Component (TDC) by KVKs across the country. He further requested the PIs for rationalization of available resources for optimum outputs and also suggested to make best use of the infrastructure established for climate change research. After detailed deliberations it has been decided to prepare a detailed technical programme for each institute along with monitoring indicators and submit to CRIDA for further processing.

14.1.22.2. Technical Program Finalization Workshop-Technology Demonstration Component

A one day meeting was organised on May 18, 2017 to finalise the programme for Technology Demonstration Component of NICRA. The meeting was chaired by Dr A K Singh, Deputy Director General (Agricultural Extension), ICAR and Co-chaired by Dr K Sammi Reddy, Director (Acting), CRIDA, Hyderabad.

Dr A K Singh emphasised the need for scaling up of the proven resilient practices and to address the complexity associated with the climatic variability. He stressed the NICRA villages be models for the climate resilience, doubling farm incomes, small farm mechanisation, low cost agriculture and integrated farming systems. Dr K Sammi Reddy, Director, CRIDA in his opening remarks explained the approach adopted and the work accomplished so far in TDC by KVKs. He expressed the need to focus towards achieving quantifiable outputs in the next phase. Dr S K Dhyani from NRM Division ICAR, explained the climatic variability in the country, the impacts of the NICRA programme and explored the opportunities for convergence with other developmental programs.

14.1.22.3. Technical Programme Finalization Workshop of AICRPAM-NICRA

The annual workshop of AICRPAM component of NICRA project was held at Dr Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli during May 22-23, 2017. The inaugural function was presided over by Dr Tapas Bhattacharya, Hon'ble Vice Chancellor, Dr BSKKV, Dapoli. Dr K Sammi Reddy, Director (Acting), ICAR-CRIDA, Dr S K Dhyani, Principal Scientist from NRM Division, ICAR, Dr M Prabhakar, PI (NICRA) and Dr U V Mahadkar, Director of Research, Dr BSKKV, Dapoli attended the function as guests of honour. Scientists from all cooperating centers and coordinating unit of AICRPAM and experts from CRIDA participated in the workshop. During the finalization of technical program, it was decided to extend the micro-level agromet advisory services to selected AICRPDA-NICRA villages and TDC-NICRA villages across the country. Dr Md Osman from CRIDA deliberated on various issues for implementation of proposed technical program at AICRPAM cooperating centres.

14.1.22.4. Technical Program Finalization Workshop of NICRA under Fisheries and Animal Sciences

A one-day Technical Program Finalization Workshop of NICRA-Partner institutes from Fisheries and Animal Science Division was held at NASC, New Delhi on May 27, 2017. The workshop was chaired by Dr Joykrushna Jena, DDG (Fisheries & Animal Science). In the inaugural address, Dr Jena reiterating the importance of NICRA project in bringing resilience to Indian Agriculture he suggested to take corrective measures based on lessons learnt in the past five years. He further highlighted the importance of Fisheries and Livestock in bringing the resilience under the changing climate. Dr K Sammi Reddy, Director (Acting), ICAR-CRIDA, Hyderabad in his opening remarks felt the need to bring more visibility of NICRA outputs among all the stakeholders and suggested to propose technical programme for the next phase of NICRA keeping in view the reduced budget and revised objectives.

14.1.22.5. Technical Program Finalization Meeting of NICRA Partner Institutes under NRM Division

One day meeting was organized on June 8, 2017 at NRM Division KAB-II, New Delhi to discuss and finalize Technical Programme of NICRA Partner Institutes under the division of Natural Resource Management. The meeting was chaired by Dr K Alagusundaram, DDG (NRM) and co-chaired by Dr KSammi Reddy, Director (Acting), CRIDA, Hyderabad. Dr K Sammi Reddy, in his welcome address highlighted

the importance of Natural Resource Management in the changing climate and the efforts made so far in the project. Dr S Bhaskar, ADG (AAF&CC) in his initial remarks suggested to revalidate the technologies developed under Strategic Research through KVKs under Technology Demonstration Component and bring visibility to project. Dr S K Chaudhari, ADG (SWC) complemented the outcomes of NICRA project and suggested to fine tune the technical programme in view of the budget restriction. Dr K Alagusundaram felt the need for extension of NICRA project for next three years and reiterated to study impact assessment of climate resilient technologies in the NICRA villages across the country. He further emphasized the need to address the issue of conservation of food in the changing climate.

