Executive Summary

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During the year 2022, various experiments were conducted under Institute, National Innovations in Climate Resilient Agriculture (NICRA) and externally funded projects. There were also outreach programmes such as Farmer First Programme (FFP), Schedule Caste Sub Programme (SCSP), Tribal Sub Plan (TSP) and CRIDA-KVK activities in Ranga Reddy district, Telangana. The achievements of all the above activities and others are briefly highlighted below.

Resource characterization

- The district-based contingency plans (DACP) were prepared for 648 districts in the country and hosted on ICAR/DAC websites (http://agricoop.nic.in/acp. html, http://www.icar-crida.res.in/) and circulated to all state agriculture departments. A total of 514 DACPs have been updated till now.
- Groundwater recharge prospect was estimated qualitatively at the district level based on the weekly rainfall of *kharif* 2022. A medium to normal groundwater recharge prospects was estimated in about 452 districts and an extremely low to very low in about 135 districts out of the 675 districts analysed.
- Based on the quantification of the changes in annual rainfall across India for two time periods (1961-1990 and 1991-2020) made from grid -based rainfall information, an increase in rainfall was observed in eastern and western parts of India. Parts of central India and states covering UP, Bihar, Jharkhand, Chattisgarh received less amount of annual rainfall during 1991-2020 compared to 1961-2020. The maximum one-day annual rainfall had decreased in the states of Punjab, Haryana, UP, Bihar, parts of West Bengal, Rajasthan.

Rainwater management

- Changes in rainfall intensities, dry spells, extreme rainfall at daily interval and wet spells at 3-7-day interval were assessed and rainfall intensity, duration and frequency relations under different climate change scenarios were developed. It was observed that while there is an increase in rainfall observed in eastern and western parts of India, parts of central and states covering UP, Bihar, Jharkhand, Chattisgarh received less amount of annual rainfall during 1991-2020 compared to 1961-2020.
- The weather data for RCP 4.6 from 2020-2049 and the base data from 1971 to 2020 for Hyathnagar geo location, were analyzed for annual peak rainfalls to understand the behaviour of extreme rainfall patterns in the region. It was observed that during the base period of 50 years, there were common peak rainfall varying from 50 to 100 mm except in 2020 with 300 mm.

Crops and cropping systems

- Strip row intercropping system of Sorghum and Pigeonpea (4:4) with BBF yielded (798 kg pigeonpea seed equivalent per ha) on par with the Strip system without BBF (779 kg/ ha) as sorghum (CSV27) grain filling was affected by 13 days dry spell and pigeonpea (TDRG 4) yields did not significantly differed with the BBF measure. However, 60-110 kg horsegram seed and fodder from Relay horsegram was a bonus from the pigeonpea interrow spacing. Strip system of Sorghum + pigeonpea (4:4)- Relay horsegram within 6 pigeonpea rows performed better than the system with sequence horsegram in absence of rainfall during post monsoon season.
- Evaluation of low-cost approaches for management of Fall Army Worm (FAW), *Spodoptera frugiperda* in maize indicated that the mean incidence larval population during the vegetative and reproductive stages was lower in chemical and integrated treatments and was more evident in maize +cowpea intercropping system than sole crop of maize.
- The population of free-living nitrogen fixing bacteria and *Pseudomonas* spp. decreased with the reduction in soil moisture content from 22 to 4.7 %.
- TmapGen+ is an automated thematic map generating web-based software tool. Thematic map is generated based on the user input. Non-GIS users can visualize their biophysical and socio-economic data as thematic maps on the fly.

- The moisture deficit stress (MS) at flowering stage and elevated temperature (eT) individually and in combination reduced biochemical and physiological parameters of maize hybrids.
- Application of recommended NPK + foliar spray of nano-urea + nano-Zn + nano-Cu being on par with 75% or 100% recommended NPK + foliar spray of either nano-N alone or in combination with nano-Zn recorded significantly higher grain yield (3211 kg/ha) compared to other treatments. In another experiment, Application of Nano-DAP with $N_{75}P_{75}KZn$ (3090 kg/ha) and $N_{100}P_{100}KZn$ (3206 kg/ha) recorded marginally higher grain yield compared to recommended dose of fertilizer without Nano-DAP ($N_{100}P_{100}KZn$) (2996 kg/ha).
- Organic sources have increased fibre content of *rabi* sorghum seeds which has physical properties such as water holding capacity and adds bulk to the diet and increases transit time in the gut which delays digestion of food in stomach resulting in the delay in cholesterol absorption in human nutrition.
- The net carbon sequestered in agroforestry systems over the simulated period of thirty years was found maximum in *Melia dubia* based agroforestry systems 201.54 Mg C/ ha/yr and the least was noticed in aonla based agroforestry systems. 64.80 Mg C/ ha/ yr.

Soil and nutrient management

- An experiment was started on maize-pigeon pea crop rotation during 2012 at GRF, ICAR-CRIDA, Hyderabad. This year results showed that in maize crop, significantly higher mean grain yield recorded in no-tillage (2694.1 kg/ha) followed by reduced tillage (2466.4kg/ha) and conventional tillage (2231.6 kg/ha).
- During this year, application of recommended NPK + foliar spray of nano-urea + nano-Zn + nano-Cu being on par with 75% or 100% recommended NPK + foliar spray of either nano-N alone or in combination with nano-Zn recorded significantly higher maize grain yield (3211 kg/ha) compared to other treatments.
- During this year, application of recommended NP + 100% recommended K through POLY4 being on par with other treatments recorded significantly higher groundnut pod yield (1556 kg/ha) compared to application of recommended NP alone or in combination with 50% K through MOP or gypsum @ 500 kg/ha, and Control.
- During this year, field experiment on the addition of different doses of Ca-bentonite (150-200 mesh natural white colour) on maize crop was conducted. Results showed that treatment viz. 15 t Ca-bentonite/ha+75% (RDF) and 15 t Ca-bentonite/ ha+100% (RDF) found quite effective in improving the maize grain yield as compared to the other treatments.
- Raised bed and CF recorded 37 and 48% higher cotton crop yield as compared to flat sowing, respectively. Similarly, cotton crop yield was higher with 125% RDF as compared to 100% RDF and control treatments. Application of 100 and 125% recommended fertilizers recorded 59 and 66% higher yield as compared to no fertilizer application. 125% RDF recorded 16% higher yield as compared to 100% RDN.
- An experiment was initiated with the integration of *in-situ* moisture conservation with CA practice in maize-pigeonpea system in 2014. This year in the maize crop, integration of *in-situ* moisture conservation practices either through conservation furrow or bed and furrow method in both CA and conventional tillage has recorded higher yield as compared to no moisture conservation treatments. Among the conservation treatments permanent conservation furrow recorded higher yields.
- A field experiment was conducted every year since 2016 in sandy loam soil of Gunegal Research Farm at ICAR-CRIDA, Hyderabad. This year results revealed that in pearl millet (PM)-horsegram (HG) sequence-pigeonpea (PP) rotation, significantly higher yield was obtained in ZT (1100 kg/ha) compared to CT (831 kg/ha) in 2022. In this experiment, pooled data of 7 years (2016-2022) revealed that significantly higher pearl millet equivalent yields were obtained in minimum tillage (MT) with 125% RDF compared to zero tillage (ZT) and conventional tillage (CT).
- Assessed the soil quality parameters and developed the soil indices (SQI and RSQI) for predominant rainfed areas of Karnataka falling in AESR-6.2

under different crops and cropping systems. Results showed that in most of the case large farmers field recorded the high values of SQI and RSQI as compared to the small farmers field.

- A Pot study was conducted with baby corn (var-IMHB-1539) to evaluate the release pattern of P. In this study, it was found that the URP (Udaipur rock phosphate) application along with zeolite was at par with SSP in maintaining soil P availability at three different stages of crop growth, while HRP (Hirapur rock phosphate) maintained the lowest soil P availability during three different stages of crop growth.

Livestock management

- In an investigation carried out to fetch the benefit of crop residue into Total Mixed Ration (TMR) as well as fortify them with suitable additives to enable indigenous sheep to overcome heat stress it was seen that garlic skin powder, curry leaf powder and onion skin powder were added to the Dry TMR @ 3% as fortification option to provide endurance to heat stress during summer. The ration had Crude protein – 11.5%, Crude fat - 4 to 5%, and Crude fibre - 18 to 19% and had good palatability. An improved growth rate was observed in terms of ADG as 66g per day in Fortified TMR (FTMR) group as compared to 51g per day in Non-fortified TMR (NFTMR) group.

Energy management

- An autonomous platform was developed with boom sprayer and weeding attachment for raised bed planting system. Developed platform tested for LiDAR guidance system and found satisfactory.
- Sorghum and maize harvester were developed for Off-set mounting of tractor for cutting, conveying and windrowing units of harvester which can be operated by the PTO and mounted on 3-point hitch.
- A prototype of battery powered reaper was developed and tested for harvesting of short and bushy crops like soybean, safflower, chickpea, rice, greengram etc. It observed that developed prototype has a great potential to reduces the drudgery involved in manual harvesting.
- A prototype of solar powered prime mover developed with 1.5 hp BLDC motor. Two separate attachments of 3 tyne cultivator and 3 row planter was also developed and tested in field condition.
- The hydraulic system assisted weeding machine gave satisfactory results across different types of weed species and moisture contents with average field capacity of 0.5ha /hr.

Socio-Economic studies and transfer of technology

- Analysis of social network map of all the four villages showed denser network in treated villages as compared to control villages. It is also found that graph density, average degree and average clustering co-efficient values are high in treated villages. Moreover, average path length and modularity are low in treated villages representing more efficient communication in these villages.
- Livelihood diversification of farm household in pigeon pea growing areas has been assessed based on diversity index for farm and non-farm activities of various categories of farmers revealed that small and marginal farmers have higher diversity index when compared to medium and large farmers.
- Farmers FIRST project demonstrated the soil test based balanced fertilizer application (26-60-0-5 kg N-P20-K20-Zn/ha) in chickpea crop in eight farmer field which produced 43 per cent higher yield seed yield over the farmer practice (22.5-57-0-0 KgN-P_2O-K_2O-Zn/ha). Demonstration of improved fodder production and management with CO-4 and Super Napier varieties resulted in a yield of 175 t/ha, which has a potential to support almost 200 sheep.
- A framework was developed to study the wellbeing which consisted of five parameters viz material, health, social security, social relations and freedom.
- Through village studies developed inequality indices and implementation of different government schemes. Inequalities in per capita household income were less than owned land inequalities. The income from livestock, off-farm and non-farm incomes are more equal. Direct benefit transfers have become the main mode of government support to small farmers.

- Productivities of important rainfed crops for rainfed and irrigated production systems were estimated at State level. A new measure developed for assessing yield sustainability of treatments/ practices evaluated in long term experiments was further improved.

Scheduled Caste Sub Programme

- As a part of "Annadata Devo Bhava" Campaign under AZADI KA AMRUT MAHOSTAV, celebrating 75 years of India's Independence, an awareness programme on "Balanced Fertilization for Soil Health Maintenance and Productivity Enhancement" was organized at Mallampeta village of Kotapally mandal of Mancherial district.
- Kadaknath birds (250 nos.) along with feed material were distributed to 40 households in Bhoparam village of Kotapally mandal for backyard poultry farming. The intervention has the potential for not only income generation but also nutritional security. The farmers could able to generate additional income through the selling of birds.
- An improved variety of red gram (PRG-176) was introduced in the cluster of eight villages of Kotapally mandal to increase the cropping intensity and soil health. To increase the area under red gram, 750 kg seeds (each 3 kg bag) distributed to 250 farmers during June 2022.
- Four stroke petrol engine power sprayers (27 nos.) were distributed to selected villages of Kotapally namely, Kondampet, Bopparam, Alugama, kotaplly, Eddabandam, Paripally, Pinnaram, Esanvai, Saraivapeta, Shetpally, Laximipur, Repanpally and Nakkalapally under custom hiring mode.

Tribal Sub Plan

- ICAR-CRIDA has developed Development of Tribal Rural Livelihood Resource Centre (TRLRC) to cater for the purpose of (i) seed and input storage and distribution, (ii) farm implements, (iii) hatchery, (iv) record keeping and office activities and (v) providing working space for shelf help group formed under TSP. Under this a multipurpose and versatile building premises was constructed to be used as a mini observatory for recording of rainfall, maximum and minimum temperature and relative humidity.
- Training and demonstration on the true representative collection of the soil samples were conducted in different villages. Farmers were trained on the proper collection of soil samples and tagging. About 113 soil samples were collected so far from the different farmer's field and analyzed for different plant nutrient parameters at CRIDA.
- About 20 farmers attended the National Seminar on "Harnessing the Potential of Panchabhutas (tatvas) for Sustainable Climate-Resilient Rainfed Agriculture" during September 28-29, 2022 at ICAR-CRIDA, Hyderabad. Farmers were provided knowledge on rainwater management, soil health management in rainfed agriculture and the importance of the Panchabhutas: Akash, Vayu, Agni, Jal, and Prithvi in sustainable agriculture.
- About 50 farmers from different TSP villages of Adilabad attended the International Conference on "Reimagining Rainfed Agroecosystems: Challenges and Opportunities" during December 22–24, 2022 at ICAR-CRIDA, Hyderabad.

All India Coordinated Research Project for Dryland Agriculture

- In semiarid Vertisols at Arjia, tillage with vibro chisel plough recorded the highest grain yield (3145 kg/ha) with higher net returns (Rs.50771/ ha), B:C ratio (2.62) and rainwater use efficiency (RWUE) (4.30 kg/ha-mm) along with the lowest soil loss of 14.2 t/ha, whereas tillage with cultivator recorded highest soil loss (18.6 t/ha) and maximum energy use efficiency (18.6 MJ/ha).
- At Jagdalpur, the application of two supplemental irrigations of 5 cm each (sprinkler) from harvested rainwater to chickpea gave significantly higher seed yield (1498 kg/ha) with higher net returns (Rs.60440/ha) and B:C ratio (2.75) compared to one irrigation (1168 kg/ha).
- At, Ballowal Saunkhri, in a PMT initiated in 2009, during *kharif*, significantly higher yield of maize (3711 kg/ha) was recorded with application of NPK (100% RDF) + FYM 10 t/ha but it was at par with all other treatments (100% NPK (DAP), 100% NPK+ S (SSP),100% NPK+ZnSO4, 50% NPK + FYM 10 t/ha, 150% NPK, 100%N through FYM and 100%N through FYM+ biofertilizers except control.

- At Indore, in a soybean-chickpea system, application of FYM 6 t/ha + N20 P13 kg/ha produced higher soybean seed yield (1080 kg/ha) with higher net returns (Rs.28100/ha), B:C ratio (2.37) and RWUE (1.35 kg/ha-mm).
- Subhumid Inceptisols at Ballowal Saunkhri, significantly higher maize grain yield was recorded with complete mechanization (3967 kg/ha) as compared to farmer's practice (3262 kg/ha) but was on par with partial mechanization (3763 kg/ha). The WUE 6.68 kg/ha-mm, net returns (Rs.43906/ha) and benefit-cost ratio (2.15) were found higher under complete mechanization

All India Coordinated Research Project on Agrometeorology

- A study on vegetation responses to meteorological drought in agricultural fields at different stations of Gujarat indicated that no significant association exist between SPEI and NDVI at Anand. This suggests crop conditions have a low dependency on monsoon wetness. However, at Bhuj, the vegetation condition of crop fields was found to be significantly responsive to the wetness of September (SPEII and SPEI2) and agricultural crop conditions during *kharif* and *rabi* seasons near Bhuj, largely dependent on the wetness of August and September months.
- At Bhubaneswar, the percentage probability for the occurrence of meteorological drought was computed for 30 years (1991-2020) at the block level for the districts of Kalahandi and Nuapada. The probability of occurrence of moderate droughts at different blocks of Kalahandi district ranged from 7 to 27 % while it was 10 to 17% in Nuapada district.
- At Jorhat, an analysis was carried out to assess the drought severity in 27 districts of Assam state using SPI with two-time scales (annual and southwest monsoon) for the period of 28 years (1988-2015) revealed that in extreme drought condition (SPI less than -2.0) was not witnessed in any districts of the state during the study period.
- Climatic water balance was worked out for Parbhani on a weekly basis and the results revealed that Moisture Availability Index increased from 24 SMW and declined from 42 SMW. The total length of the growing period was 19 weeks i.e. from 24 to 42 SMW at Parbhani.
- Bt cotton Balwan recorded a significantly higher seed cotton yield (1019 kg/ha) than hirsutum cotton AKH 081 (859.50 kg ha^{-1}) and arboreum cotton AKA 7 (767 kg/ha) at Akola. Thermal use efficiency was found to be higher for monsoon-sown crop (28 June) with respect to both seed cotton and biomass production and it decreased in subsequent late sowing.
- At Raipur, the highest RUE was recorded by three treatments (0.67 g/MJ) viz., Vaibhav sown on 10 Nov, JG-16 sown on 25 Nov and JG-14 (ZC) sown on 10 Dec. JG-16 sown on 10 Dec recorded the lowest RUE of 0.21 g/MJ across the treatments.
- Crop simulation model CERES-millet which was calibrated predicted the phenology, biomass yield and final grain yields well within the limits. The D-index values showed for anthesis, maturity days, LAI, grain yield and above-ground biomass were 0.97, 0.99, 0.99, 0.91 and 0.91, respectively.
- A simple weather-based disease prediction model for cotton leaf curl virus disease was developed by the Hisar centre. The optimum range of weather parameters with the progression of maximum PDI value from 22 to 45 SMWs was analyzed and found to be 32.3 to 36.3 °C (maximum temperature), 24.5 to 29.6 °C (minimum temperature) and 73.2 to 86.7.0 per cent (morning relative humidity) and 7.0 to 9.1 hrs (bright sunshine hours).
- The Dynamic Crop Weather Calendar (DCWC), a decision support system developed by AICRPAM has been validated for 75 districts in the country for major crops grown in the respective districts.

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

- The elevated crop canopy temperature (eT) and eCO_2 along with eT ($eT+eCO_2$) has minimum influence on the phenology of days to 50 per cent flowering of black gram genotypes, except with IPU-094-1 where an earliness of 4 days was recorded under $eT+eCO_2$ condition. The eT reduced photosynthetic rate, stomatal conductance and transpiration rate of all four black gram genotypes. The eT significantly impacted biomass

and yield components. The reduction in seed yield was mainly due to reduction in pod and seed number revealing that high temperature impacted both flowers to pod conversion and seed set.

- In potato the tuber size, biomass, yield, and marketable yield of potatoes cultivated under varying CO_2 concentrations and temperatures were analyzed. There were significant differences in the number of small (< 30 g), medium (30–80 g), and large (> 80 g) potatoes. The tuber size was greater under eCO2 than under the Control, eCO2+ eTemp conditions and smallest under eTemp conditions.
- Nutritive value of groundnut haulms in terms of CP and digestibility decreased under elevated temperature and elevated temperature and carbon dioxide environmental conditions.
- Plant abiotic stress images were classified with pre-trained image classification model VGG-16 and obtained 56% accuracy with limited dataset.
- The impact of *e*CO_2 and *e*Temp on primary parameters of *Spodoptera frugiperda* (J.E. Smith) in maize indicated that higher consumption of foliage and higher larval weights at interactive levels of both dimensions with an extended larval duration which was found to decrease with *e*Temp.
- Higher percent increase in the annual number of generations of *H. armigera* on pigeonpea was predicted to occur in FDP (7.65 to 37.83 percent) over the baseline, followed by the DP (7.47 to 21.89 percent) and NP (5.25 to 9.51percent) periods with a reduction of generation time across the four RCP scenarios. Among locations, more number of generations of *H. armigera* with reduced generation time are likely at Coimbatore and Warangal locations.
- Black gram genotypes showed high variation in terms of its physiological efficiency both under well-watered and water deficit stress conditions. Black gram genotypes PDU-1, IPU96-7 and IPU13-5 were found to be superior in yield performance as compared others.
- Nitrous oxide (N_2O) emissions factor (%) was significantly low under high pasture block of the experimental field compared to the low and medium pasture blocks and higher during rainy season. The mean estimated emission factors from the present study were lower than the IPCC (1996) default value for cattle.
- Adaptation interventions such as change of variety and foliar nutrient application enhance yield resilience to drought in soybean and chick pea in Ahmednagar district of Maharashtra.
- Assessed future climate for 2050s/2080s for RCP 8.5 at district level. Compared to baseline of 1976-2005, climatic shifts are observed in 45 districts (8.62% of the geographical area in the country) in 2050s and 87 districts (15.33% of the geographical area in the country) in 2080s as per RCP 8.5.
- Historical climate data (Precipitation, Maximum temperature and Minimum temperature) at daily scale till 2020 sourced from IMD at grid level was compiled and brought to district level.
- Adaptation interventions such as change of variety and foliar nutrient application enhance yield resilience to drought in soybean and chick pea in Ahmednagar district of Maharashtra.