14.1.22.6. Technical Program Finalization Meeting of NICRA Partner Institutes under Horticultural Sciences Division

A One-day Technical Program Finalization Workshop NICRA-Partner institute from Horticultural Science was held at IIVR, Varanasi. The workshop was Chaired by Dr A K Singh, DDG (Horticultural Science), ICAR and co-chaired by Dr K Sammi Reddy, Director (Acting), ICAR-CRIDA. Dr B Singh, Director, ICAR-IIVR, Varanasi in his welcome address appreciated the funding from NICRA in establishing climate change research facilities at IIVR. Dr M Prabhakar, PI, NICRA highlighting the achievements from Horticulture Division and briefed the purpose of the workshop. Dr K Sammi Reddy in his remarks requested to prioritize the resources in the next phase of NICRA and propose time bound activities with tangible outputs. He further suggested the need to bring more visibility to NICRA project by publishing outcomes in print & electronic media, short video clips of successful climate resilient technologies and involving policy makers in different NICRA programmes. Dr A K Singh in his opening remarks advised to address critical issues in different Horticulture crops while finalizing the technical programme. He suggested covering the major Horticulture commodities in the project so as to realize the national objective of doubling the farmers income by 2022.

14.1.23. Expert Committee Review of Research Projects

A two-day NICRA Expert Committee meeting was organized at NASC, New Delhi during October 23-24, 2017. Dr T Mohapatra, Secretary, DARE and DG, ICAR in his address set the road map for next phase of NICRA with outputs that have impact at national level. Progress of 13 ongoing projects from Competitive Grants and two projects under Sponsored component were reviewed under the Chairmanship of

Dr K Alagusundaram, DDG (NRM) and co-chaired by Dr S Bhaskar, ADG (AAF & CC). Dr K Sammi Reddy, Director (Acting), ICAR-CRIDA, Hyderabad presented the overview of progress under NICRA under CG and Sponsored components and the need for thorough monitoring of the progress by the expert committee. For each project a sub-committee of relevant members from NICRA Expert Committee was formed to mentor and monitor the progress of the projects. The committee deliberated on the identification of themes for inviting new proposals under Competitive Grants component for the next phase of NICRA. On this occasion, four publications from ICAR-CRIDA, Hyderabad *viz.*, Farm innovations in climate resilient agriculture, Up-scaling farm machinery custom hiring centres in India: A policy paper, "Roots of rainfed crops and Issues and remedies in rainfed farming" (in Hindi) was released by the Hon'ble DG, ICAR.

15. Distinguished Visitors

Dr K Alagusundaram, Deputy Director General (NRM) visited ICAR-CRIDA on August 16, 2017 to review the research activities and oversee the completion of Climate Research Facilities (FATE, CTGC and SCADA) at Hayatnagar Research Farm (HRF), Hayathnagar. Dr K Sammi Reddy, Director (Acting) along with Project Coordinators, Heads of Divisions/Sections, other Scientists, staff of Administration and Finance have accompanied the DDG to HRF. The DDG (NRM) expressed his satisfaction about the progress made in installation of Climate Research Facilities. He visited the farm machinery workshop and gave valuable suggestions for improving the workshop facilities.

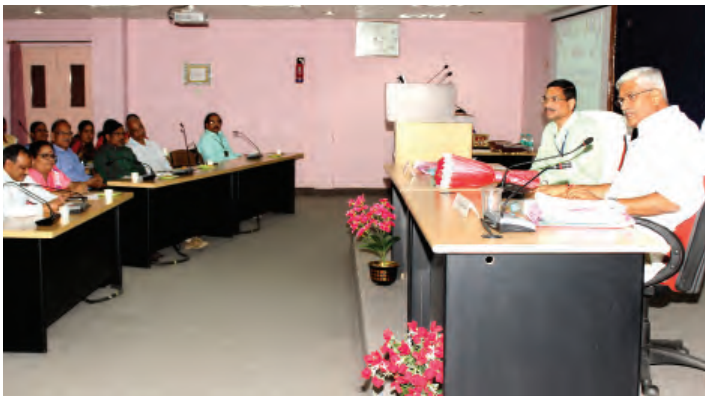
A **Canadian delegation** visited ICAR-CRIDA on November 17, 2017. The team interacted with the Director and Scientists of the institute. The team got acquainted with the technologies developed by the institute displayed in Dryland Gallery and were exposed to various research facilities present at ICAR-CRIDA.

Shri Chhabilendra Roul, Addl. Secretary, DARE & Secretary, ICAR visited ICAR-CRIDA on January 16, 2018. Dr K. Sammi Reddy, Director (Acting), ICAR-CRIDA welcomed Shri Roul and apprised him the activities and achievements of ICAR-CRIDA. Shri Roul addressed scientists and staff of ICAR-CRIDA and appreciated ICAR-CRIDA technologies, NICRA facilities and emphasized the need to create more impact of ICAR-CRIDA rainfed technologies and custom hiring centres on farmers' fields particularly in small and marginal famers' holdings in rainfed areas of the country. He visited CRIDA facilities such as Plant Phenomics, OTC and Dryland Gallery.

Later, he inaugurated the Feed the Future-India Triangular Training programme on "Strategies for Enhancement of Farmers Income in Dryland Agriculture". Smt. Usha Rani, Director General, MANAGE, Directors of ICAR Institutions situated in Hyderabad have also participated in the programme.

In the afternoon, Shri Roul visited newly established Climate Research Complex facilities (FATE, CTGC, SCADA), Krishi Vigyan Kendra (Ranga Reddy district) and dryland farm implements workshop at Hayathnagar Research Farm.

Hon'ble Minister of State for Agriculture and Farmers' Welfare, Government of India, Shri Gajendra Singh Shekhawat Ji visited ICAR-Central Research Institute for Dryland Agriculture, Hyderabad on March 24, 2018. At the outset, Dr K Sammi Reddy, Director (Acting) welcomed Shri Shekhawat Ji and briefed him about the mandate, organizational structure and major achievements of the Institute. Hon'ble Minister appreciated the accomplishments of the Institute. Later he interacted with the scientists on various aspects of rainfed agriculture research for development in the Country. He urged the scientists to address the issues of rainfed farmers in a holistic way. He felt that there is an urgent need to enhance the capacity of Indian farming community about the recent technological advancements for enhanced farm productivity. He explained the main motive of Mera Gaon Mera Gaurav (MGMG) programme while appreciating the efforts made by CRIDA under MGMG programme, wherein 15 groups of CRIDA scientists with 4 scientists in each group and adopted 15 villages, he suggested that the success stories of CRIDA has to be spread in these villages so that the net income of farmers is enhanced. He said that reverse engineering approach has to be adopted for doubling the farmers' income by 2022. He has advised the scientists to follow the 'Farm to Lab' approach instead of 'Lab to Land' approach so that research can address the actual problems faced by the farmers. He also informed that the Government is linking agriculture to global markets so that the Indian farmers can take the advantage of global market demands for their agriculture products. ICAR as an organization now should shift from 'farm to fork' to fork to farm' so that such agri-products could be promoted to increase farm income substantially. On this occasion, he also released two publications.



Dr Trilochan Mohapatra, Secretary DARE and Director General, ICAR visited ICAR-CRIDA, Hyderabad on March 25, 2018 to inaugurate the CTGC facility. This facility is the major one in Climate Change Research Complex at Hayathnagar Research Farm, ICAR-CRIDA. The complex houses three major state-of-the-art facilities *viz.*, Free Air Temperature Elevation (FATE) system, Carbon dioxide and Temperature Gradient Chambers (CTGC) and Supervisory Control and Data Acquisition (SCADA) based Automatic Rainfall Simulator and Lysimeter.

Other visitors

Officials

S. No.	Date of visit	Affiliation of Visitors	No. of visitors
1.	May 24, 2017	Agricultural University (GOCFAU-G)	38
2.	June 22, 2017	NAARM	45
3.	July 5, 2017	SAMETI	23
4.	October 3, 2017	NAARM (FOCARS), Hyderabad	40
5.	December 10, 2017	Karnataka State Dept of Agriculture	10
6.	December 28, 2017	Different Departments, Raichur, Karnataka	29
7.	February 7, 2018	New Recruited Agricultural Scientists from NAARM, PJ TSAU	48