Technology Demonstration Component (TDC)

- During the year, deficit rainfall of 78% in June, 51% in July and 35% in August were observed in NICRA village Tenar, Garhwa district of Jharkhand. The *kharif* season received 553 mm (38% deficit) rainfall in 43 rainy days. Delayed onset of monsoon was observed in the NICRA village delaying the sowing of *kharif* crops.
- To reduce the impact of water logging in lowlands, KVK has demonstrated flood tolerant variety Swarna sub-1. The variety experienced submergence conditions at the time of sowing and tillering stage. The flood tolerant variety produced higher yield of 56.6 q ha-1 compared to the farmer's variety 42.5 q/ha with higher net income.
- Drought tolerant and short-duration varieties of maize (DHM-121), black gram (PU-01), sorghum (CSV-15) and intercropping systems of maize + black gram (DHM-121 + PU-01) in 2:2 ratio were demonstrated in Dholikhera NICRA village of Bhilwara district of Rajasthan . The varieties produced higher yields up to 42% compared to local varieties and obtained a net income of Rs.21,000 to 40,000/ha.

- Direct seeding of rice (DSR) method was demonstrated In Chandauna village of Darbhanga district of Bihar for taking up timely sowing as the district received deficient rainfall during the year. The soaked seeds were directly sown in the field without nursery raising and water saving. Demonstrations were taken up in 40 farmer's fields. The DSR resulted in 15% higher yield and 38% higher net returns over the transplanting method in comparison to non-NICRA farmers.

Women in agriculture

- Various programmes like National Girl Child day, International women's day, Poshan Vatika along training on different livelihood generation activities for farm women were conducted by the Institute for women in agriculture.

Human Resource Development (HRD)

- During the year, 15 scientists, 5 technical and 2 finance staff participated in various training programmes as a part of human resource development.

Participation of staff in conferences, meetings, Workshops, Seminars and Symposia

- The scientists of the institute participated in 100 different Conferences, Meetings, Workshops, Seminars and Symposia during this year.

Awards and recognitions

- The Institute received three awards and sixteen scientists received awards, fellowships and recognitions from national academies, professional societies and other institutions.

Publications/Software/Websites/Database

- Ninety seven research articles (international/ national peer reviewed journals), other publications books, reports, bulletins, training manuals, brochures, including 40 book chapters were published and mobile apps were also developed. The contributions of scientists also appeared in the form of several policy papers, popular articles, leaflets, presentations in conferences and radio programmes. Developed/ maintained software, websites and databases at Institute.

CONTENTS

Introduction 1

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

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

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

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

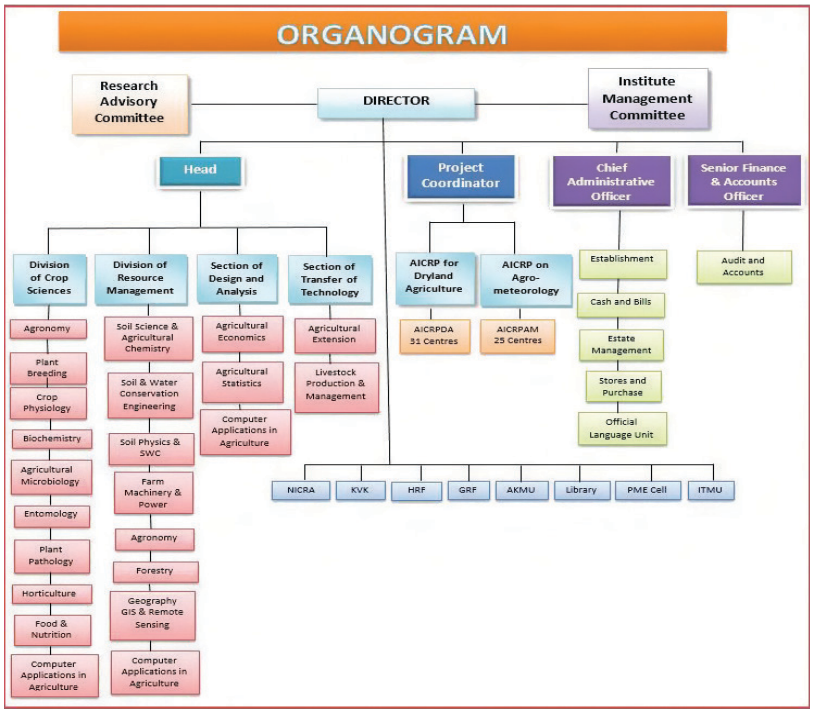
Mandate

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

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

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

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



Infrastructure

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

Research Farms

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

Hayathnagar Research Farm HRF

Gungal Research Farm GRF

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

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

CRIDA Annexe building

CRIDA Annexe building

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

Conference hall in the annexe building

State of art Climate Research Facilities

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

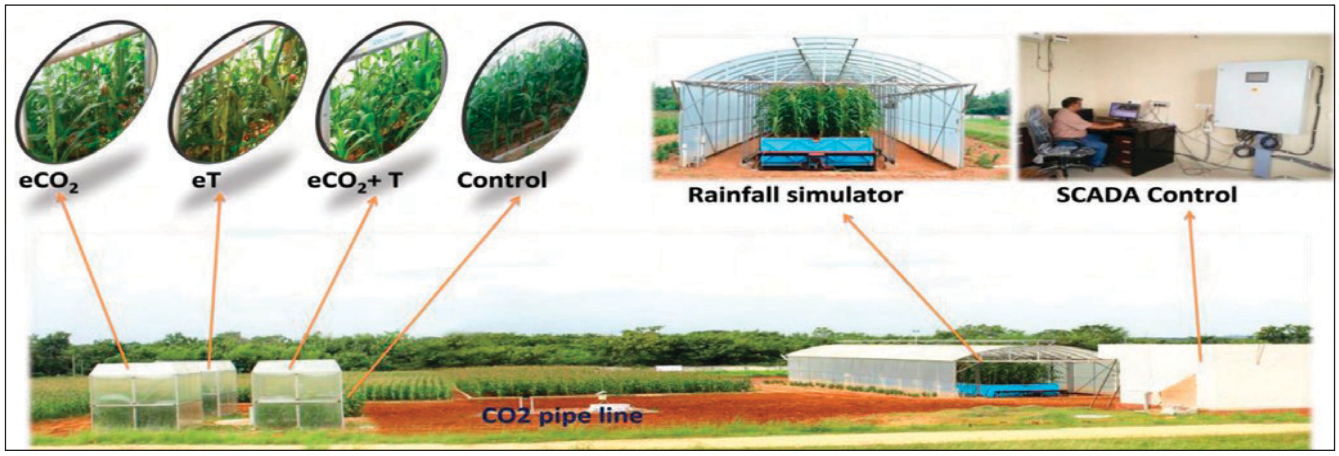
Free Air Temperature Elevation (FATE) facility: This research facility with elevated temperature conditions over ambient is intended to conduct controlled experiments with other manipulative parameters such as CO_2 enrichment and moisture deficit stress on intact ecosystems under natural environmental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

FATE facility

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

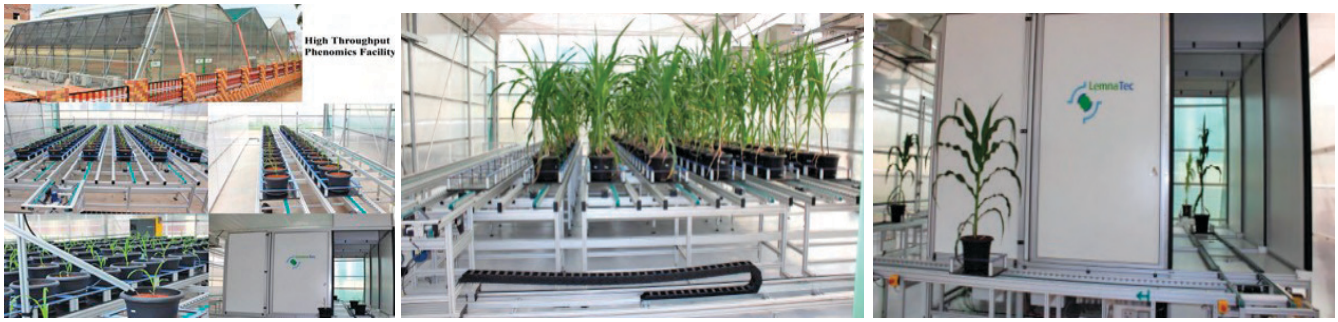
CTGC facility

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



SCADA based rainfall simulation and precision type lysimeters facility

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



Phenomics facility

Open Top Chamber facility: Six Open Top Chambers were set up to assess the impact of elevated CO_2 concentration on crops and soils.

OTC facility

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

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

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

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

Agro-met data bank

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

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

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

Central laboratory

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

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

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

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

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

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

Plant molecular biology laboratory

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

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

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

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

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

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

Dryland Gallery

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

Auditorium

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

Agriculture (CeRA) to access 2000 plus scholarly peer-reviewed journals from the renowned publishers in the disciplines of agricultural and related sciences.

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

Financial Statement for 2023 as on 31st March 2023 (*Rupees in lakhs)*

CRIDA		AICRPDA		AICRPAM	
Sanctioned	**Utilized**	**Sanctioned**	**Utilized**	**Sanctioned**	**Utilized**
4277.20	4277.20	2244.68	2244.68	792.69	792.69

Research Highlights

2

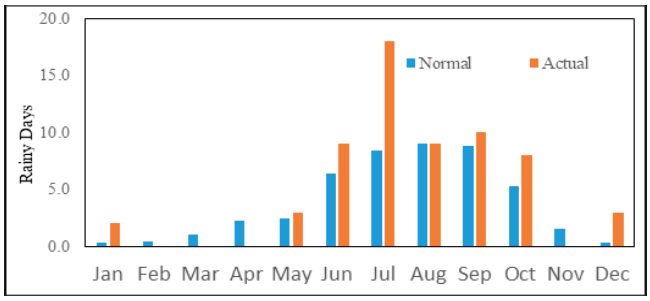
2.1. Resource characterization

2.1.1. Weather conditions at Hayathnagar Research Farm (HRF)

At HRF, the total annual rainfall during 2022 was 1026.4 mm which was 37 per cent higher than normal (751 mm). During the winter season, 15 mm rainfall was recorded in January, while no rainfall was received during February. During the summer season (March-May), 45 mm rainfall was recorded which was 41 per cent deficit than normal (77 mm). Excess rainfall was received during southwest monsoon (June-September) season, i.e. 769 mm which was 43% more than normal rainfall of 529 mm. 197.4 mm rainfall was received during post-monsoon (October December) season which was 44 per cent higher than normal rainfall of 136.8 mm. During post-monsoon season, above normal rainfall was received in October (177.1 mm) and December (18.8 mm) months when compared to normal rainfall of 112.5 mm and 3.8 mm, respectively. While in November, 92 per cent large deficit rainfall was recorded than the normal rainfall of 20.8 mm.

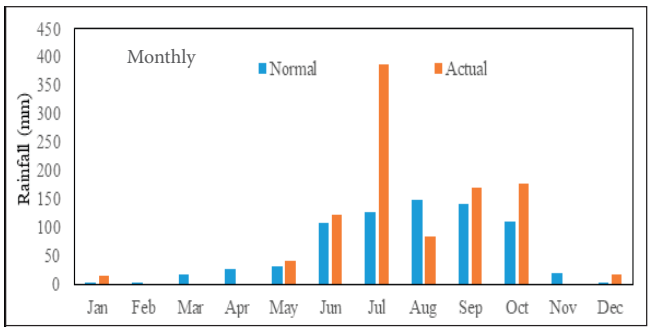
The southwest monsoon (June-Sept) rainfall was distributed in 46 rainy days while the annual rainy days were 62. The month-wise rainy days during southwest monsoon 2022 were June (9 days), July (18 days), August (9 days) and September (10 days).

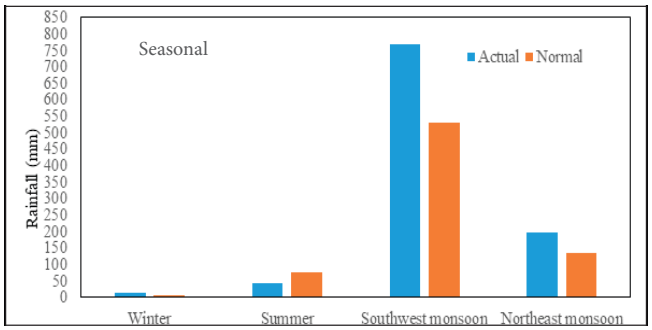
The country as a whole received 925 mm rainfall during the southwest monsoon season, 6 per cent excess than the long period average (LPA) of 869 mm.



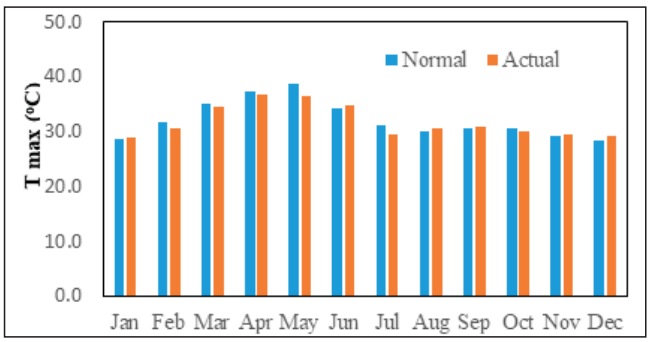
Month-wise actual and average rainy days at Hayathnagar Research Farm, CRIDA

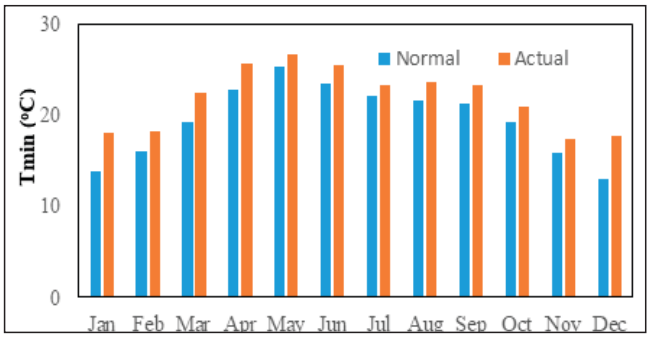
During the year 2022, the monthly average maximum temperature was above normal during January, June, August, September, November and December months while the below normal maximum temperature





Monthly and Seasonal rainfall in mm in Hayathnagar Research Farm, CRIDA



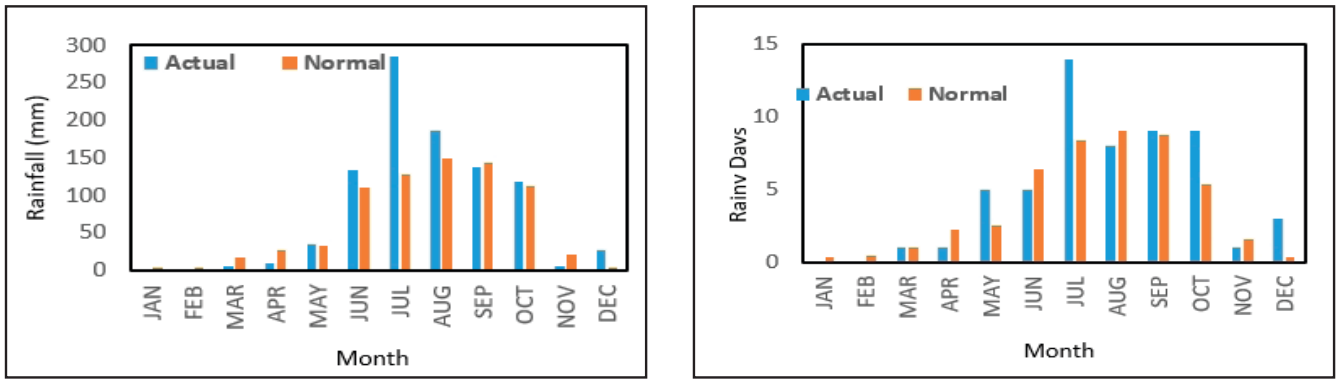


Month wise maximum and minimum temperature at Hayathnagar Research Farm, CRIDA

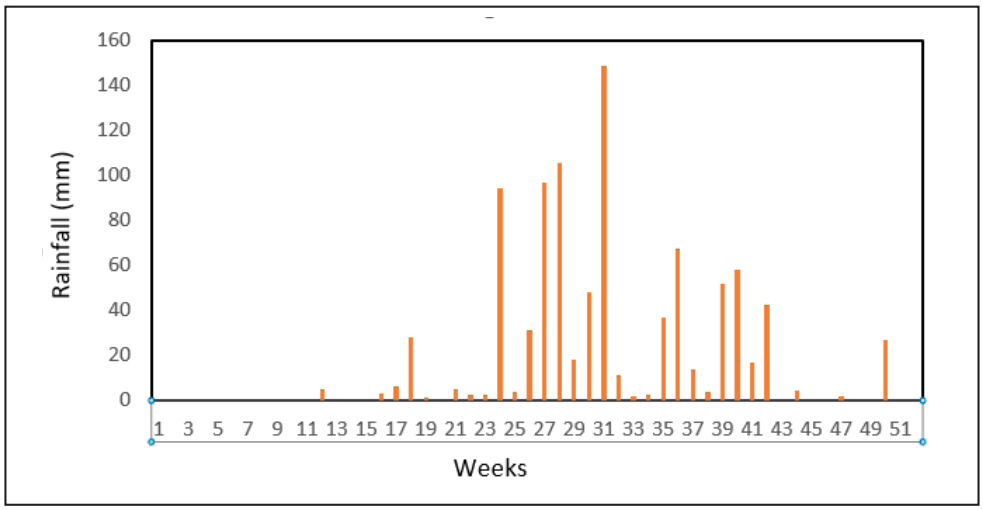
was recorded in other months. The highest positive deviation in monthly average maximum temperature from normal was observed in December (0.8°C) followed by August (0.6°C). At the same time, the average monthly maximum temperature was 2.3 and 1.7°C lesser than normal in May and July, respectively. The monthly average minimum temperature was above normal in all months during the year 2022. The highest positive deviation in monthly average minimum temperature from normal was observed in December (4.7°C) followed by January (4.1°C), March (3.1°C).

2.1.2. Weather conditions at Gungal Research Farm (GRF)

The total annual rainfall during 2022 was 968.4 mm which was 29 per cent excess than the normal (751.1 mm) at Gungal Research Farm. Among the seasons, the winter season (Jan-Feb) was the driest (0 mm) followed by the summer season (Mar-May), during which a rainfall of 49 mm was received against the average rainfall of 08 and 77 mm, respectively. During the southwest monsoon season (June-Sept), 741.6 mm rainfall was received and it was 40 per cent more than the normal rainfall of 529.5 mm. During this season, July and August months experienced excess rainfall than normal (July 123 per cent and August 23 per cent) while lesser than average rainfall was received in September (-4 per cent). An amount of 150.4 mm rainfall was received during the post-monsoon season (Oct-Dec) which was 10 per cent more than the normal rainfall of 136.7 mm. Regarding the distribution of rainfall, southwest monsoon rainfall was distributed in 36 rainy days while the average number of rainy days was 30. In the case of summer and post monsoon seasons, rainfall was received in 7 and 13 rainy days, respectively. The highest number of rainy days was observed in July (14) followed by September (9), October (9).



Monthly rainfall distribution and number of rainy days during 2022 at GRF

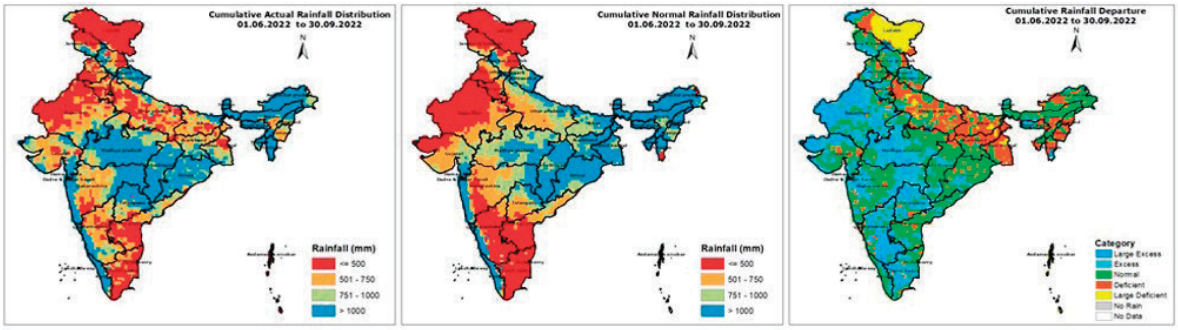


Weekly rainfall received at GRF

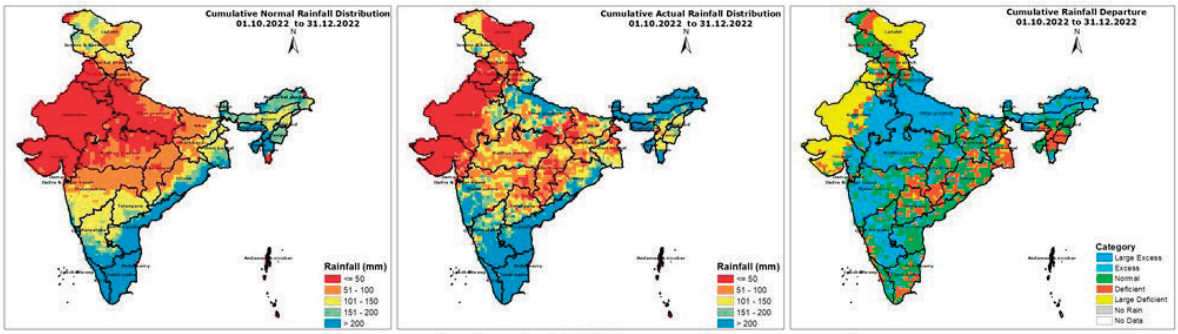
2.2. Rainwater Management

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

A collaborative project between ICAR-CRIDA, Hyderabad and IWMI, Sri Lanka was carried out as part of ICAR-IWMI work plan to 1) validate the South Asia Drought monitoring system index (IDSI) for rainfed and irrigated agriculture for selected drought prone sub-districts on developmental scale, 2) evolve mechanism of linking spatial drought information with drought management planning on near real time basis at sub-district level and district level and develop spatially distributed integrated drought mitigation plans including supply, augmentation and demand management interventions as improved preparedness to drought proofing, and 3) develop and recommend protocol for drought monitoring and mitigation with inbuilt contingency measures including capacity development. Monsoon season (both south west and north east) for rainfall departures, dryspells and maximum dryspell during the season were monitored. District based normal, actual and departure from normal was estimated for each district and for whole India is given in the following figures.



Seasonal monitoring of rainfall from June to September



Seasonal monitoring of rainfall from October to December

Categorization of districts (as per IMD criteria) based on normal rainfall and actual status during *kharif* season 2022

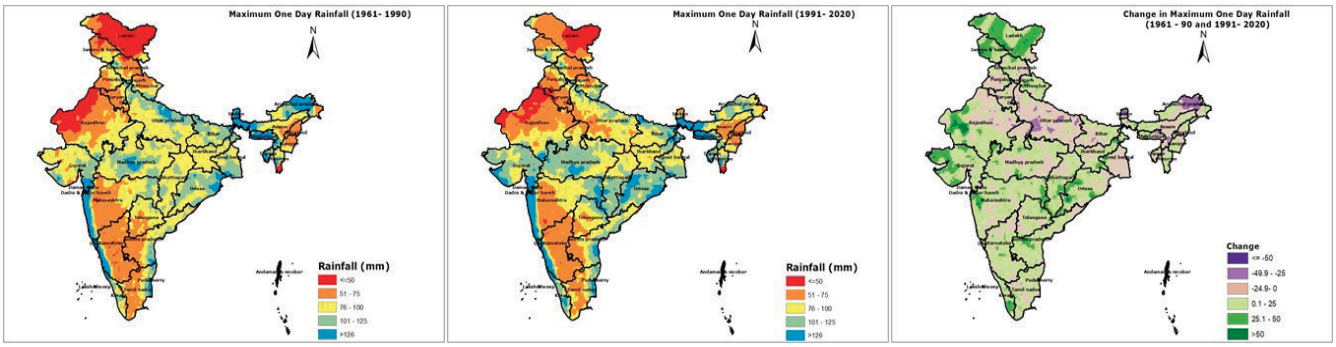
Normal Rainfall (mm)	LD	D	N	E	LE	No. of Districts
<500	5	21	42	39	39	146
500-750	9	40	49	37	9	144
750-1000	1	80	63	36	16	196
1000-1500	1	33	70	25	1	130
>1500	1	13	53	10	1	78
No. of Districts	17	187	277	147	66	694

2.2.2. Prioritized water conservation options and designs considerations under climate change scenario

Changes in rainfall intensities, dry spells, extreme rainfall at daily interval and wet spells at 3-7-day interval were assessed and rainfall intensity, duration and frequency relations under different climate change scenarios were developed. The major objectives were 1) To assess the runoff potential at sub district level across India for different cropping systems and 2) To prioritise and redesign the water harvesting systems (both *in-situ* and *ex-situ*) for different agro ecologies.

Based on grid based rainfall information, quantification was made for changes in annual rainfall across India for two time periods i.e. 1961-1990 and 1991-2020. While there is an increase in rainfall observed in eastern and western parts of India, parts of central and states covering UP, Bihar, Jharkhand, Chattisgarh received less amount of annual rainfall during 1991-2020 compared to 1961-2020.

Maximum one day annual rainfall is increased in many districts across the country. In the states of Punjab, Haryana, UP, Bihar, parts of West Bengal, Rajasthan, the maximum one day annual rainfall had decreased.



Changes in maximum on day rainfall for two time periods of 1961-1990 and 1991- 2020

2.2.3. District Agricultural Contingency Plans (DACP)

ICAR (through NRM division and CRIDA), based on the suggestion of The Parliamentary Consultative Committee on Agriculture, Food, Civil supplies and Consumer Affairs, Government of India (GOI), along with agricultural universities and KVKs developed contingency plans at district level for 650 districts spread across all the 126 agro-climatic zones of the country to deal with weather related aberrations. The district based contingency plans are prepared for 650 districts in the country and hosted on ICAR/DAC websites **http://agricoop.nic.in/acp.html, http://crida.in/** and circulated to all state agriculture departments during interface meetings. A total of 514 DACPs have been updated till now.

During the year 2022, following the forecast of India Meteorological Department (during April and May) and SASCOF (during April), from above normal rainfall condition to normal condition, interface meetings were organised across six states (Rajasthan, Maharashtra, Jharkhand, Gujarat, Telangana and Karnataka) during the season.

During the season, normal to above normal monsoon was witnessed in many states, deficient to large deficient monsoon was observed in states of Uttar Pradesh, Bihar, Jharkhand, West Bengal and parts of North East Region. However, these states received above normal rainfall during the months of October to December in large number of districts facilitating better *rabi* prospects. Since the commencement of organization of interface meetings for operationalization of contingency plans from 2014, a total of 61 meetings were held across different states.

2.2.4. Groundwater recharge prospects

The rainfall distribution coupled with total rainfall greatly influence the ground water recharge during the monsoon period. Since the exact estimation of groundwater recharge would require considerable time and large quantities of data, a qualitative estimation of groundwater recharge prospects due to rainfall was devised by interpreting the rainfall received on a week

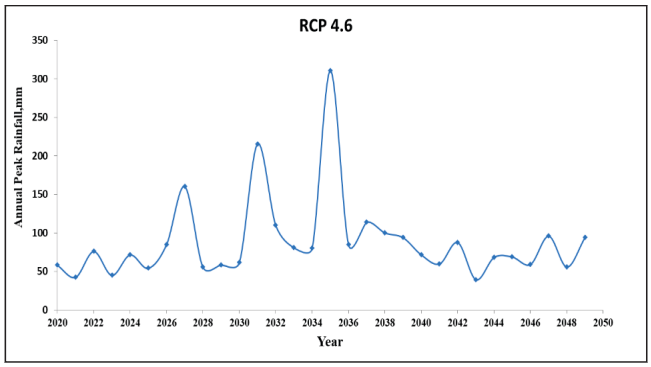
to week basis at district level. For example, if scanty rainfall is received in more than 65% of weeks or deficit rainfall is received are more than 80% of weeks on cumulative basis, the recharge possibility is considered to be extremely low.

Rainfall data available from IMD (www.imd.gov.in) during the current monsoon was utilized for the analysis purpose. Based on the above criteria analyzed for about 675 districts in major states of the country, groundwater recharge due to monsoon rainfall was medium to normal in about 452. Extremely low to very low ground water recharge prospects was estimated in about 135 districts.

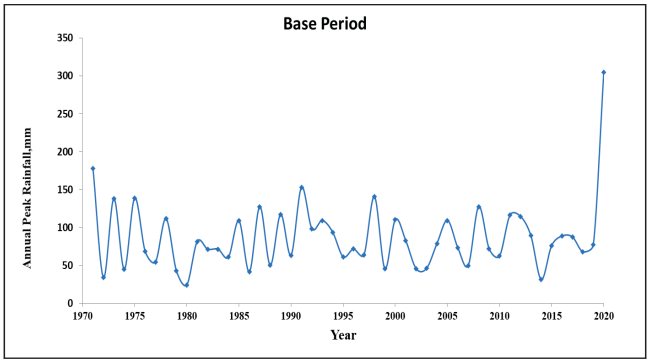
2.2.5. Peak rainfall analysis for developing Intensity-Duration-Frequency curves for RCP 4.6

The weather data for RCP 4.6 from 2020-2049 and the base data from 1971 to 2020 for Hyathnagar geo location, were analyzed for annual peak rainfalls to understand the behaviour of extreme rainfall patterns in the region. It was observed that during the base period of 50 years, there were common peak rainfall varying from 50 to 100 mm except in 2020 with 300 mm. However, during the period from 2020 to 2049 (30 years), there were three peaks of rainfall varying from 150 to 300 mm at an increment of 5 years alternatively happening in the time series. After mid year of RCP 4.6, the peak rainfall drastically reduced with the range of 50 to 100 mm indicating no regular pattern of peak rainfall in the region.

The above weather peak data were analyzed using IMD1/3 rule, probability analysis and frequency analysis using extreme gumbel distribution, the Intensity-Duration and Frequency curves for Hyathnagar were constructed as presented in the following figures for

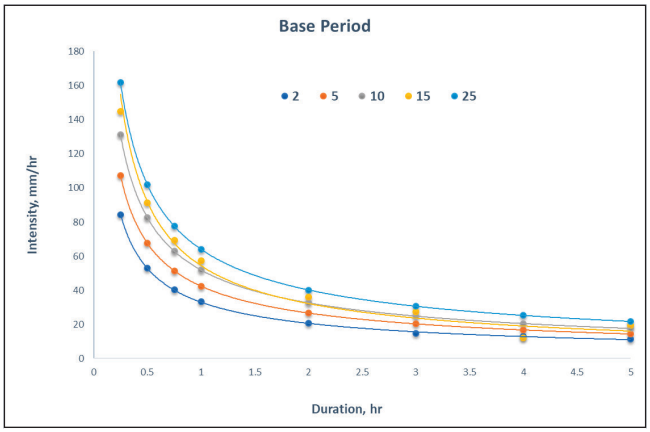


Annual peak rainfall for RCP 4.6 scenario during 2020 to 2049

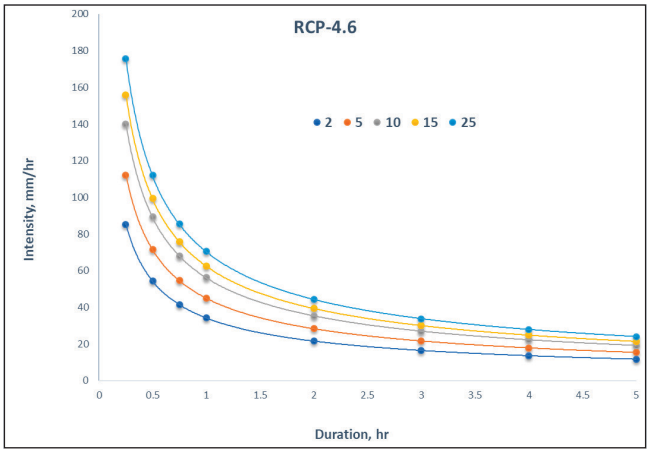


Annual peak rainfall in base period during 1971 to 2020

understanding the extreme rainfall intensities in the region. The peak rainfall was split into intensity for different durations (0.25, 0.5, 0.75, 1.0, 2.0, 3.0, 4.0 and 5.0 hrs) for different frequencies (2, 5, 10, 15, 20, 25). The analysis indicated that the intensities are maximum at all frequencies in RCP 4.6 having increasing trend in the intensities for all time durations. The average increase observed in RCP 4.6 was 7.93% over the base period intensities. However, the maximum increase was observed in lower durations of 0.25, 0.5 and 1 hr.



Intensity -Duration - Frequency curves for RCP 4.6 scenario



Intensity-Duration - Frequency curves for the base period

2.3. Crops and cropping systems

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

Maize is mostly cultivated under rainfed condition during *kharif* season in India. The rainfed maize crop often get exposed to various abiotic stresses specially drought. Drought stress at anthesis-silking initiation and grain filling stages causes significant yield losses in maize. Although number of hybrids are available in the seed chain, but these are mainly developed for irrigated system. The performance of hybrids under drought stress is very low as compared to irrigated system. Developing drought tolerant hybrids with better water use efficiency is very important to feed the ever-increasing population. Identification of drought tolerant inbred, hybrids for water deficit conditions is paramount to break the yield plateau in stress prone rainfed condition. Identification of morpho-physiological traits associated with drought stress and using them in evaluation of genetic resources will be critical in crop improvement program.

Seventeen experimental hybrids were evaluated under rainfed conditions during *kharif* 2022. The flowering and yield related traits such as days to anthesis (DA), days to silking (DS), anthesis silking interval (ASI), plant height (PH), cob height (CH), cob length (CL), cob girth (CG), row number per cob (RNC), seed number per row of cob (SNR), cob weight (CW), hundred seed weight (HSW), fodder weight (FY) and grain yield per plant (GY) were recorded. In another experiment, thirty selected recombinant inbred lines (RILs) of the mapping population (HKI161/SNJ201126) were evaluated rainfed conditions. A third experiment was conducted consisted of thirty short listed selected genotypes for identifying tolerant genotypes under rainfed conditions.

The grain yield among hybrids varied from 85.15 – 117.50 g/plant. Among hybrids evaluated SNJ2011-26/SNJ2011-37, HKI7660/SNJ2011-26, SNJ2011-37/RJR-385, RJR-385/SNJ2011-37, HKI-161/RJR-385, Z101-15/HKI-161, HKI-161/SNJ2011-26, SNJ2011-26/Z101-15 performed comparatively better than other hybrids. The selected thirty RILs also showed high variation for grain yield and yield attributes.

In another experiment where 30 genotypes were evaluated, showed high variation for yield and its attributes. Among these genotypes, Z-101-15, SNJ-2011-70, DTL-4-1, DTL-2, Z-96-5, RJR-385, SNJ-2011-37 performed better than others.

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

Horse gram [*Macrotyloma uniflorum* (L.) Verdc] is an important drought hardy, climate resilient dual-purpose rainfed crop adaptable to grow in poor soils with very minimum or nil input and after care. It is the cheapest source of protein, vitamins, minerals and dietary fibre for the rural and tribal population. It is known as a poor man's pulse because it is consumed only by the less privileged population of the society. The unfavourable taste and flavour of the cooked products and more cooking time are few of the reasons behind its less popularity. In addition to this, it contains some anti nutrient factors like phytates, poly phenols etc. These anti nutrient factors were found to be antioxidants and play beneficial role in reduction of coronary heart diseases, diabetes and obesity.

This year twenty-two genotypes of horse gram genotypes including six checks were evaluated in RBD under rainfed conditions at HRF. Days to 50% flowering ranged from 53-70 days, plant height from 52.17 to 98.6 cm, number of branches per plant ranged from 3.6 to 9.2, number of pods per plant ranged from 31.4 to 146, pod weight per plant ranged from 2.47 to 9.37g, pod length per plant from 4-5 (cm), seeds per pod from 4-7, hundred seed weight from 2.55 to 3.51g and seed yield from 2.4 to 4.97g. Variability analysis revealed high variability for number of pods and low or medium genotypic coefficient of variation for most of the characters. Highest heritability was observed for days to 50% flowering, followed by number of pods and seed yield. The characters days to 50% flowering, number of pods and pod weight were highly correlated with seed yield. Twenty-two genotypes were divided in to 7 clusters and the clusters V and VII were solitary. The character days to flowering contributed maximum towards genetic diversity followed by days to flowering, number of pods, hundred seed weight, seed yield and pod weight. Days to 50% flowering and number of pods

were positively and significantly correlated with seed yield per plant. Pod weight recorded significant positive correlation with plant height and number of pods per plant. Number of pods per plant showed significant positive correlation with days to 50% flowering and plant height. Seeds per pod was highly significantly correlated with pod length.

Evaluation of horse gram germplasm from ICAR-NBPGR

Around hundred germplasm received from ICAR-NBPGR regional station, Hyderabad was evaluated in augmented block design at Hayathnagar Research Farm. Data was recorded on yield and yield parameters. Scoring for yellow mosaic virus was also done.

Evaluation of mutant population

Three released varieties of horse gram CRIDA 18R, CRHG-19 and CRHG-22 were treated with two doses of EMS (Ethyl Methane Sulfonate) *viz.*, 0.2 and 0.3%. The surviving plants of M_1 population were harvested on single plant basis and the seeds were sown separately on separate rows to advance the generation. M_2 population was evaluated for biometrical characters and selected plants were harvested on single plant basis to advance to the next generation.

Evaluation of F_2 and F_3 population of horse gram

Generation advancement of 9 F_2 crosses and 12 F_3 crosses of horse gram were carried out. Single plants were selected, data were recorded and harvested. There was lot of variation for yield and its attributes.

Multilocation trial of horse gram

Twelve entries including three released varieties of CRIDA as check were evaluated in RBD in three replications at HRF. The entries HG-22-23 was earlier in flowering and maturity and the entry HG-22-15 recorded longest days to flowering and maturity. HG-22-19 was the highest yielding entry followed by HG-22-22 and HG-22-23.

Breeder seed production of released varieties

Breeder seed production of CRIDA released varieties *viz.*, CRHG-19, CRHG-22 and CRIDA 18R were carried out and about 12 quintal breeder seed is produced during this year.

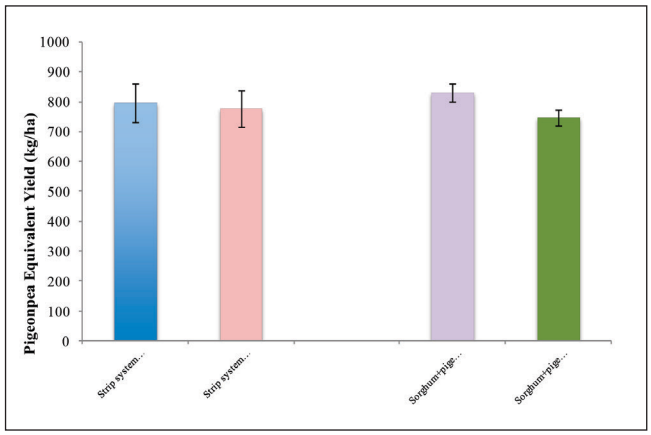
Field view of germplasm evaluation

Field view of mutant population evaluation

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

An experiment on evolving mechanized operations other than the mechanized sowing of strip row intercropping systems (already established) in cropping systems suitable for rainfed lands (for which), along with the soil and water conservation measure of BBF was carried out in Hayathnagar Research Farm during the year 2022. As a bonus opportune crop (either as a relay crop or as a sequence crop in place of harvested medium duration cereal/millet crop/short duration legume), horsegram in this case, with mechanized management operations was also tried. CRIDA nine row planter with a bar of 2.7 m was used for the successful sowing of the system and also the BBF planter was used successfully. The test crops were sorghum/bajra, pigeonpea and horsegram as an opportune crop. In this experiment, performance of

strip row intercropping system with BBF was compared with the strip row intercropping system without BBF. Both the sorghum and pigeonpea crop yielded on an average 3-4q and 4-5q per hectare respectively in addition to fodder yield from both sorghum and horsegram. In spite of two high rainfall events occurring during the first 40 days of the cropping period, there was no noticeable difference in grain production between the strip row intercropping systems with BBF and those without BBF for the rainfall distribution in 2022. These high rainfall events have negative impact on retention of BBF in rainfed Alfisols. Pigeonpea as a cash crop component did not perform well with reduced plant height (120-135 cm), declined branch number (10-12) due to rainless period from mid-October to mid-December besides it being a medium duration crop. Sorghum performed well while relay horse gram did not suffer from lack of sunshine in the pigeonpea rows.



Pigeonpea seed equivalents (kg/ha) of 4:4 Sorghum and Pigeonpea strip row intercropping systems with and without Broadbed and Furrow, with the opportune horsegram relay or sequence cropping during 2022

Field view of 4:4 Sorghum and Pigeonpea strip row intercropping systems- Kharif 2022

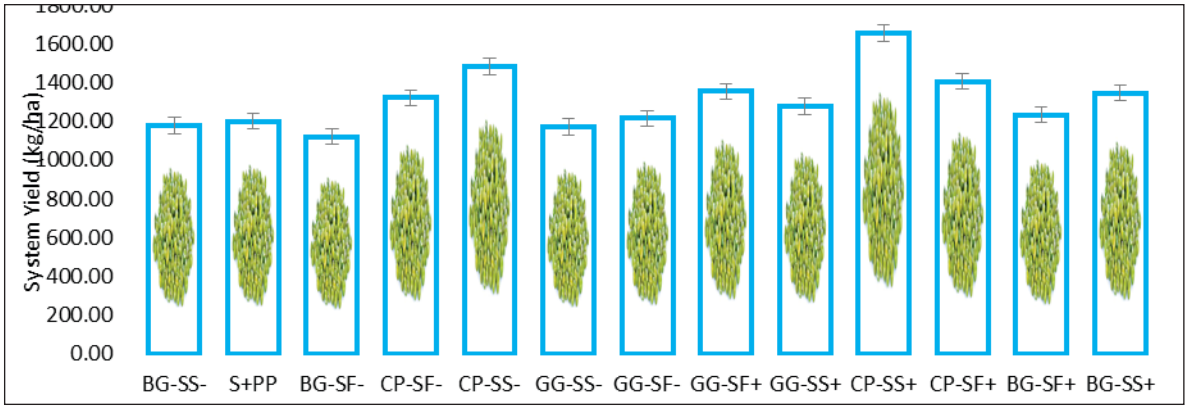
2.3.4. Development of resource efficient climate resilient cropping system in rainfed Alfisols

A field experiment was carried out with 13 pulse-oilseed cropping system to identify a remunerative and climate adaptive double cropping system and to quantify the effect of rain water management and rotation benefit on partitioning of assimilate and safflower yield. The systems were green gram-safflower (without rainwater management), green gram-safflower (with rainwater management), cowpea -safflower (without rainwater management), cowpea -safflower (with rainwater management), black gram -safflower (without rainwater management), black gram-safflower (without rainwater management), green gram-sesame (without rainwater management), green gram-sesame (with rainwater management), cowpea -sesame (without rainwater management), cowpea-sesame (with rainwater management), black gram-sesame (without rainwater management), black gram-sesame (with rainwater management) and sorghum + pigeonpea. The pulses were sown during the *kharif* and the oilseed crops were sown after the harvest of pulse crop (October). The crops under rainwater management were given 2 supplementary irrigation (3mm) from the water harvested.