Farmers

S. No.	Date of visit	Affiliation of Visitors	No. of visitors
1.	August 1, 2017	Madurai, Tamil Nadu	20
2.	August 22, 2017	ATMA farmers from Namakkal, Tamil Nadu	40
3.	August 22, 2017	ATMA farmers from Pudukottai, Tamil Nadu	27
4.	August 29, 2017	ATMA farmers from Betul (Jhadegovn) district, Madhya Pradesh	27
5.	August 30, 2017	ATMA farmers from Betul (Amla) district, Madhya Pradesh	26
6.	August 30, 2017	ATMA farmers from Betul (Chilcholi) district, Madhya Pradesh	30
7.	August 30, 2017	ATMA farmers from Betul (Barhapara) district, Madhya Pradesh	20
8.	August 30, 2017	ATMA farmers from Betul (Multai) district, Madhya Pradesh	27
9.	August 30, 2017	ATMA farmers from Betul (Banoor) district, Madhya Pradesh	25
10.	August 31, 2017	ATMA farmers from Betul (Ghododongri) district, Madhya Pradesh	65
11.	September 6, 2017	Farmers from Madhya Pradesh	20
12.	September 13, 2017	Cuddalore, Tamil Nadu	18
13.	September 13, 2017	Farmers from Ramanathapuram, Tamil Nadu	10
14.	January 24, 2018	Farmers from Belgavi, Karnataka	57
15.	February 7, 2018	Farmers from State Department of Agriculture, Betul, M.P	8
16.	March 12, 2018	Morappur Block, Dharmapuri district	21

Students

S. No.	Date of visit	Affiliation of Visitors	No. of visitors
1.	May 2, 2017	TNAU, Mettupalayam, Tamil Nadu	38
2.	August 23, 2017	PG College of Agricultural Sciences, Namakkal, Tamil Nadu	83
3.	September 12, 2017	Erode Pvt. College, TNAU, Tamil Nadu	52
4.	September 12, 2017	TNAU, Madurai, Tamil Nadu	100
5.	September 13, 2017	TNAU, Pudukkottai, Tamil Nadu	52
6.	September 13, 2017	Students from Tamil Nadu	55
7.	Octber 28, 2017	Students from HCRI(W), Trichy, Tamil Nadu	45
8.	November 14, 2017	Students from Adhiparasakthi Agril. College, Kalavai, Tamil Nadu	38
9.	November 17, 2017	Students from TRIAD, TNAU, Tamil Nadu	97
10.	November 17, 2017	IV Year B.Sc. Students (Horti) Kalvai, Tamil Nadu	71
11.	November 25, 2017	Students from Tanjavur, TNAU, Tamil Nadu	52
12.	November 28, 2017	Students from UAS, Bangalore	52
13.	November 29, 2017	Students from AA college, Vellore, Tamil Nadu	20
14.	December 15, 2017	Students form Kumulur, Trichy, Tamil Nadu	68
15.	December 16, 2017	Students from Koraikal, Puducherry	96
16.	January 6, 2018	Assam Agricultural University, Jorhat	19
17.	January 8, 2018	Students from Cornell University, New York	25
18.	March 20, 2018	B.Tech. (Agril. Engg) students from VNMKV, Parbhani	85
19.	March 20, 2018	Students from VNMKV, Parbhani	85
20.	March 23, 2018	DKS College of Agriculture, Bhatapara (IGKV, Chattisgarh), B.Sc. (Agril.) III year students	25

16. Personnel

Institute staff (As on March 31st, 2018); Not a gradation list

Director Cell	
Dr K Sammi Reddy	Director (Acting)
Shri M S R Anjaneyulu	Personal Assistant
Smt M Vanitha Raman	Personal Assistant
Shri Prem Babadur Karki	Skilled Support Staff
All India Coordinated Research Project for Dryland Agriculture (AICRPDA)	
Dr G Ravindra Chary	Project Coordinator
Dr K A Gopinath	Principal Scientist (Agronomy)
Dr Boini Narsimlu	Senior Scientist (Soil & Water Conservation Engg.)
Smt P Anantha V Rao	Chief Technical Officer
Smt N Lakshmi Narasu	Private Secretary
Shri N Manikya Rao	Skilled Support Staff
Shri S Shankara Reddy	Skilled Support Staff