Sesamum without rain water management

Safflower with rainwater management

Cowpea with rainwater management

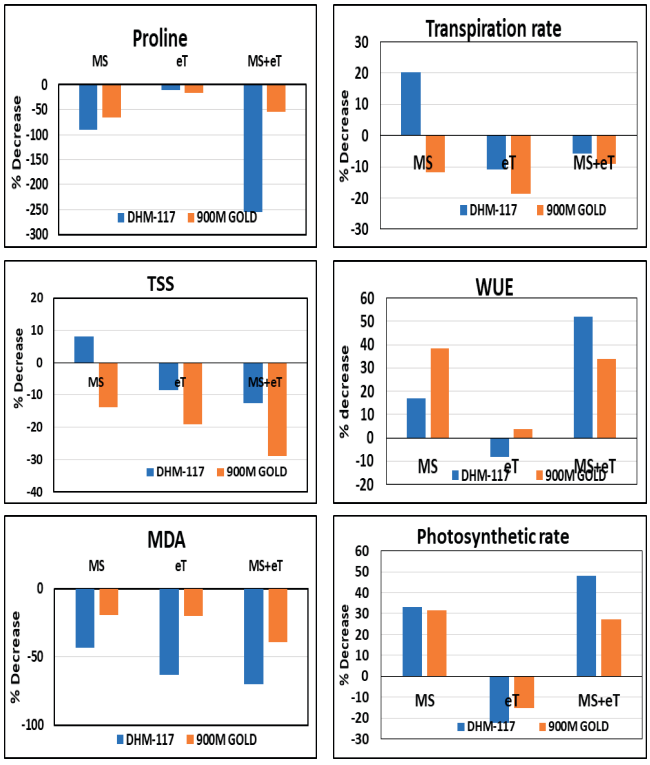


System yield of various pulse-oilseed cropping system

Since the outputs from each system are different, they were compared on the basis of green gram equivalent yield and system productivity. The highest system productivity of 1695kg/ha was obtained with cowpea -sesame (with rain water management), followed by cowpea -sesame (without rain water management) (1484kg/ha) on par with cowpea- safflower (with rain water management) (1407kg/ha). Higher yield of cowpea and higher market price of sesame contributed to higher system productivity of these system.

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

Two maize (*Zea mays* L.) genotypes- DHM-117 and 900M GOLD were assessed for physiological, growth and yield responses under moisture deficit stress (MS) at flowering stage raised under ambient and elevated temperature (eT) conditions. During the crop growth period the maximum temperature ranged from 24.0 to 34.2°C. The study revealed that MS and MS+eT significantly decreased photosynthetic rate (A_{net}) of both the genotypes whereas eT condition improved it. Among the genotypes, 900M GOLD was less impacted than DHM-117 and the MS+eT has higher impact than MS. The impact of these conditions on A_{net} was higher than transpiration rate (Tr) and this reflected in decreased WUE. Increase in temperature (eT), MS and MS+eT resulted in decreased RWC, cell membrane stability and increased MDA content and accumulation of total soluble sugars and proline. Among the two genotypes, the impact of stresses was high for proline in DHM-117 while for TSS in 900M GOLD. The impact of MS+eT on these parameters was higher than individual impact of MS and eT revealing that combination of two abiotic stresses have additive impact on physiological performance of this C4 crop. The reduction in total biomass was higher under MS and MS+eT condition than eT, while eT condition improved the grain yield of both maize genotypes indicating that higher temperature improving the partitioning of biomass towards grain. Both stress conditions improved the HI revealing that it triggered higher partitioning of biomass towards seeds.



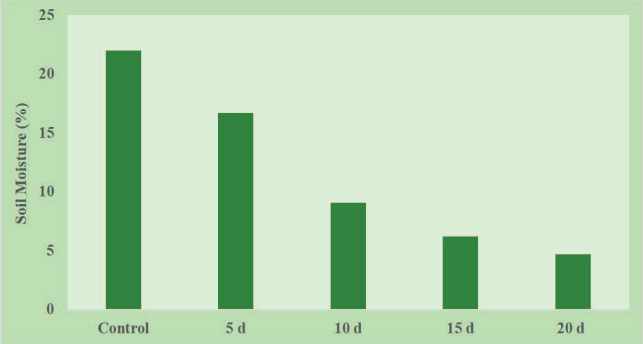
Response of biochemical and physiological parameters of two maize hybrids- DHM-117 and 900M GOLD under moisture stress (MS), elevated temperature (eT) and their combination (MS+eT) conditions

MDA- Malondialdehyde; TSS- Total soluble sugars; WUE- Water use efficiency

Among the two genotypes, 900M GOLD recorded less reduction of both biomass and grain yield under these conditions. The higher accumulation of sugars & proline especially under these abiotic stress conditions enabled the tolerant genotype to perform better.

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

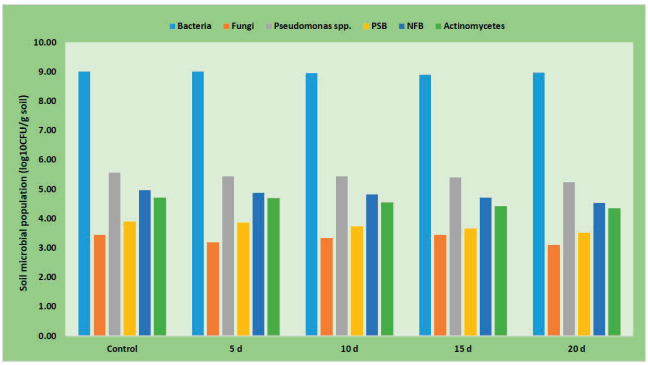
A pot experiment with groundnut (cv. K-9) as a test crop was conducted for the 2nd consecutive season under rainout shelter to evaluate the effect of varying levels of soil moisture stress on soil microbial population and plant growth as well as physiological properties.



Soil moisture (%) at different levels of moisture stress

Influence of differing soil moisture content on different functional groups of soil microorganisms

The soil moisture content at field capacity and 20 days moisture stress was 22.0% and 4.7 %, respectively. Culturable soil microbial population such as bacteria, fungi, *Pseudomonas* spp. actinomycetes, free living nitrogen fixing bacteria (NFB) and phosphorus solubilizing bacteria (PSB) was enumerated by using appropriate growth media. The population of NFB, *Pseudomonas* spp. and PSB decreased with the reduction in soil moisture content from 22.0 % to 4.7%.



Effect of soil moisture stress on culturable soil microbial population

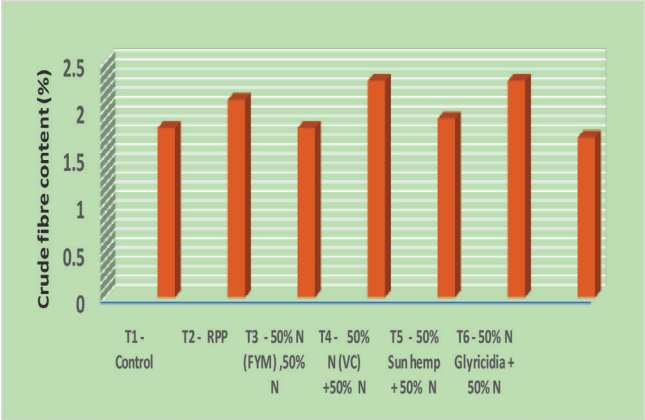
*PSB-Phosphorus solubilizing bacteria, NFB- Free living nitrogen fixing bacteria, d- Days after moisture stress

The soil moisture stress was imposed at 42 DAS (flowering) and 91 DAS (pod development). Plant physiological parameters such as relative water content, total soluble sugars and proline contents were measured at different levels of soil moisture content. Relative water content reduced from 89.73 % to 23.50 % with the depletion in soil moisture content. Total soluble sugars (TSS) and proline ranged from 12.57 – 36.03 (mg/g fresh weight) and 0.16 -1.40 (mg/g fresh weight) respectively. Proline and TSS contents increased with decrease in soil moisture content. The plant parameters such as plant biomass, shoot length, number of pods and pod weight were recorded. The plant biomass ranged from 92.50 to 354.50 (g/plant) and decreased with the reduction in soil moisture content.

2.3.7. Nutritional profiling of major rainfed crops from diverse agro ecologies

This study has been taken up to study different nutritional parameters in major rain fed food crops across different agro-ecological zones of the country.

According to the seven treatments T1- Control, T2- RPP (Recommended package of practices), T3- 50% N through FYM + 50% N inorganic sources, T4- 50% N through vermi compost + 50% N inorganic sources, T5 - 50% N through sun hemp + 50% N inorganic sources, T6- 50% N through glyricidia toppings + 50% N inorganic sources and T7- 50% N Crop residues + 50 % N inorganic sample were collected from AICRPDA centre, Vijayapura, Karnataka. Crude fibre in *rabi* sorghum were estimated in these samples.

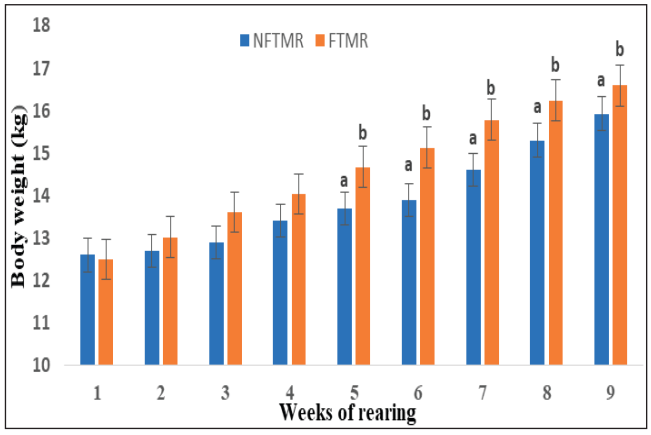


Rabi sorghum collected from AICRPDA centre, Vijayapura, Karnataka

Crude fibre content (%) of different Rabi sorghum treatments

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

Sustainable nutrient management by scientifically utilizing the crop residues and their suitable fortification can economize the small ruminant production system in dryland regions of India. The current investigation has been carried out to fetch the benefit of crop residue into Total Mixed Ration (TMR) as well as fortify them with suitable additives to enable indigenous sheep to overcome heat stress. The overall objective of the project is to prepare combinations of dry crop residues as fortified TMR ration for fattening sheep.



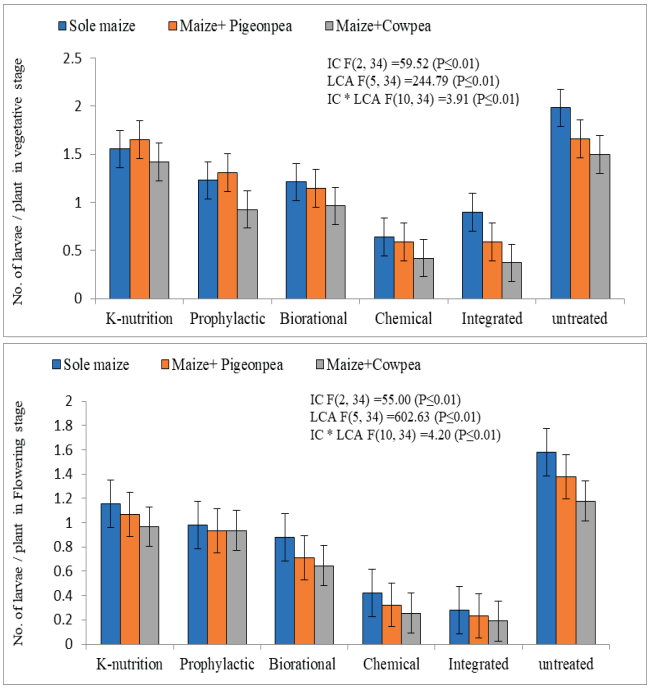
Body weight (kg) of Nellore sheep during 90 days of rearing under fortified and non-fortified TMR feeding regimen

Garlic skin powder, curry leaf powder and onion skin powder were added to the Dry TMR @ 3% as fortification option to provide endurance to heat stress during summer. The ration had Crude protein – 11.5%, Crude fat - 4 to 5%, and Crude fibre - 18 to 19% and had good palatability. An improved growth rate was observed in terms of ADG as 66g per day in Fortified TMR (FTMR) group as compared to 51g per day in Non-fortified TMR (NFTMR) group.

2.3.9. Evaluation of low-cost approaches for the management of Fall Army Worm (FAW), *Spodoptera frugiperda* in maize

Different experimental trials were conducted to evaluate the low-cost approaches for the management of Fall Armyworm (FAW) in maize crops. The fall armyworm (FAW), *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae), is a new invasive polyphagous insect pest, causing severe defoliation and significant yield losses in important cereal crops like maize, and rice, sorghum, cotton, and vegetables. Control of this insect pest by adopting chemical control measures is found to be costly and unsustainable. With this background evaluation of low-cost approaches for the management of Fall Armyworm (FAW) was initiated. Creation of crop diversity by adopting intercropping systems like maize + pigeonpea and maize+ cowpea in a 1:2 ratio was done and was compared over maize sole crop. The three cropping systems were included as main plots and sequential application of various pest control options/ components was adopted to have low-cost evaluation. Various pest control options/treatment areas follow i. application of K nutrition (higher dose of K@ 20 kg/ ha), ii. Prophylactic (application of dry fine sand after sieving in leaf whorl of maize crop at regular intervals, Application of 5% sugar solution), iii. Biorational (application of NSKE 5% and Vitex negundo leaf extract solution 1/10 w/w), iv. Chemical (insecticide application of emamectin benzoate, chlorantraniliprole, Thiodicarb, v. Integrated measures (integration of all measures excepting chemical treatment), and vi. untreated check (without any application for pest control). These served as subplots and the design of the experiment was a split plot and all were replicated thrice. Data on pest incidence and the impact of various pest control approaches on the absolute larval population during the vegetative and flowering stages across three cropping systems is depicted here.

Significant variation of the larval population was noted among three cropping systems and treatments in the vegetative and flowering stages. The reduction of pest population was higher in chemical and integrated treatments and was at par with each other. The rest of the treatments also caused a reduction of the larval population than the untreated check. The mean incidence larval population during the vegetative stage



Effect of cropping systems and low external input pest management approaches on larval incidence of Spodoptera frugiperda during the vegetative and flowering stages in maize

was lower in chemical and integrated treatments ($F_{5,34}$ = 244.79 (P≤0.01) and was more evident in Maize +cowpea intercropping system ($F_{2,34}$ = 59.52 (P≤0.01) than the sole crop of maize crop. The interaction between cropping systems and treatments was also significant ($F_{10,34}$ = 3.91 (P≤0.01). A similar trend was noted during the flowering stage also.

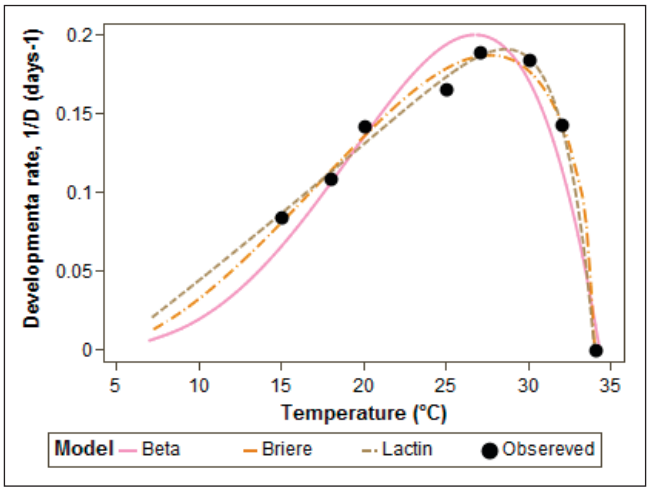
2.3.10. Crop Pest Surveillance and Advisory Project (CROPSAP)

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

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

2.3.11. Temperature dependent growth and development of sorghum aphid

Laboratory experiments were conducted under environmental growth chambers to study the effect of different temperatures on growth and development of sorghum aphid, *Melanaphis sacchari*. The studied were undertaken at seven constant temperatures (15, 18,20, 25, 27, 30 and 32 ± 1°C). The relative humidity was maintained in the chambers at 60 ± 10%, photoperiod at 12: 12 hrs. The growth, survival, developmental duration & fecundity was observed at frequent intervals. Estimated pre-oviposition, oviposition, post-oviposition, adult longevity and fecundity per individual at seven constant temperatures. Growth parameters and temperature thresholds were estimated for nymphal stages using four different linear and non-linear models *viz.*, Campbell, Ikemoto Takai model, Lactin – 2 and Simplified beta type function.



Temperature-dependent developmental rate of larval instars of Sorghum aphid estimated by non-linear models

Rate of development of first and third instars was linear from 15-30°C and 15-25°C respectively. Ikemoto-Takai linear model fit was better than Campbell model across all nymphal instars. However, the total nymphal development rate was fitted better by Campbell model with an R^2 of 0.8. The thermal constant, k for the nymphal instars were between 10.9 to 17.6 DD. For total nymph the estimated thermal degree days was 98.9. The nonlinear relationship between developmental rate and temperature for different nymphal instars and total nymph of Sorghum aphid was fitted well by all the three nonlinear models *viz.*, Lactin-2, Briere and β type distribution function model by additionally including rates at 32°C. The estimated upper temperature threshold T_{max} by Lactin-2 and Briere models was 34.0°C across all instars. The estimated T_{opt} for the total nymphal development were 28.6, 27.7 and 26.8 from Lactin-2, Briere and Beta function respectively.

Estimates of temperature thresholds for nymphal development of *sorghum aphid* using linear and non-linear regression analysis

Model	Parameters	Instar 1	Instar 2	Instar 3	Instar 4	Total Nymph
Campbell model	T_{min}	6.8	3.5	7.3	2.2	4.7
	R^2	0.5323	0.4318	0.4918	0.3112	0.8066
Ikemoto Takai model	LDT	11.9	12.7	10.3	13.2	7.2
	R^2	0.7321	0.7584	0.7793	0.7475	0.6668
	Topt	30.0	29.4	27.1	27.7	28.6
	Tmax	34.0	34.0	34.0	34.0	34.0
	R^2	0.991	0.962	0.990	0.980	0.992
Briere	Topt	28.2	27.9	27.3	27.0	27.7
	Tmax	34.0	34.0	34.0	34.0	34.0
	R^2	0.940	0.952	0.972	0.983	0.989
Simplified beta type function	Tmax	34.3	34.4	34.2	34.3	34.3
	R^2	0.824	0.838	0.974	0.921	0.905

2.3.12. TmapGen+: Online Interactive Thematic Map Generator

TmapGen+ is an automated thematic map generating web-based software tool. Thematic mas is generated based on the user input. Non-GIS users are able to visualize their biophysical and socio-economic data as thematic maps on the fly. The software was developed in Python3 language and Geopandas, an open-sourced library used for manipulation of geospatial data. Geometric operations are performed by shapely for file access and matplotlib for plotting. A web interface was developed using Streamlit open-source app framework to create thematic map in three steps. Step 1: User has to select base map for which the thematic map has to be generated. Step 2: Download data template for the selected base map and fill the user data for each parameter. This interface can read up to 5 user parameters. Step 3: Upload filled data template for generating the thematic map.

The developed software has the following functionality:

- Range: Each numerical range is displayed with a specific color.
- Point Density: The points to be added on the map represent data values. Values are higher in areas where the points are dense. The total number of points is distributed over the area boundary to express the value of the area.
- Individual: Each value in the data sheet is represented by a different color and symbol. In this thematic map type, thematic can be created from both numerical and character information.
- Double Variable: It provides two different information about the object to be displayed simultaneously by creating double thematic on the data.