All India Coordinated Research Project on Agrometeorology (AICRPAM)	
Dr P Vijaya Kumar	Project Coordinator
Dr Santanu Kumar Bal	Principal Scientist (Agri. Meteorology)
Dr A V M Subba Rao	Senior Scientist (Agri. Meteorology)
Dr Rajkumar Dhakar	Scientist (Agri. Physics)
Mr M A Sarath Chandran	Scientist (Agri. Meteorology)
Shri I R Khandgonda	Senior Technical Officer
Shri S Ratna Shankar Rao	Personal Assistant
Shri A Mallesh Yadav	Skilled Support Staff
Division of Resource Management (DRM)	
Dr K Sammi Reddy	Head
Dr K L Sharma	Principal Scientist (Soil Science and Agri. Chemistry)
Dr Kaushalya Ramachandran	Principal Scientist (Geography)
Dr G Rajeshwar Rao	Principal Scientist (Agro-forestry) upto dated: Feb 21, 2018
Dr K Srinivas Reddy	Principal Scientist (Soil and Water Conservation Engg.)
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 and Water Conservation Engg.)
Dr B Sanjeeva Reddy	Principal Scientist (Farm Machinery Power)
Dr Ravikant V Adake	Principal Scientist (Farm Machinery Power)
Dr Manoranjan Kumar	Principal Scientist (Soil and Water Conservation Engg.)
Dr B Krishna Rao	Principal Scientist (Soil and Water Conservation Engg.)
Dr R Rejani	Senior Scientist (Soil and Water Conservation Engg.)
Mr N S Raju	Scientist (Computer Applications in Agriculture)
Dr G Venkatesh	Scientist (Agro-forestry)
Ms Pushpanjali	Scientist (Soil Science and Agri. Chemistry)
Dr A K Indoria	Scientist (Soil Physics)
Dr V Girija Veni	Scientist (Soil Science and Agri. Chemistry)
Dr Sumanta Kundu	Scientist (Agronomy)
Mr Dhimate Ashish Satish	Scientist (Farm Machinery Power)
Shri Ram Kumar	Assistant Chief Technical Officer
Shri K Venkanna	Assistant Chief Technical Officer
Shri K L Prasad	Senior Technical Officer
Shri A Chandraiah	Technical Officer
Shri K Shankaraiah	Technical Officer
Smt V Renu	Personal Assistant
Shri B Krishna	Technical Assistant
Shri Mukund Chalkapur	Technical Assistant
Shri Golla Raju	Senior Technician
Shri Chakali Balaiah	Skilled Support Staff

Division of Crop Sciences	
Dr M Maheswari	Head
Dr N Narayana Reddy	Principal Scientist (Horticulture)
Dr S Desai	Principal Scientist (Plant Pathology)
Dr S K Yadav	Principal Scientist (Bio-chemistry)
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 Jyothilakshmi	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 (Agri. Entomology)
Dr M Manjunath	Scientist (Agri. Microbiology)
Dr A Gopala Krishna Reddy	Scientist (Horticulture)
Dr K Salini	Scientist (Plant Breeding)
Ms V Visha Kumari	Scientist (Agronomy)
Smt P Laksmi Narasamma	Assistant Chief Technical Officer
Shri Jainender	Assistant Chief Technical Officer
Smt D G M Saroja	Senior Technical Assistant
Smt B Saraswati	Personal Assistant
Shri S S Sishodia	Technical Officer
Shri P Satish	Technical Assistant
Shri Md Asif Ahmed	Skilled Support Staff
Section of Transfer of Technology (TOT)	
Dr G Nirmala	Head & Principal Scientist (Agri. Extension)
Dr D B V Ramana	Principal Scientist (Livestock Production & Management)
Dr K Ravi Shankar	Principal Scientist (Agri. Extension)
Dr K Nagasree	Principal Scientist (Agri. Extension)
Dr Prabhat Kumar Pankaj	Senior Scientist (Livestock Production & Management)
Dr Jagriti Rohit	Scientist (Agri. Extension)
Dr Anshida Beevi C N	Scientist (Agri. Extension)
Shri K Surender Rao	Chief Technical Officer
Smt V L Savithri	Senior Technical Officer (Economics)
Shri S Yadagiri	Technical Officer
Shri K Satthaiah	Technical Officer
Dr S R Yadav	Assistant Director (OL)
Smt M A Rekha	Personal Assistant