2.3.13. Development of temperature-based phenology model for maize stem borer (*Chilo partellus*)

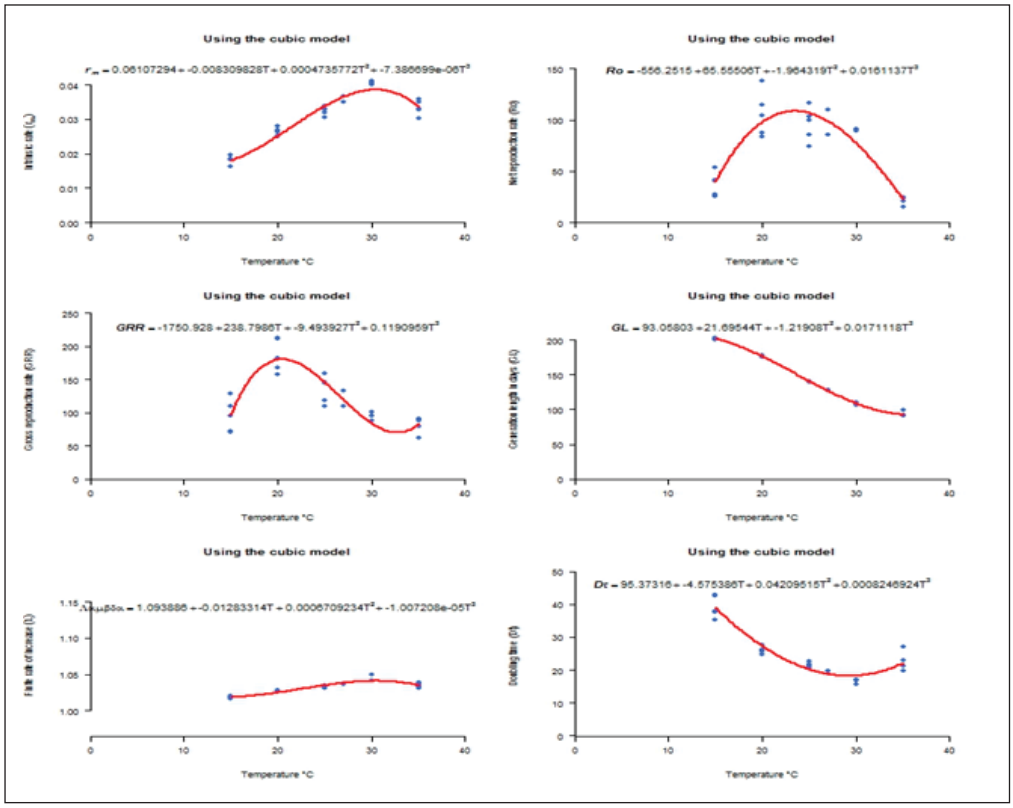
Laboratory studies were conducted to develop an inclusive temperature-dependent population growth model for maize stem borer, *Chilo partellus* Swinhoe (Lepidoptera: Crambidae). The larvae were reared on maize leaves. Experiments on life tables were conducted at different constant temperatures of 15, 20, 25, 27, 30 and 35°C. The data on durations of egg, larval, pupal and adult and total development periods at each temperature were recorded. The Insect Life Cycle Modelling (ILCYM) software version 3.0, developed by the International Potato Centre, Lima, Peru (https://research.cip.cgiar.org/confluence/ displayilcym Downloads) was used for the development of process-based temperature-driven and age-stage structured *C. partellus* phenology model. The model was validated using life-table data at fluctuating temperatures. Finally, with life table parameters, temperature inclusion in the phenology model using a cosines approximation of temperature, three indices such as growth index (GI), activity index (AI), establishment risk index (ERI) are estimated. The risk indices thus estimated were employed in the "potential population distribution and mapping" module of ILCYM for visualizing the risk maps. The module facilitated spatial simulations of pest populations through grid-based within a defined area according to grid-specific monthly temperatures interpolated from available databases (www.worldclim). The process generated ASCII files (.asc) which were converted to grid format (.grd) for visualizing the risk maps by importing in DIVA-GIS (http://www.diva-gis.org). The indices were mapped for predicting the suitability for establishment and survival of *C. partellus* in India under present and future climatic scenarios.

Results indicated that, the temperatures within the evaluation range have a greater influence on the development of the immature life stages of *C. partellus*. The duration of the immature stages and the time required completing the cycle from egg to adult decreased significantly with increasing temperatures within the temperature range of 15°C to 35°C temperature. The observed mean development times for all the immature life stages were fastest at 35°C (Egg: 4.7 ± 0.62; Larva: 24.21 ± 0.19; Pupa: 7.72 ± 0.73), and lowest at 15°C (Egg: 14.93 ± 0.19; Larva: 59.45 ± 0.19; Pupa: 23.83 ± 1.28). The cumulative frequencies of development times of each life stage and temperatures were plotted against normalized developmental times by fitting a complementary logit distribution curve for all stages. The best fit model was selected based on Akaike's Information Criterion (AIC), a well-known goodness of fit indicator. Inverse of durations of immature development and adult survival (1/days) were taken as rates of development and survival, respectively. The non-linear regression model was fitted to establish the relationship between development rate and temperature. For describing the temperature dependence of development rate of immature stages, Logan 1 function was fitted for all the stages at various constant temperatures. The thermal reaction norms were well fitted by the Logan 1 model as indicated by the smallest value of AIC (-49.34) and highest value of coefficient of determination (R^2 0.99) for egg stage, for larvae and pupa with smallest value of AIC (Larva: AIC of -71.16; Pupa: AIC of -74.34) and highest value of coefficient of determination (Larva: R^2 0.99; Pupa: R^2 >0.98), respectively. The senescence rate for both the female and the male adults increased linearly from low to high temperatures. The modified fourteen parameter version of Sharpe and DeMichele model for male and female provided a good fit to the observed mean senescence rates for both the adult sexes. The temperature dependent mortality rates for egg and pupa of *C. partellus* were well fitted by the Polynomial 2 model as indicated by the smallest value of AIC (Egg: AIC < -37.19; pupa: AIC < -23.71) and highest value of coefficient of determination (Egg: R^2 > 0.99; pupa: R^2 > 0.90) respectively and for larval stage of *C. partellus,* Wang 7 model were well fitted as indicated by the smallest value of AIC (< -19.27) and highest value of coefficient of determination (R^2 > 0.95). The optimum temperature for survival of immature life stages of *C. partellus* are within the range of 25 to 30^{0}C (>85% survival of all the immature stages). A non-linear regression model, Janisch and Analytis was fitted to find out the effects of various constant temperatures on total number of eggs produced by a female adult during her whole life span. Eggs were produced by females from temperature regimes between 15-35°C, with the minimum number of total eggs per female at 15^{0}C (147.20) and peak egg laying at 27°C (352.4) in their gonotrophic cycle. Egg laying was lowest at 15°C decreased with increase in temperature after 30°C,

indicating the unsuitability of temperatures below and above this range for its oviposition. The relationship between cumulative oviposition rate and female age was well described by the Gamma function.

Life table parameters

Using 'stochastic simulation tool' in ILCYM which is based on rate summation and cohort up-dating approach, the life table parameters *viz*., gross reproductive rate (GRR), net reproductive rate (Ro), intrinsic rate of natural increase (rm), finite rate of increase (λ), mean generation time (T) and doubling time (Dt) were estimated. Results indicated that these life table parameters of *C. partellus* varied significantly with temperature and were found to have cubic relationship with temperature. Finite rate of increase (λ) which is the indicator of reproductive value of new egg was highest at 30°C and thereafter showed a negative relationship with temperature. The intrinsic rate of increase (*rm*), and finite rate of increase (λ) increased with increase in temperature from 15°C to 30°C and decreased with increase in temperature. Intrinsic rate of increase (*rm*), varied from 0.015 females/female/day at 15°C to 0.14 females/female/day at 30°C. An increase in mortality with decrease or increase in temperature indicates the non-linear relationship. The suitable range for *C. partellus* reproduction was observed between 25-30°C. *C. partellus* population attained a maximum net reproductive rate 'R_o' (215.66 females/female/generation) and total fecundity (631.62 individuals/female/generation) at 30°C temperature. After that the net reproductive rate and gross reproductive rate decreased with increase in temperature; at higher temperatures less fecundity was recorded. Values estimated for 'T' indicate that the mean length of generations decreased from 97.27 days at 15°C temperature to minimum of 31.83 days at 35°C and shortest doubling time was observed at 35°C (15.26 ± 0.05 days). Fitting of a polynomial model to the estimated life table parameters predicted temperatures between 27-30°C as a favourable range for *C. partellus* development, survival and reproduction, where high reproductive potential and shorter generation length were observed. From our findings it is understood that the 'r_m' and 'λ' increased with increase in temperature from 15°C and later started declining from 30°C with increase in temperature.



Life table parameters of C. partellus estimated at six constant temperatures. Intrinsic rate of natural increase (a), Net reproduction rate (b), Gross reproductive rate (c), Mean generation time (d), Finite rate of increase (e), and Doubling time (f).

The average number of generations that *C. partellus* population can complete in a year under the current (2000) and the future (2050) climatic conditions are determined using the third module of ILCYM. The results indicated significant increase in activity index and establishment risk index at future (2050) climatic conditions compared to current climatic conditions. There is increase in the average number of generations of *C. partellus* population under future (2050) climatic conditions compared to the current (2000) climatic conditions.

2.3.14. Evaluation of multipurpose tree species based agroforestry systems

A study was initiated under alternate land use and ecologically sustainable agriculture with 12 indigenous MPT's based agroforestry system with finger millet (KMR 301) as an understory crop and stylos on the intra-spaces and bunds of the trenches between MPTs in rainfed Alfisol at Hayatnagar Research farm. The MPTs (*Ailanthus excelsa*, *Bauhinia purpurea*, *Hardwickia binata*, *Butea monosperma*. *Dalbergia latifolia*, *Chloroxylon swetienia*, *Grewellia robusta*, *Pterocarpus santalinus*, *Syzygium cuminii*, *Azadirachta indica*, *Madhuca longifolia* var *latifolia* and *Tamarindus indica*) were selected on the basis for their ability to provide fodder, fuel and furniture and other forest products. The system is being evaluated under two modules *viz.*, silvi-agriculture and silvi-pasture system. The main objective of the study is to assess the performance of MPTS based agroforestry systems under rainfed Alfisols. The investigation was set up in randomized block design with four replication and four trees per replication for a total of 16 trees per species. Staggered trenches were laid out *viz.,* 08 nos. per species, as a soil and water conservation measure. In *kharif* 2022, finger millet var. KMR 301 was sown using tractor drawn CRIDA six row planter in the interspaces of the planted MPTS at 45 x 10cm spacing. Recommended dose of fertilizer (RDF) (40:20:20 kg N, P_2O_5, K_2O/ha) was applied to the test crop. Intercultural operations were done using a specially modified tractor drawn weeder. *Stylosanthes hamata* was sown in the MPT's intra-spaces and also on the bunds of the staggered trenches for green fodder yield. Results of pooled data (four year) indicated that, crop under *Dalbergia latifolia* with and without staggered trenches recorded maximum average grain yield of 3.94 and 5.63 q/ha, respectively under rainfed conditions compared to other MPTs.

2.3.15. Evaluation of bamboo species suitable for Southern Telangana region

Bamboo is one of the fastest growing and among the world's most important and versatile plants. Bamboo has the potential to be incorporated into agroforestry systems in the rainfed areas due to their diverse adaptability, multiple utility and quick returns. The bamboo has very high potential to enhance the farm income, but its potential has not been harnessed fully under rainfed agroforestry systems. Hence, a study was initiated during 2021 at the research farm of ICAR-CRIDA, to evaluate the growth performance of three bamboo species for its suitability under rainfed Alfisols and also to assess the potential of bamboo-based rainfed agroforestry system to enhance productivity and economic returns. This study will enable to develop and standardize bamboo-based agroforestry system suitable for rainfed Alfisols.

The experiment was set up with three bamboo species (*Bambusa balcooa*, *Bambusa tulda* and *Bambusa nutans*), four soil and water conservation measures (SWCM) (Rectangular trench, Horse shoe shaped trench, Tri-centric pits and no trench) and three intercrops (Finger millet, pigeonpea and green gram) with three replicates. For each bamboo species, 12 clumps (3 x 4; Rows x clumps) per replication was established at 8 x 8 m spacing. Recommended dose of fertilizer (RDF) was applied as recommended by National bamboo Mission to the planted bamboo species.

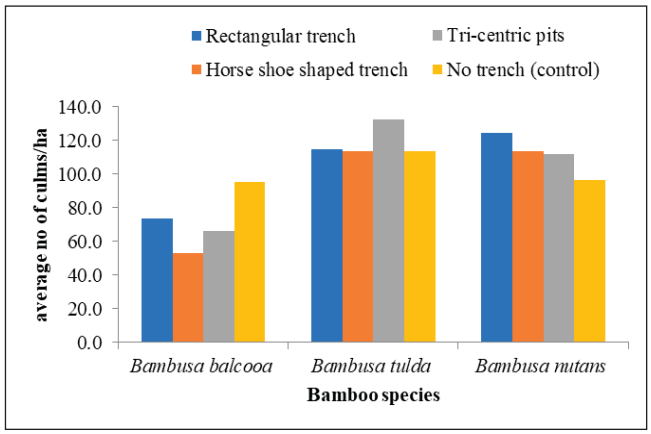
The survival was 97% at the end of second year of planting. Observations on culm height, collar diameter and number culms for each bamboo species raised under different soil and moisture measures. species were recorded. On an average, the 5th internodal length (cm) and 5th internodal diameter (cm) varied in the range of 20.2 to 21.4 and 2.45 to 2.79; 19.9 to 20.8 and 1.70 to 1.93; 18.6 to 20.3 and 1.63 to 2.18 for *Bambusa balcooa*, *Bambusa tulda* and *Bambusa nutans* with different soil and water conservation measures, respectively. On an average, no. of culms/ha under rainfed Alfisols varied in the range of 53 to 96 (*Bambusa balcooa* with different SWCM); 114 to 132 (*Bambusa tulda* with different SWCM); 97 to 125 (*Bambusa nutans* with different

A. Rectangular trench

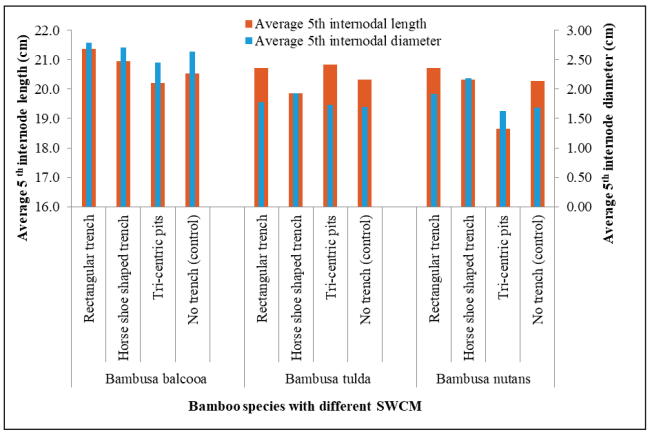
B. Horse shoe shaped trench

C. Tri-centric pits

Soil and water measures adopted in bamboo experimental field in rainfed Alfisols



Number of culms/ha of three bamboo species under rainfed Alfisols



Average 5th internodal length and 5th internodal diameter of three bamboo species under rainfed Alfisols

A. Finger millet + bamboo-based agroforestry system

B. Pigeon pea + bamboo-based agroforestry system

C. Green gram + bamboo-based agroforestry system

Field view of bamboo based rainfed agroforestry systems in Alfisols

SWCM) at the end of 2nd year. During 2022, results of average grain yield (q/ha) of finger millet varied in the range of 2.45 to 7.34; 2.42 to 6.48 and 2.39 to 6.20 under interspaces of *Bambusa balcooa*, *Bambusa tulda* and *Bambusa nutans* based agroforestry systems with different SWCM, respectively with control yield of 15.9 q/ha. The average yield (q/ha) of pigeonpea grown under the interspaces of *Bambusa balcooa*, *Bambusa tulda* and *Bambusa nutans* based agroforestry systems with different SWCM varied in the range of 3.3 to 8.4; 3.3 to 8.5 and 3.1 to 8.4, respectively with control yield of 14.0 q/ha. Average yield (q/ha) of green gram (intercrop) ranged from 2.5 to 5.8; 2.3 to 5.8 and 2.9 to 5.9 for *Bambusa balcooa*, *Bambusa tulda* and *Bambusa nutans* based agroforestry system with different SWCM, respectively with control yield of 9.3 q/ha.

2.3.16. Collection and evaluation of tamarind, *Tamarindus Indica* L. germplasm from rainfed areas of Deccan and Bastar Plateau

Systematic Evaluation of 23-year-old 40 accessions of tamarind in the field at HRF was carried out for flowering, yield, and fruit characteristics, flowering started form first week of May-2022 and continued up to the end of September month. Out of 40 accessions evaluated 23 accessions there was a flowering and fruit yield. The flowering was not uniform among all the accessions; there was a staggered flowering in accessions like Hasnur- 3, PKM-1and NTI-85. Best promising accessions for the year 2021-2022 are BDM-3, Red, Vellore-29, KRMR, SMG-3 and Hasnur-5. As a part of collection germplasm from rainfed areas of Deccan and Bastar plateau. From the identified 20 trees from different places in Telangana and selected two promising trees for Based on the desirable traits are collected and added to the germplasm block.

Tamarind fruit is full of acidity which combines well with sugar, chilli and other flavours, hence its pulp is used to prepare a variety of traditional refreshing and highly energetic drinks. Ready to serve (RTS) drink with tamarind pulp of three different varieties we. Ready to serve (RTS) drink is a type of fruit beverage which contains at least 10% of fruit juice and 10-degree Brix total soluble solids (TSS) with 0.3% acidity. It is not diluted before serving, hence it is known as ready to serve beverage. Raw material, ingredients, required are: pulp/juice (1.5 litre), sugar (685 g), citric ac (3.5 g), water (7.8 litre), ginger (200g) and Potassium meta-bisulphite (1.5 g).

Ready to serve drink [Tamarind (95%) + Ginger 5%]

Procedure for preparation of ready to serve (RTS) drinks

1. Take fruit pulp/juice and mix with syrup which is prepared by mixing sugar with water and citric acid.
2. Ginger is added 5% of the tamarind juice.
3. Homogenize the mixture for proper mixing.
4. Heat the drink to boil for pasteurization.
5. Fill in the glass bottles (200ml capacity) while still hot.
6. Crown cork the bottles and process in boiling water for 20-25 minutes.
7. On cooling, label the bottles and store in cool and dry place.
8. Potassium meta-bi sulphate (KMS) added to the RTS drink as preservative.

2.3.17. Quantification and valuation of ecosystem services from agroforestry systems in rainfed agroecological regions

Studies have shown that agroforestry has the potential to maintain agricultural productivity, conserve biodiversity in agricultural landscapes as well as helps to mitigate climate change impacts. It has the potential to enhance soil fertility, reduce erosion, improve water quality, enhance biodiversity, increase aesthetics, and sequester carbon. However, a comprehensive analytical framework for quantifying and valuing ES is missing or is at infancy. The present study aims to develop total economic value (TEV) framework that considers both the use and non-use values. Therefore, a research project entitled 'Quantification and Valuation of Ecosystem Services from agroforestry systems in different rainfed agro ecologies' was initiated. The litter decomposition study was carried using litter bag technique. The decomposition of dry matter in relation to N, P, K and other nutrients were investigated in custard apple-based agroforestry system. The litter quality prior to decomposition and the chemical composition of decomposed litter over time were determined in the laboratory. The decay constant (k) found for custard apple was 0.97 yr^{-1}. The mass loss and decay constant studies were also conducted. The nutrients concentration was found to decrease gradually at the end of the experiment (210 days). Conversely, nutrients concentration decreased rapidly throughout the

experiment period. The loss was in the range of 20.86 in 30 days after placement to 13.87 grams at the end of 210 days.

Carbon sequestration potential of agroforestry systems

CO_2 Fix model was used to determine the carbon sequestration potential of the agroforestry system. This method is purely based on CAI (Current Annual Increment)

Melia dubia recorded highest carbon sequestration potential 6.74 Mg C /ha/yr followed by guava and custard apple (4.40) and (4.41) Mg C /ha/yr respectively. The least was noticed in aonla (2.16) and tamarind-based agroforestry system (3.72). The net carbon sequestered in agroforestry systems over the simulated period of thirty years was found maximum in Melia dubia based agroforestry systems 201.54 Mg C /ha/yr and the least was noticed in aonla based agroforestry systems. 64.80 Mg C /ha/yr.

Estimated carbon sequestration potential of groforestry systems (Mg C /ha/yr)

Parameters			Melia dubia	Tamarind	Guava	Custard apple	Aonla
Spacing (M)			5 x 5	10 x3	3.5 x 3.5	5 x 5	5 x 5
Number of trees per hectare			400	333	816	400	400
Age of trees (Years)			6	8	5	12	14
Tree Biomass (above and below ground) in Mg DM/ha	Baseline	Biomass	21.39	44.54	42.23	31.87	20.69
	Simulated		441.27	277.55	317.62	307.81	155.70
Tree Biomass carbon (Mg C/ ha)	Baseline	Carbon	10.26	21.37	20.27	15.29	9.93
	Simulated		211.80	133.22	152.45	147.74	74.73
Net carbon sequestered in agroforestry systems over the simulated period of thirty years (Mg C /ha)		Carbon sequestered	201.54	111.84	132.18	132.45	64.80
Estimated carbon sequestration potential of agroforestry system (Mg C /ha/yr)			6.74	3.72	4.40	4.41	2.16

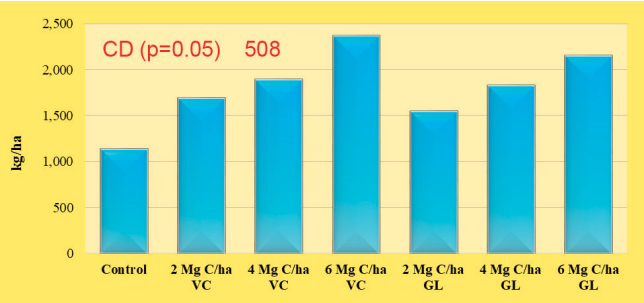
Double ring infiltrometer under tamarind based AFS

Placement of litter bags under custard apple based AFS

2.4. Soil and nutrient management

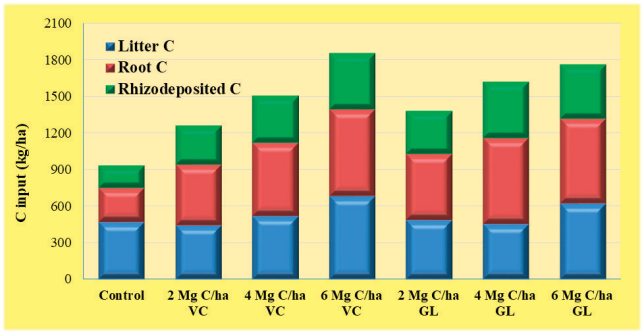
2.4.1. Estimating the carbon sequestration potential of semi-arid soils using carbon saturation concept

A field experiment is being conducted at Hayathnagar research farm since 2018 to investigate the carbon saturation behavior of the soil under heavy loading of carbon inputs with pigeonpea-castor crop rotation. In 2021-22, castor hybrid DCH 177 was grown. Fresh vermicompost (VC) and gliricidia loppings (GL) were applied to soil at rates of 0, 2, 4 and 6 Mg C/ha. The highest castor seed yield (2368 kg/ha) was obtained with 6 Mg C/ha through vermicompost followed by 6 Mg C/ha through gliricidia loppings (2151 kg/ha).



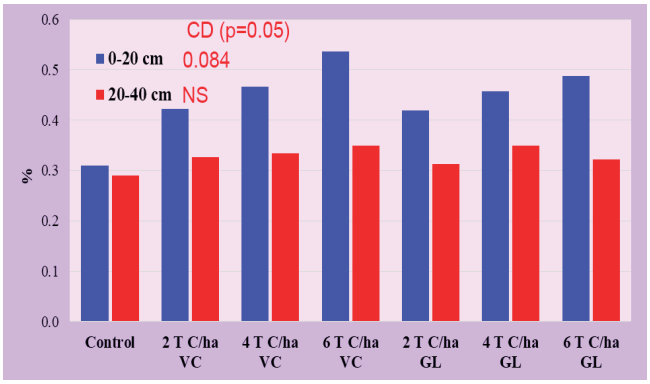
Seed yield of castor with C input types and loading rates.

A maximum of 1857.7 kg C/ha was added to the soil in the 6 Mg C/ha through vermicompost treatment through litter, roots and rhizodeposition while in control plots 943.3 kg C/ha was added.



Crop C inputs to soil with C input types and loading rates.

After 4 years of treatments, organic carbon in 0-20 cm soil differed significantly with treatments and the highest organic C was recorded with 6 Mg C/ha through vermicompost (0.536%) followed by 6 Mg C/ha through gliricidia loppings (0.487%). There were no significant differences in organic carbon at 20-40 cm depth.



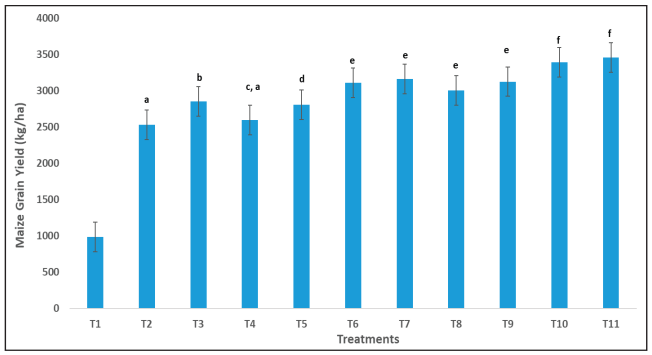
Organic carbon in soil with C input types and loading rates after 4 years of treatments.

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

The districts of Karnataka Bijapur, Raichur, Kalburgi, Yadgir and Bidar cover the study area. The collected samples were analysed for soil texture, bulk density, PAW, MWD, pH, EC, CEC, OC, N, P, K, exch. Ca, exch. Mg, exch K, S, Zn, Mn, Cu, Fe, dehydrogenase, urease, acid phosphatase, alkaline phosphatase enzyme activity and MBC. The soil samples were collected at the grid point of 20*20 km from these five districts of Karnataka from the large and small farmer fields. In the study area soil type ranges from deep black, mixed black, mixed to red soil and texture of the ranges from clay to sandy clay. Results showed that in most of the case large farmers recorded the high values of the different soil parameters. The PAW, MWD and BD ranged from 3.12 to 15.21%, 0.36 to 0.72 mm and 1.19 to 2.10 Mg m^{-3}, respectively in different farmers filed in the study area of Raichur district. The pH, ECs, CEC, OC, available N, P and K ranged from7.70 to 8.78, 0.22 to 0.58, 5.89 to 43.67Cmol (+) kg^{-1}, 0.23 to 0.64%, 188.16 to 288.51 kg ha^{-1}, 11.39 to 22.78kg ha^{-1} and 76.80 to 832.14kg ha^{-1}.The available S, Ca, Mg, Ca+Mg and Na ranged from 18.35 to 73.48,3.40 to 25.00, 0.92 to 12.74, 4.31 to 36.74 and 0.42 to 5.27, respectively. The DTPA available Zn, Cu, Mn, Fe and boron ranged between 0.10 to 0.97, 2.51 to 7.95, 0.36 to 1.73,2.32 to 6.25 and 0.18 to 0.54 ppm. The soil enzymes values ranged from 1.38 to 4.53 for dehydrogenase, 26.34 to 75.35 for acid phosphatase, 55.22 to 115.33 for alkaline phosphatase and 90.30 to 327.90 for MBC.

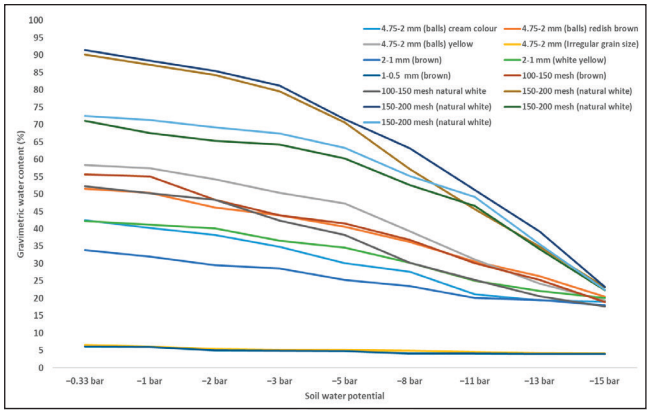
2.4.3. Effect of Ca-bentonite on soil moisture dynamics and availability of nutrients in semi-arid rainfed Alfisols

Addition of Ca-bentonite with high water holding capacity and during drought can be attempted specifically in the case of Alfisols, to improve maize yield. During this year a field experiment on different doses of Ca-bentonite (150-200 mesh natural white colour) in maize crop conducted. Treatments includes:T1=Control, T2=75% (RDF), T3=100% (RDF), T4= 5 t Ca-bentonite/ha+75%(RDF), T5=10 t Ca-bentonite/ha+75% (RDF), T6=15 t Ca-bentonite/ha+75% (RDF), T7=20 t Ca-bentonite/ha+75% (RDF), T8= 5 t Ca-bentonite/ha+100%(RDF), T9=10 t Ca-bentonite/ha+100% (RDF), T10=15 t Ca-bentonite/ha+100% (RDF) and T11=20 t Ca-bentonite/ha+100% (RDF). Results showed that added levels of the Ca-bentonite along with 75% RDF and 100% RDF improved the maize grain yield. The treatments 15 t Ca-bentonite/ha+75% (RDF) and T10=15 t Ca-bentonite/ha+100% (RDF) found quite effective in improving the maize grain yield as compared to the rest of the treatments.



Effect of different Ca-bentonite doses and RDF on maize grain yield.

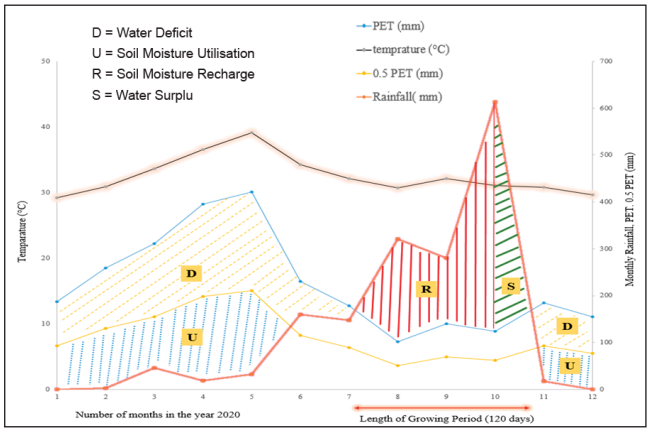
Similarly, the water release pattern of soils plays a significant role crop production particularly during drought. In laboratory, water release curve for different Ca-bentonite materials was developed. Water release pattern shows that it linearly releases the water as the pressure increase irrespective the Ca-bentonite materials. Results indicates that the as size of the Ca-bentonite materials decreased the plant available water capacity increases. The highest plant water available capacity was observed with 150-200 mesh natural white colour Ca-bentonite material.



Water release curve for different Ca-bentonite materials.

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

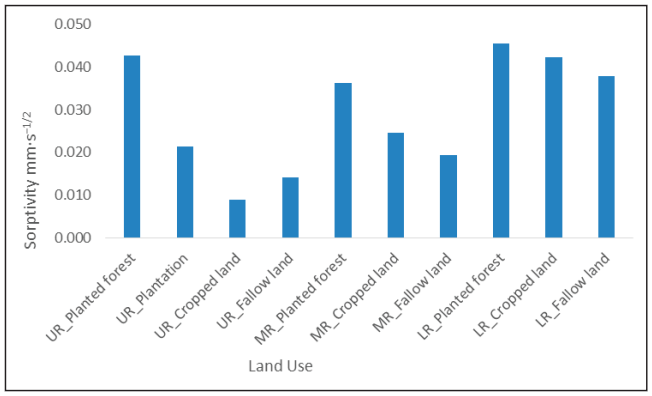
In semi-arid regions, the connecting aboveground and belowground processes to investigate how soil redistribute rainfall and nutrient and their impact on subsurface flow, is an overlooked phenomenon. Water balance depicts inflow to any water system or area is equal to its outflows plus change in storage during a time interval thus helps in deciding the length of growing period for a region. The Length of growing period for the micro-watershed was 120 days. The growing period provides a framework for summarizing temporally variable elements of climate, which can then be compared with the requirements and estimated responses of the plant.



Water balance diagram with Length of growing period and mean monthly temperature of the Hayathnagar micro-watershed.

Sorptivity is a component of the flow processes and needs to be incorporated in any application where adsorption or desorption of a fluid from a porous media is occurring due to a potential change at a

surface boundary. Under different elevation from upper to lower there was an increase in sorptivity under all land use system except for planted forest in the middle reach. The highest sorptivity was found for planted forest at lower reach (0.046 mm·s$^{-1/2}$) while lowest was for cropped land at upper reach (0.009 mm·s$^{-1/2}$).



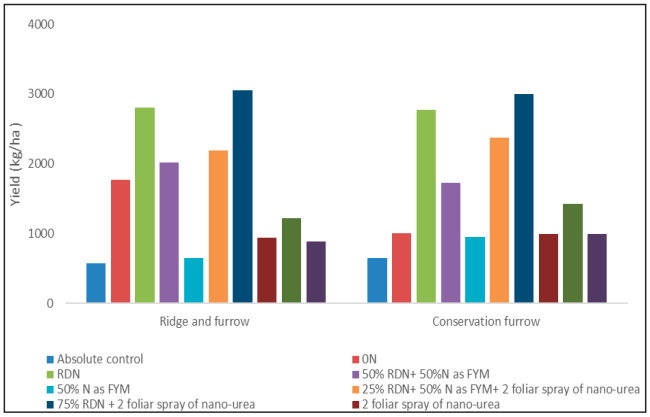
Sorptivity of soil under different Upper (UR), Middle (MR) and Lower (LR) elevation and land use.

2.4.5. Enhancing the bio-availability of rock phosphate P through the application of natural zeolite

Most of the RPs are reasonably suitable for direct use in acid soils but has not effective for neutral to alkaline soils. Recent technology is to use zeolite that enhances P release from RP and has several additional benefits like improving water use efficiency, nutrient use efficiency and better crop performance. For this purpose, two types of rock phosphate were collected –(i) Hirapur rock phosphate (HRP) (P_2O_5 content < 12%) and (ii) Udaipur rock phosphate (URP) (P_2O_5 content > 22%). Both the rock phosphate was evaluated for release of P content in the laboratory and found that both were maintaining low available P content when applied singly however when applied with zeolite the availability was increased by 5% and 10% respectively. Pot study was conducted with baby corn (var-IMHB-1539). The treatments included two levels of P (50 and 100 kg/ha); three levels of zeolite (0, 2.5 and 5 t/ha), two levels of FYM and three sources of P (SSP, HRP, URP). In this study, it was found that the URP application along with zeolite was at par with SSP in maintaining soil P availability at three different stages of crop growth while HRP maintained the lowest soil available during three different stages of crop growth.

2.4.6. Enhancing resource use efficiency through moisture conservation and nano-nitrogen in rainfed maize

To study the effect of integrated nutrient management practices with nano-fertilizer under *in-situ* soil moisture conservation practices in dryland cultivation on nitrogen use efficiency a project was initiated on 'Enhancing Resource Use Efficiency through Moisture Conservation and Nano-nitrogen in Rainfed Maize' at GRF in 2022. A field experiment was conducted with the following treatments: control (0N), RDN, 50% RDN + 50% N as FYM, 50% N as FYM, 25% RDN + 50% as FYM + 2 foliar spray nano-N, 75% RDN + 2 foliar spray nano-N, 2 foliar spray nano-N, foliar urea (2%), only water, Absolute control under two *in-situ* soil moisture conservation practices; ridge and furrow and conservation furrow. The administration of 75 % RDN + 2 foliar spray nano-N gave 5 times higher yield compared to that of absolute control and was similar to that of RDN. No significant difference in the yield was observed between the two *in-situ* soil moisture conservation practices adopted.

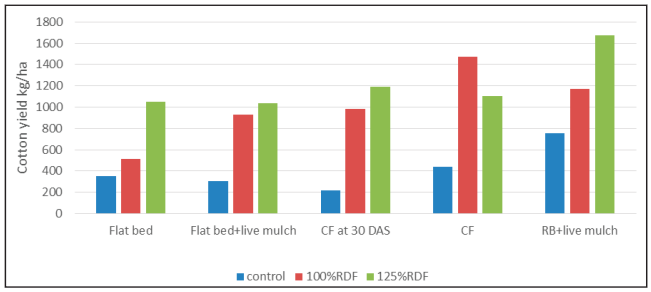


Effect of integrated nutrient management with nano-N on maize yield (kg/ha).

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

More than 65% of the cotton in Telangana state is cultivated in red soils (Alfisols) under rainfed conditions. A project was initiated in 2021 to examine the feasibility of producing higher yields of cotton under dryland conditions using moisture conservation

and nutrient management practices. The experiment was taken in *kharif* 2022, second year of the project, cotton was grown with 5 main treatments as *in-situ* moisture conservation and 3 sub treatments as nutrient management practices. *In-situ* moisture conservation treatments recorded higher yield as compared to flat sowing. Among *in-situ* moisture conservation treatments CF formed at the time of sowing in flat sowing and raised bed method recorded higher yield as compared to CF at 30DAS. Raised bed and CF recorded 37 and 48 per cent higher yield as compared to flat sowing and live mulch respectively. Similarly, cotton crop yield was higher with 125 per cent RDF as compared to 100 per cent and control treatments. Application of 100 and 125 % recommended fertilizers recorded 59 and 66% higher yield as compared to no fertilizer application. 125 % RDF recorded 16 % higher yield as compared to 100 % RDN.



Impact of in situ moisture conservation and fertilizer levels on cotton yield.

Crop growth in conservation furrow+125% RDF.

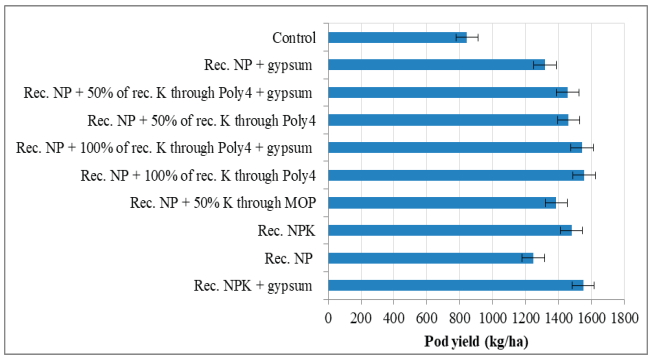
Crop growth in flat bed with live mulch +125% RDF.

2.4.8. Effect of foliar application of different nano fertilizers on nutrient use efficiency, drought stress tolerance, productivity and economics of rainfed crops

A field experiment was conducted during *kharif,* 2022 at Gungal Research Farm (GRF) of the institute to study the effect of nano-urea, nano-Zn and Nano-Cu alone and in combinations with different doses of recommended NPK on rainfed maize. Application of recommended NPK + foliar spray of nano-N + nano-Zn + nano-Cu being on par with 75% or 100% recommended NPK + foliar spray of either nano-N alone or in combination with nano-Zn recorded significantly higher grain yield (3211 kg/ha) compared to other treatments. Application of 75%N + 100% P, K & Zn + foliar spray of nano-N produced 6.1% higher grain yield (2948 kg/ha) than that of recommended NPKZn alone. Another field experiment was conducted during *kharif,* 2022 at GRF of the institute to study the effect of Nano-DP and Nano-Zn alone and in combinations with different doses of NPK on rainfed maize. Seed treatment with nano-DAP was also done for treatments involving nano-DAP application. Nanofertilizers were sprayed @ 2 ml/liter water at 30 days after sowing as per the treatment. The seed yield of maize differed significantly among the treatments. Soil application of Zn @ 25 kg/ha along with 100% recommended NPK had no significant effect on yield (2290 kg/ha) compared to application of recommended NPK alone (2269 kg/ha). Application of Nano-DAP with $N_{75}P_{75}KZn$ (3090 kg/ha) and $N_{100}P_{100}KZn$ (3206 kg/ha) recorded marginally higher grain yield compared to recommended dose of fertilizer without Nano-DAP ($N_{100}P_{100}KZn$) (2996 kg/ha). Application of $N_{75}P_{75}KZn$ + foliar spray of Nano-DAP recorded significantly higher grain yield compared to that of $N_{75}P_{75}KZn$ (2534 kg/ha). In addition, the grain yield of maize further increased when Nano-DAP was applied along with Nano-Zn. The treatment $N_{75}P_{75}K$ + Nano-DAP +Nano-Zn produced grain yield of 3294 kg/ha whereas application of $N_{100}P_{100}K$ + Nano-DAP +Nano-Zn produced grain yield of 3242 kg/ha.

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

Besides conventional fertilizers, other multi-nutrient compositions like Ploy4 (polyhalite) (K_2SO_4.$MgSO_4$.2$CaSO_4$.2H_2O) could be potential sources for nutrient management in groundnut and for maintaining/restoring soil fertility. A field experiment was conducted during *kharif,* 2022 at GRF to study the effect of POLY4 in combination with different doses of recommended NPK and gypsum on rainfed groundnut. The recommended dose of fertilizer was 20:40:50 kg N, P_2O_5 and K_2O/ha. All the nutrients except gypsum were applied as basal at the time of sowing. Gypsum was applied at flowering stage of the crop as per the treatments. Application of recommended NP + 100% recommended K through POLY4 being on par with other treatments recorded significantly higher pod yield (1556 kg/ha) compared to application of recommended NP alone or in combination with 50% K through MoP or gypsum @ 500 kg/ha, and Control. Application of recommended NP + 50% K through POLY4 recorded similar yield (1461 kg/ha) as that of recommended NPK (1479 kg/ha).



Effect of treatments on pod yield of groundnut.

Performance of groundnut with application of rec. NP + 50% K through POLY4.

2.4.10. Effect of polyhalite application on maize yield, nutrient use efficiency and GHGs emission under rainfed condition

As polyhalite is a natural fertilizer material, it has very low carbon footprint compared to synthetic materials. In this study, effect of polyhalite application on crop yield, use efficiency of nutrients, soil properties, GHG emission and economic viability were assessed. A field experiment was initiated in 2021 in Gunegal Research Farm (GRF), ICAR-CRIDA, Hyderabad in Alfisol under rainfed condition. Experiment was conducted on maize crop (DHM 117 with 9 treatments viz., T_1=Rec. NP+ S equivalent to T_3 through S Bentonite, T_2=Rec. PK (100% K through MOP) + S equivalent to T_3 through S Bentonite, T_3=Rec. PK (100% K through Poly4), T_4=Rec. NPK (100% K through MOP) + S equivalent to T3 through S Bentonite, T_5=Rec. NPK (100% K through Poly4), T_6=Rec. NPK (75% through Poly4+25% through MOP) + 25% remaining S through S Bentonite, T_7=75% N +100% P +K (100% K through MOP) + S equivalent to T_3 through S Bentonite, T_8=75% N +100% P +K (100% K through Poly4), T_9=75% N +100% P +K (75% through Poly4+25% through MOP) + 25% remaining S through S Bentonite. Results revealed that significantly higher leaf area index at 30, 60 and 90 DAS were observed in NPK (75% Poly4+25% MOP) + 25% S treatment which was at par with NPK (100% K-Poly4) and NPK (100% K-MOP) + S. Dry matter production at harvest was higher in NPK (75% Poly4+25% MOP) + 25% S. Early tasseling was observed in PK (100% K-MOP) +

Crop growth under different treatments.