Section of Design & Analysis (SDA)	
Dr C A Rama Rao	Head & Principal Scientist (Agri. Economics)
Dr B M K Raju	Principal Scientist (Agri. Statistics)
Dr R Nagarjuna Kumar	Scientist (Computer Application in Agriculture)
Dr Josily Samuel	Scientist (Agri. Economics)
Smt C Kanaka Durga	Personal Assistant
Prioritization, Monitoring and Evaluation Cell (PME Cell)	
Dr Mohammed Osman	Head & Principal Scientist (Agro-forestry)
Dr S S Balloli	Principal Scientist (Soil Science)
Dr Arun Kumar Shanker	Principal Scientist (Plant Physiology)
Dr B M K Raju	Principal Scientist (Agri. Statistics)
Dr B Krishna Rao	Principal Scientist (Soil & Water Conservation Engg.)
Mr N S Raju	Scientist (Computer Applications in Agriculture)
Dr Josily Samuel	Scientist (Agri. Economics)
Mr M A Sarath Chandran	Scientist (Agri. Meteorology)
Shri Manish Tomar	Technical Assistant
Shri P Ramakrishna	Technical Assistant
Library	
Dr Arun Kumar Shanker	OIC
Shri G Prabhakar	Senior Technical Officer
Krishi Vigyan Kendra	
Dr V Maruthi	Head & Principal Scientist (Agronomy)
Dr S M Vidyasekhar	Chief Technical Officer (Plant Protection)
Smt A Vidyadhari	Assistant Chief Technical Officer (Home Science)
Dr D Sudheer	Senior Technical Officer (Veterinary Science)
Er S Vijaya Kumar	Senior Technical Officer (Agri. Engineering & Farm Implement)
Shri G Shrikrishna	Senior Technical Officer (Horticulture)
Smt G M Shashi Rekha	Stenographer (Grade-III)
Shri V Pandurangaiah	Skilled Support Staff
Hayathnagar Research Farm (HRF), Hayathnagar	
Dr K Srinivas	OIC
Shri S Srinivasa Reddy	Assistant Chief Technical Officer (Farm Superintendent)
Shri Ganesh Ramji Hedau	Assistant Chief Technical Officer
Shri Hemanth Sahu	Technical Assistant
Shri E Buchaiah	Technical Assistant
Smt Avula Lalitha	Skilled Support Staff
Smt N Indiramma	Skilled Support Staff
Shri Bantu Shankar	Skilled Support Staff
Shri B Kurmaiah	Senior Technician
Smt N Laxmamma	Skilled Support Staff
Shri J Mallesh	Skilled Support Staff

Gunegal Research Farm (GRF), Gunegal	
Dr S S Balloli	OIC
Shri Y Yellappa	Technical Officer (Farm Superintendent)
Shri K Rajeshwar	Technician
Smt B Anjamma	Skilled Support Staff
Agriculture Knowledge Management Unit (AKMU)	
Dr N Ravi Kumar	OIC
Shri P Chandra Sekhar	Assistant Chief Technical Officer
Works	
Dr Manoranjan Kumar	OIC
Dr R Nagarjuna Kumar	Member
Shri S Gopala Rao	Assistant Chief Technical Officer
Shri D Srinivas	Technical Officer (Electrical)
Shri B Anjaiah	Skilled Support Staff
Vehicle section	
Dr Ravikant V Adake	OIC
Shri K Ganesh	Technical Officer
Shri P Raju	Senior Technician
Shri K Shankar	Senior Technician
Shri Ahmed Pasha	Senior Technical Assistant
Landscape	
Dr A G K Reddy	OIC
Dr K Sreedevi Shankar	Member
Dr R Nagarjuna Kumar	Member
Shri Govinda Lingaiah	Technician
Administrative Section	
Shri B D Phansal	Chief Administrative Officer
Shri Saurabh Meena	Administrative Officer & D.D.O.
Shri V Sanu	Assistant Administrative Officer
Shri K Narsimha	Assistant Administrative Officer
Smt D Kalpana	Assistant Administrative Officer
Er C V K Nageswara Rao	Chief Technical Officer & S.P.O.
Shri K Shankar Reddy	Technical Officer
Smt K V Manikyam	Private Secretary
Shri S Ratna Shankar Rao	Personal Assistant
Smt G L Swathi	LDC
Shri B Kiran Kumar	Skilled Support Staff
Shri B Ramakrishna	Skilled Support Staff

Finance and Audit Section	
Shri A Srinivasamurthy	Senior Finance & Accounts Officer
Shri G Jagan Mohan Rao	Assistant Finance & Accounts Officer
Smt N K Anupama	Junior Finance & Accounts Officer
Shri Ch Srinivas	Senior Technical Officer
Shri M Krishna Reddy	Assistant
Shri K Gowtham Reddy	Assistant
Shri Putta Santosh	Assistant
Ms Sneha Verghese	Assistant
Shri M Yadaiah	Assistant
Shri V Venunath	LDC
Smt J Kavitha	LDC
Shri G Udaya Bhaskar	LDC
Shri G Anjaiah	Skilled Support Staff
Guest house	
Shri B D Phansal	In-charge
Shri D Shridhar	LDC
Shri Kesar Bahadur Karki	Skilled Support Staff
Shri K Chandraiah	Skilled Support Staff

हर कदम, हर डगर
किसानों का हमसफर

भारतीय कृषि अनुसंधान परिषद

Agrisearch with a human touch

Contact address

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जय किसान
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