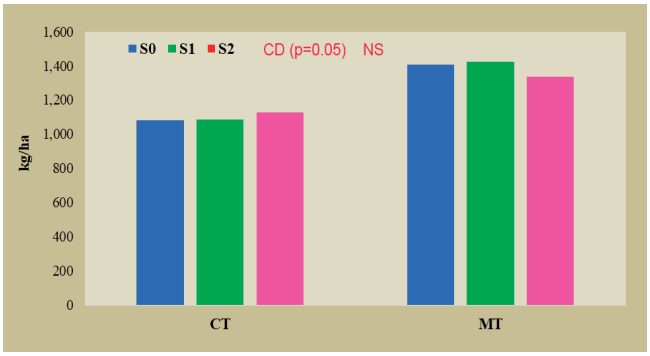
S treatment and early silking was observed in PK (100% K-Poly4). Significantly higher cob length (21.03 cm), cob girth (18.40 cm), cob weight (269 g), no of grains per cob (548) was observed in NPK (100% K-Poly4), whereas, significantly higher 100 seed weight (33.1 g), grain yield (4241 kg/ha) and stover yield (5216 kg/ha) was observed in NPK (75% Poly4+25% MOP) + 25% S. There was a slight decrease in pH in NP+S treatment. There was a slight buildup of K in PK (100% K-Poly4) due to lower uptake of K. K use efficiency increased by 10.4% with application of K through Poly 4 compared to MOP application. Significantly higher cumulative seasonal CO_2 and N_2O emission was observed in PK (100% K-Poly4) treatment, whereas lower cumulative seasonal CO_2 emission was observed NPK (100% K-MOP) + S treatment and lower cumulative seasonal N_2O emission was observed in 75% N +100% P +K (100% K-Poly4) treatment.

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

Field experiments were conducted at different locations, with different cropping systems, soil types, and rainfall. The experiments were conducted at CRIDA, 2 AICRPDA centers and on-farm (2 KVK and farmers fields). The experiments were conducted on location specific crops to develop CA technologies for different soil types and cropping systems.

2.4.11.1. Conservation tillage farming strategies and crop residue management for soil health improvement and higher crop productivity in sorghum-blackgram system in rainfed Alfisol

A long-term experiment was initiated during 2013 with sorghum and blackgram as test crops in yearly rotation at Hayathnagar research farm. The experiment was laid out in a split-plot design with two tillage practices: conventional (CT) and minimum (MT) and three residue retention treatments viz; no residue application (S0), retaining the residue by cutting the crop at 35 cm height (S1), retaining the residue by cutting the crop at 60 cm height (S2) in case of sorghum. For black gram crop, the residue retention treatments were no residue (S0), 50% residue retention (S1) (clearing of residue from alternate rows), 100% residue retention (S2). In the 10th year of the study, blackgram variety PU 31 was grown in *kharif* 2022. Blackgram yields varied from 1082 to 1424 kg ha^{-1} across the treatments. Seed yield



Blackgram seed yield with tillage and residue management practices.

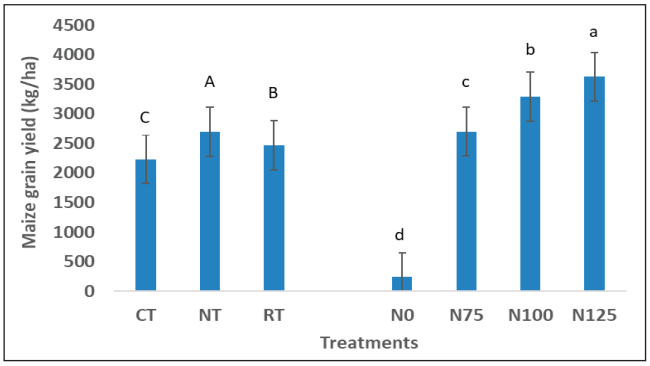
Blackgram (variety PU 31) crop under minimum tillage and maximum residue retention.

of blackgram did not show any significant differences with either tillage or residue management practices.

2.4.11.2. Impact of conservation agriculture practices on soil physical properties in maize-pigeonpea crop rotation under rainfed Alfisols

To optimize the tillage practices and nitrogen levels for improving the soil health of dryland farming system (maize-pigeonpea crop rotation) and farm productivity and profitability, a project initiated in 2012. Maize was grown during *kharif* 2022. Treatments include: In main plot- three tillage practices, *viz.* 1. Conventional Tillage- Summer ploughing + Cultivator +Disc harrow before sowing and no residue retention of previous pigeopea crop. 2. Reduced Tillage-One time cultivator+ Disc harrow before sowing+ Residue retention up to 30 cm plant height of previous pigeopea crop and 3. No tillage-Direct sowing + Residue retention up to 30 cm stem height of previous pigeonpea crop. In sub plot 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).

Effect on maize grain yield: This year maize crop was sown. Results revealed that both tillage practices and nitrogen management did not influence the seed germination of maize crop. About 20.7 and 10.5% significantly higher mean maize grain yield recorded in NT and RT as compared to the CT, respectively and about 9.2 % higher seed yield recorded in the NT as compared to the RT. The added level of the nitrogen enhanced the seed yield significantly. Due to continuous omission of the nitrogen in control plot (N-0) the yield recorded very low as compared ot he other nitrogen levels. The recorded maize grain yield in N-0, N-75, N-100 and N-125 was 231.2, 2668.1, 3326.3 and 3639.9 kg ha^{-1}, respectively. The interactive effect of tillage practices and nitrogen levels found to be non-significant.

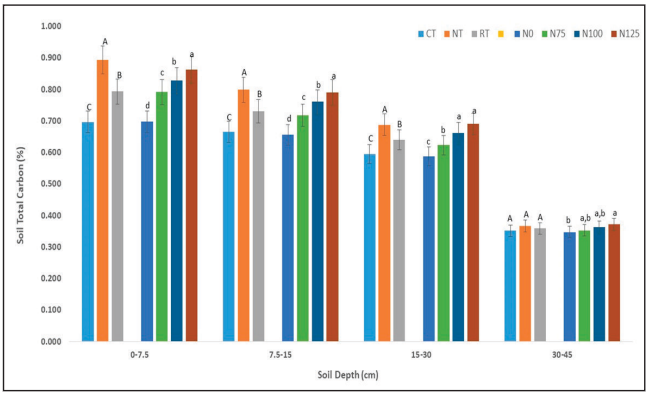


Mean effect of tillage practices and nitrogen levels on maize grain yield (kg/ha).

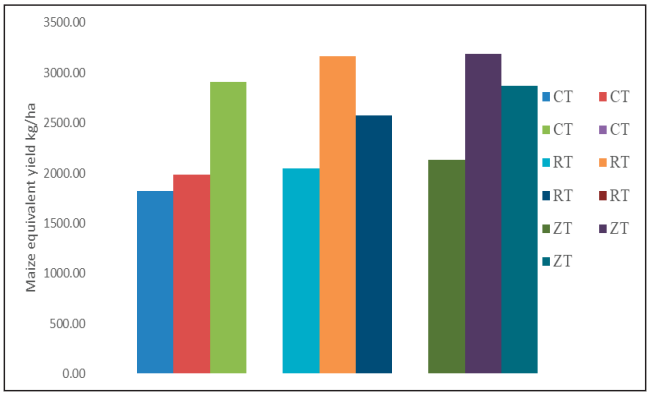
Effect on soil total carbon in different soil depths: The analysis of soil samples after seven year of this long-term experiment on soil total carbon revealed that more effect of tillage practices and nitrogen levels observed on upper soil depth. In NT in 0-7.5, 7.5-15, 15-30 and 30-45 soil depth, 28.1, 20.1, 15.6 and 4.4% higher total carbon observed as compared to the CT. In RT, 13.9, 9.9, 7.7 and 2.2% higher total carbon observed in 0-7.5, 7.5-15, 15-30 and 30-45 soil depth, respectively. As compared to the RT, in NT 12.5, 9.2, 7.3 and 2.2% higher soil total carbon observed in 0-7.5, 7.5-15, 15-30 and 30-45 soil depth, respectively. Although, at 30-45 soil depth, tillage practices found non-significant. The added levels of nitrogen significantly influenced the soil total carbon in different soil depth. About 16.4, 15.2, 10.0 and 4.3% higher soil total carbon observed at N-125% as compared to N-0 in 0-7.5, 7.5-15, 15-30 and 30-45 soil depth, respectively. The corresponding increase in NT and RT was 32.4, 28.8, 15.6 and 9.3%, and 21.1, 17.2, 15.1 and 7.86% observed in N-125% as compared to their respective N-0, respectively.

2.4.11.3. Comparing different tillage practices and residue levels in increasing crop productivity, profitability, resource conservation and mitigation of climate change

This year maize +cowpea intercropping system was evaluated on different levels of castor residues with different tillage practices like conventional tillage, reduced tillage, zero tillage, and different residue levels by harvesting pigeonpea crop and foxtail millet at different heights (0 cm, 10 cm and 30 cm) to increase the residue contribution to the field. In the subplots the intercrop cowpea was introduced in 10 and 30 cm. The foxtail millet was also harvested at different levels. The results revealed that zero tillage and reducrd tillage recorded 19 and 4% higher maize equivalent yields as compared to conventional tillage. respectively. The maize equivalent yields in 10 and 30 cm recorded significantly higher yield as compared to no residues. 10 and 30 cm height crop residues recorded 23 and 20% higher yield as compared to no residue.



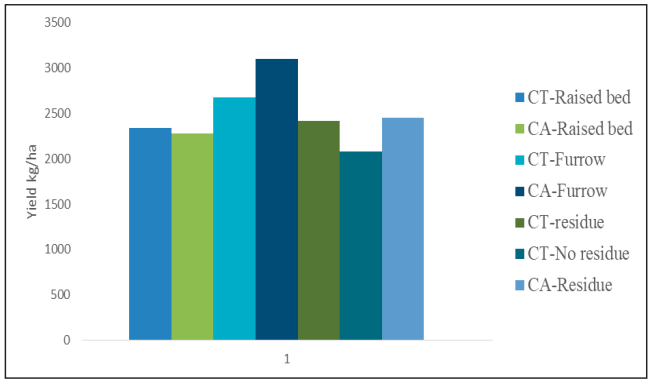
Effect of tillage practices and nitrogen levels on soil total carbon in different soil depths.



Influence of tillage and residue levels on maize equivalent yield.

2.4.11.4. Integration of in situ moisture conservation practice as complementary practice with CA

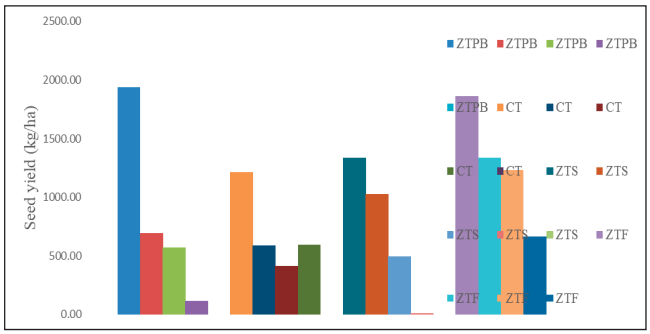
An experiment was initiated with the integration of in-situ moisture conservation with CA practice in maize-pigeonpea system in 2014. The experiment was laid out in RBD with different treatments (conventional planting without residues, conventional planting with residues, conventional tillage formation 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. This year maize is taken as test crop. Conventional tillage without residues recorded lowest yields. Integration of *in-situ* moisture conservation practices either through conservation furrow or bed and furrow method in both CA and conventional tillage has recorded higher yield as compared to no moisture conservation treatments in both the crops. Among the conservation treatments permanent conservation furrow recorded higher yields. The higher yields in moisture conservation treatments were due to higher retention of soil moisture as compared to no moisture conservation.



Influence of different in situ moisture conservation treatments on maize seed yield.

2.4.11.5. Integration of *in-situ* moisture conservation and weed management practices as complementary practices along with CA

An experiment was initiated with integration of *in-situ* moisture conservation and weed control along with CA practices as complimentary practices. Pigeonpea was the test crop. This year integration of *in-situ* moisture conservation practices through permanent bed and furrow, permanent conservation furrow recorded 15 and 40% higher pigeonpea yields as compared to conventional tillage without moisture conservation treatment, respectively. Among the weed control treatments pre-emergence + post emergence herbicide application recorded higher yields as compared to other weed management practices. Reduction in crop yield in un weeded treatment in ZT normal sowing was higher than in conventional tillage and zero tillage with *in-situ* moisture conservation. It was observed that ZTF recorded higher yield in control since dhaincha is grown as intercrop.



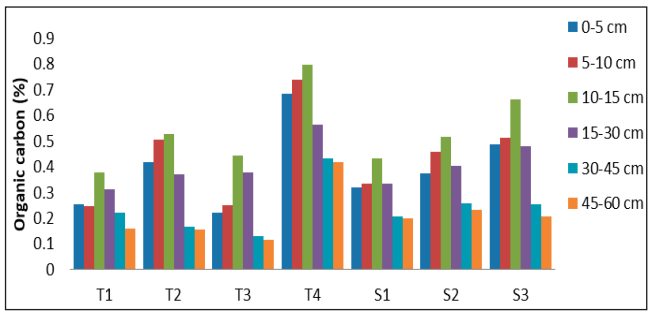
Influence of different treatments on pigeonpea seed yield.

2.4.11.6. Foxtail millet-greengram system on Alfisols with soil and water conservation measure (sustainable intensification)

A field experiment is being taken up in Gunegal Research Farm of Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad. The experiment was laid out in split plot design with four tillage treatments: T_1- conventional tillage (CT) and T_2- minimum tillage (MT), T_3- zero tillage (ZT) and T_4- zero tillage with soil and moisture conservation practices. and three residue retention treatments viz; farmers' practice of harvesting close to the ground without any retention of residues (S_1), harvesting *kharif* crop at 30 cm height (S_2), harvesting only pods/panicles and retaining the entire residue as such (S_3). Setaria and greengram were used for the study.

Results showed that among the tillage practices, zero tillage with soil and moisture conservation practices (T_4) recorded significantly higher organic carbon after greengram harvest. Lower organic carbon was recorded in conventional tillage (T1). Zero tillage with soil moisture conservation practices (T_4) recoded 38.28% higher setaria residue cover biomass over conventional tillage (T_1). Among the residue retention levels,

harvesting only pods/panicles and retaining the entire residue as such (S_3) treatment recorded higher residue cover biomass and organic carbon over S2 and S_1.

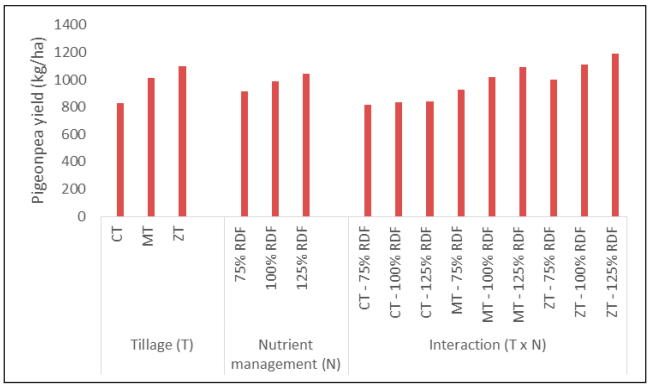


Effect of tillage practices and residue retention levels on organic carbon (%) after greengram crop harvest.

2.4.11.7. Evaluation of system productivity and profitability in major rainfed cropping systems under conservation agriculture practices

A field experiment was conducted every year since 2016 in sandy loam soil of Gunegal Research Farm at ICAR-Central Research Institute for Dryland Agriculture (ICAR-CRIDA), Hyderabad with different treatments: zero tillage (ZT- no till, direct seeded with residue retention), minimum tillage (MT- One ploughing, sowing with residue retention) and conventional tillage (CT- two ploughing with disk plough, one harrowing and sowing) as main plots and 75% RDF, 100% RDF (pearl millet: 80-40-30 kg N, P_2O_5, K_2O ha^{-1}, horsegram on residual fertility, pigeonpea: 20-50-0 kg N, P_2O_5, K_2O ha^{-1}) and 125% RDF as subplots, to study the effect of tillage practices and different doses of fertilizers on performance of pearlmillet (MP MH21) and horsegram (CRHG 4). Another set of experiment was conducted on cotton (ADB 542) - pigeonpea (WRGE 93) rotation. Results revealed that in pearl millet (PM)-horsegram (HG) sequence-pigeonpea (PP) rotation, significantly higher yield was obtained in ZT (1100 kg/ha) compared to CT (831 kg/ha) in 2022. Pooled data of 7 years (2016-2022) revealed that significantly higher pearl millet equivalent yields were obtained in minimum tillage (MT) with 125% RDF compared to zero tillage (ZT) and conventional tillage (CT). Yield increase in MT was 12.6% over ZT and 19% over CT.

In cotton-pigeonpea rotation analysis of pooled data of 7 years (2016-2022) revealed that significantly higher cotton equivalent yield (CEY) was obtained with minimum tillage with 125% RDF as compared to zero tillage (14.2% increase) but at par with conventional tillage.



Effect of tillage and different fertilizer doses on pigeonpea yield.

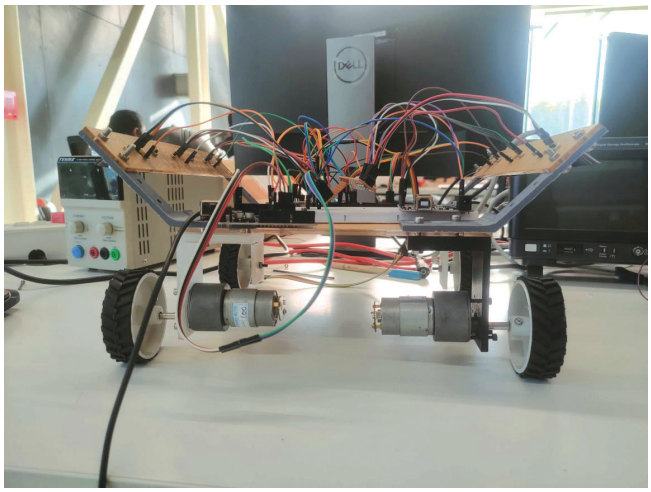
Significantly higher SOC was observed in ZT and MT (5.6 g/kg) compared to CT. Significantly higher very-labile and non-labile C was observed in ZT, higher labile C was observed in MT. Significantly higher microbial biomass carbon and dehydrogenase activity was observed in ZT with 125% RDF, whereas higher urease activity was found in CT with 125% RDF. There was a slight decrease in bulk density (1.58 g/cc) in ZT compared to CT (1.64 g/cc). There was a slight buildup of available N and K (kg/ha) in surface soil in ZT. Significantly higher water-soluble K and exchangeable K was observed in ZT compared to MT and CT, but non-exchangeable K was at par in MT and ZT. Higher energy output/input was observed in ZT. N_2O emission was lesser in ZT (19%) compared to CT and MT.

Crop growth of cotton and pigeonpea in different treatments.

2.5. Energy Management

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

The autonomous platform was developed with main rigid frame, drive wheels, and steering wheels. The drive wheels comprise an agricultural lug tire with dimensions of 3" x 12" powered by 350W DC motor as a propulsion system. Further, sensor based steering system with small robotic platform was designed to study the sensor works, data acquisition, and interpretation. It works on LiDAR based sensing and marker-based navigation control for the robot to follow furrows and it was developed with the help of T-Works which is a Prototype manufacturing fecilitating centre of Government of Telangana. It consists of LiDAR based point distance sensor either side of the platform to sense the distance of frame from the furrow wall. Further, it consists two optical encoder equipped DC geared motor to powered the platform. All sensors and motors are taking the signals from ATmega2560 microcontroller. The algorithm was developed to operate the motors in such way that the platform will run in furrows by taking navigation signals from distance sensors.



Front view of small robotic platform with motor

Further, A battery-operated boom type spraying system was developed for autonomous platform. It consists of double motor pump, spraying boom equipped with five nozzle, 25 lit tank etc. The nozzles on the boom were spaced equally and can be closed as per requirement. All the standard commercially available components were procured and reworked for tight fitments to avoid fluid leakages during the sprayer development. The swath width of sprayer can be adjusted as per spray requirement. Entire bed area with both furrows can be covered during herbicide spraying. Moreover, row specific spraying can alsobe done by adjusting the nozzles As designed sprayer is battery operated, automation in sprayering operation like target oriented spraying will become easy. Another attachment for weeding on raised bed has been developed. It is basically consists of linear actuator, T shape weeding tool with tyne, spacing adjustment clamps etc. Linear actuators actuate the weeding tools up and down as per the sensor signal. It is proposed to use the colour sensors to identity the weeds primerily. The actuator can take a load of 300 N. Separate actuator can used for different tynes depends as per the need.

A view of autonomous platform equipped with spraying and Weeding tool attachment (Potato crop)

2.5.2 Development of tractor mounted harvester for maize and sorghum crops

Newly developed harvester basically operated by the PTO drive and offset monting which consist rotating blade assembly, vertical drum conveyor and vertical flat conveyor. The rotating blade assembly consisted four blades covering 1300 mm width of operation whereas vertical conveyor assembly consist four vertical cylinders fitted with fins on its periphery. The rotational speed of blade and drum can be varied using PTO speed and gear arrangements. The conveyor assembly is able to carry the stems to a side without the forward dropping. The crop guide (rotary drum) present in front of machine guide the crop towards rotary cutter. The rotating blade

assembly consisted three/four rotary blade on one disc. After cutting, vertical roller equipped with fins convey the crop towards windrower. Vertical drum conveyor assembly consist of four vertical cylinders fitted with star wheel on its periphery. The earlier model which is of tractor front mounted harvester was unable to perform the desired operation. Hence, it is planned to work with the Off-set type PTO operated harvester to test the effecacy of the designed mechanism with the help of our MoA signed industry.

A view of tractor side mounted sorghum harvester

The cutting can be done by using the blades operated around 800-1000 rpm which will cut the stem by impact and shear force. These blades are mounted at the bottom of the hallow rollers which guides the cut stems to the conveying zone.. Two stage conveying system are planned to convey the stems vertically in two direction. First conveying operation is provided at the cutting unit to pick up the cut crops towards inclined conveyer for windrowing the cut stems towards one side of harvester..

In hallow roller type conveying, two counter rotating lugged cylinders mounted on axis of blade with minimum clearance and move in counter directions to pick up the cut stems and also to pull inside. The centre to centre distance of pulleys was kept as 650 mm. The overall diameter of 560 mm and height of cylinder is about 600mm (Adjustable). On each cylinder 48 triangular lugs are fixed in three steps. The windrow conveyor has mounted exactly backside of the conveying cylinder with an adjustable inclination angle just beside to the horizontal conveyer. A reel mechanism was also provided to pull the stems in to the cutting zone so that the stems will not fall forward during the harvesting time unlike to the first model. It is still under manufacturing stage.

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

Battery powered reaper for harvesting of short and bushy crops was developed at Farm Machinery Research Workshop (FMRW) of ICAR - CRIDA, Hyderabad.. Field testing of developed prototype conducted on soybean and safflower. The average plant density and height of soybean varied between 20-25 plants per m^2 and 35-55 cm at the time of harvesting. It was observed that developed mechanism cut the crop stems very smoothly with better cutting efficiency. Simultaneous cutting and windrowing mechanism working well. Moreover, it cuts the stem from the ground level. Further, minimum grain losses were observed as compared to conventional cutting mechanism. Manoeuvrability of machine is good and one man can operate it easily. This prototype also tested on others crops like chickpea, soybean, rice, safflower etc.

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

Prototype of solar powered vehicle was developed at Farm Machinery Research Workshop. It consists of 1.5-hp BLDC motor (48 V 28 amps), motor controller, solar charge controller, gear box, power transmission mechanism etc. Operating power is given to BLDC motor from 3-hp solar PV module (Stationary) through solar charge controller and motor controller using suitable cable. Earlier(2021-22) prototype was

tested for weeding operation using blade harrow and rotary tool which gave satisfactory performance when solar irradiance were above 3 kW/m²/day (August-September). During 2022-23, the prototypes of solar powered 3-tyne cultivator for shallow tillage and 3-row planter for sowing were tested in field conditions. It was observed that these operations need higher solar irradiance than weeding operations due to increase in depth of operation. Overall carrying weight of the machine was also increased due to mounting of 3-row planter which resulted in travel speed lower than 1 km/hr. Whenever solar radiations are too low the machine was operated on batteries of equivalent power which improved tillage depth and operational speed. Batteries are charged on solar panel.

Shallow tillage operation with solar-cum-bettery operated three tyne cultivator

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

The machine tool bar composed of two components: a fixed tool post and extendable V-shaped arm with rotary working tool. The tool post is made of 11.5 cm size square bar and 160 cm in length. The one end of post is attached to tractor chassis using multi-functional tool holder bracket and other end is provided a rectangular shaped hollow bracket to facilitate V arm attachment. The V arm total length including tubular plain bar part (70 cm) is 145 cm in length. The tubular plain bar part is fitted into tool post bracket and other end provided a rotary disc header, which can be fitted soil stirring fingers or weed biomass cutting devices. The V- arm is provided with two 2 jacks, one to provide vertical movement to a limited extent to the rotary disc header and the other jack to provide lateral movement while in operation to facilitate extension and traction of rotary disc tool under tree canopy for better weed control close to tree trunks. Depending on the weed control requirement, either weed biomass cutting devices or soil manipulation blades could be fitted interchangeably. The weed biomass mowing rotary disc working width was 80 cm with 3 cutting devices, whereas the soil mechanical manipulation was 45 cm in width. The tractor attached rear hydraulic system with proper components and linkages powers the rotary header. The machine was tested in weed biomass shredding in custard apple orchards with predominantly grown up weed species commonly known such as Alteranthera triandra (Joy weed), Celosia Argentea (Cockscomb), Casia Tora (Ringworm plant) and mixed weeds , whose height ranged from 15 to 120cm. The machine performance was found satisfactory. The moisture contents of these weeds ranged from 89.8% db (dry basis) to 2.71 times the weed dry weight. The soil moisture content varied from 6.03 to 10% db. The machine field efficiency was 0.5ha / hr.

Horticulture crop before and after machine operation

2.6. Socio-economic studies

2.6.1. Farmer centric natural resource development for socio-economic empowerment in rainfed areas of Southern Telangana region

Soil and water conservation Interventions

Micro sprinklers, micro irrigation drip systems with scheduled fertigation for vegetable crops and portable raingun system for field crops were designed and installed at different locations of the adopted village for high value crops such as Chilli and Tomato. Two farm ponds were constructed of size 13*13*8 ft^3 in each of Rakamcharla and Devanoniguda villages of Pudur mandal, Vikarabad district for rainwater harvesting.

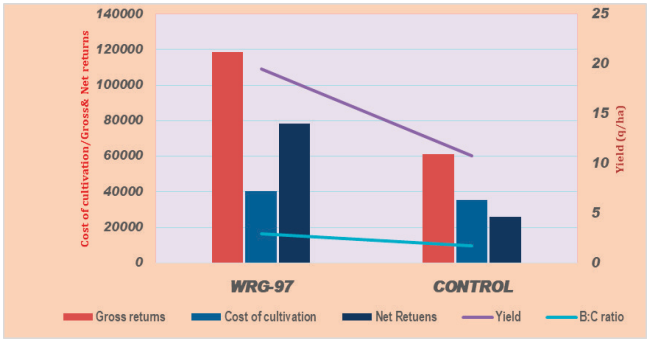
Farm pond constructed in Rackamcharla village and Devanoniguda village

Raingun in operation in farmers' fields

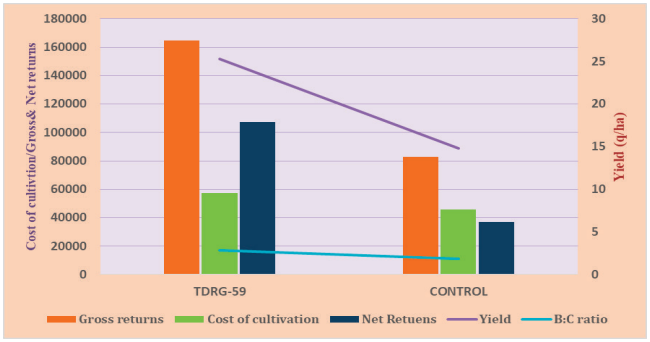
Crops and Cropping Systems

Field demonstrations on improved pigeon pea varieties

New two improved pigeon pea varieties TDRG 59 and WRG-97 were introduced and demonstrated in 200 ha of 300 households in adopted villages of Vikarabad district. TDRG 59 was found to be resistant to Fusarium root wilt and sterility mosaic virus. Nine row planter was demonstrated for sowing maize and pigeon pea crop in 4:1 Maize + pigeon pea intercropping system in 40 ha in *kharif* season. Good management practices resulted in good yield for farmers despite high rainfall initial vegetative stages of crop growth during June and July months.



Cost of cultivation, returns and yield of WRG 97 pigeon pea variety



Cost of cultivation, returns and yield of TDRG 59 pigeon pea variety

Soil fertility status of FFP adopted village

Using the soil test data, Soil Health Cards were prepared for 100 farmers of Medikonda village and distributed to farmers on World Soil Day (5th December 2022). The soil test data indicated that almost all soils were deficient in available N, high in available P and K. Importantly 70-80% of soils in these villages were low in available S and B. Therefore, field demonstrations are being conducted on farmers' fields in *rabi* season of 2022 on chickpea to demonstrate the beneficial effect of S application along with N and P.

Small farm mechanization

Four types of farm implements were extensively demonstrated which were used across various crops just by replacing working minor components such as seed metering plates in planters both for sole and intercropping systems, flat and rotary blades for power weeder as for weed density; in case of brush cutter circular toothed blade for crop harvesting and sharper wire device for weed biomass cleaning from field bunds.

Usage and performance of various implements and machines in the study area

Machine / Implement	Crops	Usage, Acres	Field capacity, acres/ hr	Cost saved %
9 – row planter	Maize, Redgram + Maize, Bengal gram	45.0	1.05	21.0
Manual weeders	Vegetables, Flowers	20.0	0.09	15.0
Power weeder	Cotton, Maize, Redgram	23.0	0.2	20.5
Brush cutter	Paddy harvesting Maize stalk Field bunds cleaning	15.50	0.32	23.8

The tractor operated 9-row planter is most popularly used machine for various crops covering 45 acres and saved about 21% cost in seeding operations. The manual and power operated weeders reported a cost saving of 15 % and 20.5%, respectively. The engine operated brush cutter saved highest 23.8% cost in harvesting of crops like paddy, maize stalk.

CRIDA Planter in operation

Brush cutter demonstration for paddy harvesting in Pudugurthy village

Pigeon pea + maize intercrop sown with machine

Manual weeder demonstration in Medikonda village

Livestock production and management

Promotion of backyard poultry varieties (Srinidhi and Vanraja): A total of 50 women farmers of Medikonda village, Pudur mandal were covered under this intervention on 14th February, 2022. Twenty-five chicks with chick feed, hover with bulbs and bamboo baskets were given to them as a part of good management practice which resulted into an improved profit of Rs. 5,942 per household and an increased protein intake of 12.7% per household.

Group of Vanaraja and Kadaknath birds reared by the women farmers of Medikonda village

Area-specific mineral mixture supplementation in small ruminants and dairy animals: A total of 45 farmers were covered under this intervention in Gangupally and Pudugurthy village. An overall increase of 7.3% in ADG (equivalent to net profit of Rs 225 per animal) was observed in goat and an overall increase of 5.7% in milk yield (equivalent to net profit of Rs 1215 per animal) was observed in dairy cows.

Promotion of mineral licks in small ruminants: A total of 12 goat rearing farmers in Gangupally village were covered under this intervention which resulted into negligible kid mortality (1.5%) and improved growth rate (3.9% in ADG) equivalent to a net profit of Rs. 78 per animal. One block was found to be sufficient for a herd of 5 goats for 2 months.

Interaction meeting with farmers of Gangupally village

Improved fodder production and management (Super Napier): Twelve farmers from Pudugurthy village were covered under this intervention which resulted into a yield of 135 t/ ha which has a potential to support almost 175 sheep.

Extension Activities

Training program-cum-field day on soil and water conservation techniques

Topics of soil health management, crop, livestock and horticulture were discussed for the FFP beneficiaries on 03rd August 2022 in the FFP adopted villages and about 50 farmers of Gangupally and Rakamcharla participated in the program. After training, an exposure visit to farm ponds at farmers' field was also organized.

Field Day at farm pond

World Pulses Day at farmer FIRST Village

World Pulses Day was celebrated on 10th February, 2022 to create awareness about the importance of pulses. A field day-cum demonstration of control of root wilt in Chickpea crop was also organized for the farmers of Gangupally village.


Field day cum demonstration at farmers field

World soil Day at farmer FIRST village

World soil day was celebrated on the theme "Soil: Where food begins?" on 5th December, 2022 at Medikonda Village, Pudur Mandal, Vikarabad District. Around 100 farmers participated in the programme.

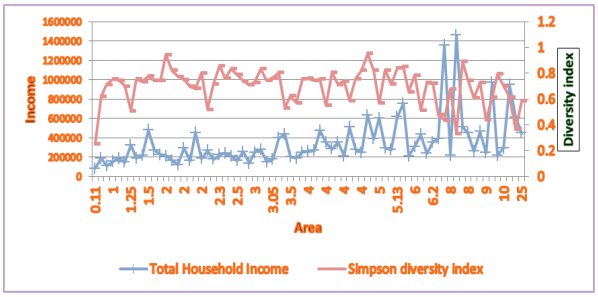
Celebration of world soil day

2.6.2. Livelihood diversification strategies in rainfed areas of Telangana State

The Livelihood diversification pattern and strategies adopted by farming community cultivating rainfed crops in different rainfed regions of Telangana State has been studied. Livelihood diversification index (LDI) for marginal and small farmer was found to be 0.7340 and 0.7346 respectively which was higher than medium category of farmer (0.6560) and large farmer (0.5779), which indicated small farmers explore more sources of income as land is meager when compared to the large farmers.

Regression of agriculture net income on Diversity Index Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	t-value	Sig
	B	SE	Beta		
(Constant)	220140.45	40664.003		5.414	.000
Diversification index	190922.28	57114.555	-.369	-3.343	.001



Distribution of respondents with total household income vs diversity index

2.6.3. Development of strategic framework for up scaling of proven technologies in rainfed areas

Factors like farm size, annual income, irrigation, information seeking behaviour, extension contact, participation in extension activities and relative advantage, trialability and access to technology have significant correlation with technology spread of stress tolerant variety.

2.6.4. Evaluation of communication networks for the adoption of rainfed technologies – An experimental study

To analyze the communication pattern among the farmers after the intervention social network analysis was carried out using software Gephi 0.9.2 version. Network parameters for the control villages indicated that friends, relatives, progressive farmers, AEO and input dealers form the major sources of agricultural information. At the same time scientists from ICAR, AEO, friends, relatives and progressive farmers were the major information sources in treated villages as perceived by the farmers.

Centrality measures of information sources

Information sources	Salkarpet			Komreddypally			Kondapur			Vennached		
Centrality measures	D	CC	BC	D	CC	BC	D	CC	BC	D	CC	BC
Friends	18	0.48	440.90	18	0.48	468.37	21	0.51	258.54	20	0.51	273.65
Relatives	15	0.39	413.32	14	0.38	408.03	16	0.41	237.94	14	0.40	230.57
Neighbours	9	0.40	206.81	8	0.36	175.95	9	0.42	116.33	8	0.37	111.98
Progressive farmer	13	0.43	290.81	12	0.41	316.78	14	0.50	269.60	13	0.48	270.34
AO	9	0.44	167.98	9	0.43	200.37	13	0.50	114.37	12	0.49	108.03
AEO	13	0.51	431.93	12	0.49	347.32	21	0.59	314.00	19	0.56	266.17
SAU	8	0.42	75.36	6	0.41	47.05	5	0.46	37.83	4	0.42	35.98
ICAR	5	0.39	29.64	3	0.38	4.06	28	0.60	419.62	27	0.59	465.29
Input dealers	10	0.41	113.44	11	0.42	182.7	7	0.40	34.97	6	0.37	29.14

Comparison of social network parameters among control and treated groups was done by applying Multi-variate Analysis of Variance, Hotelling's T^2 test and it was found to be significantly different among these groups.

Comparison of attributes of social network using MANOVA

Particulars	Control		Treated		F	Sig.
Villages	Salkarpet	Komreddypally	Kondapur	Vennached	2062.551*	0.022
Graph density	0.064	0.06	0.088	0.082	40.692*	0.024
Modularity	0.425	0.442	0.272	0.294	117.207*	0.008
Average path length	2.902	2.948	2.498	2.585	60.742*	0.016
Average degree	3.37	3.185	4.667	4.37	50.315*	0.019
Average clustering coefficient	0.152	0.121	0.279	0.288	82.952*	0.012

*Significantly different

2.6.5. Multidimensional study on wellbeing outcomes in relation to agricultural interventions: evidences from semi-arid regions of India

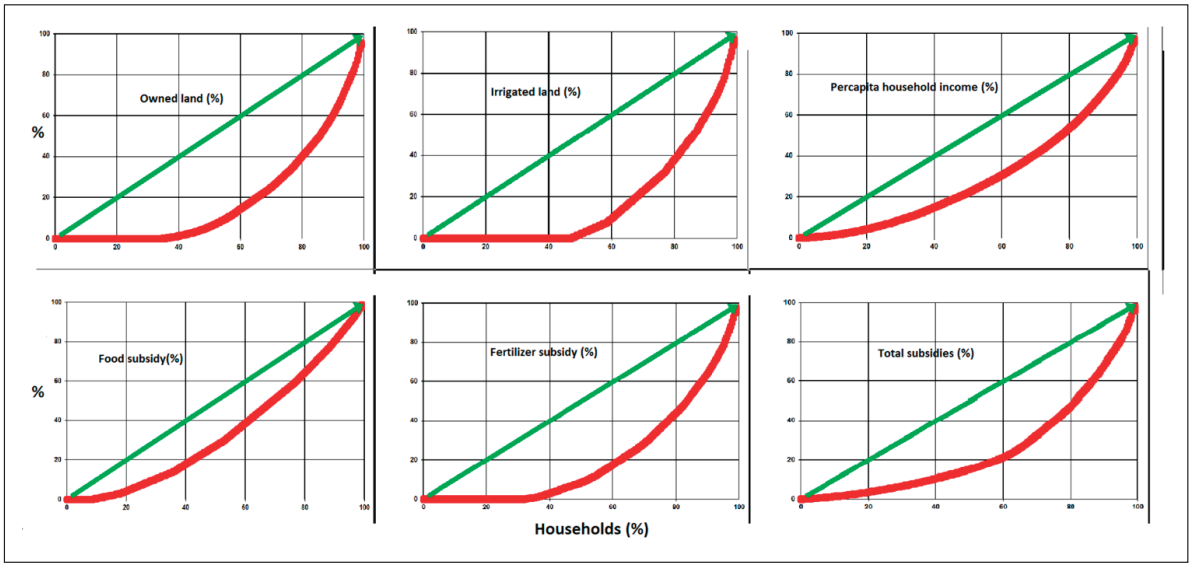
A framework was developed to study the wellbeing which consisted of five parameters viz material, health, social security, social relations and freedom. In addition to above parameters, food insecurity, risk and uncertainties, and its management study was also included in the schedule to study the holistic study of wellbeing.

2.6.6. Assessment of adoption potential and constraints for popularizing/ upscaling Raised Bed Planter (RBP) and Broad Bed and Furrow Planter (BBF) in unreached areas

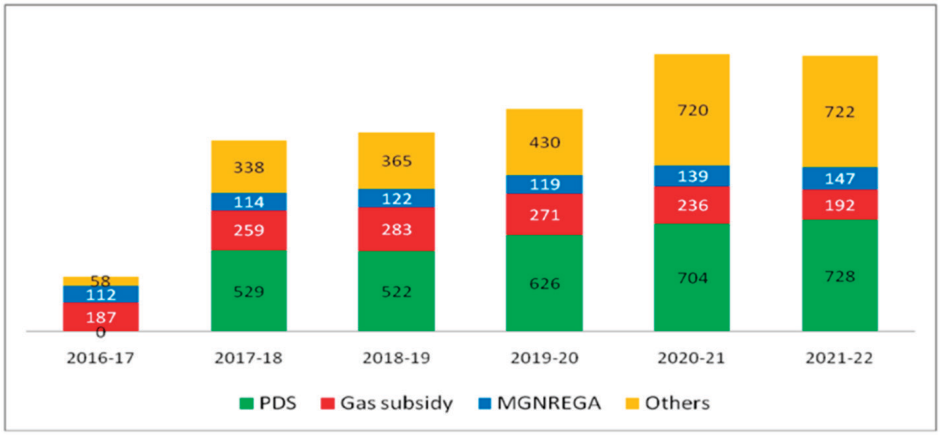
RBP and BBF Planters were demonstrated in selected cropping systems and farmers' fields of Telangana and field constraints in its adoption were identified from different stakeholders. Crop germination was good and yield obtained was about 3q/acre.

2.6.7. Building longitudinal panel data on development pathways in dryland villages

The questionnaire was developed and pre-tested to understand the level of technology adoption, farm mechanization, cropping pattern and off-farm and non-farm incomes. The land inequalities are persistent problem in the villages, but inequalities in per capita household income is reduced as households are adopting pluri-activities like casual labourer in agriculture and non-agriculture, livestock and non-farm employment. Lorenz curve shows that inequalities in land and fertilizer and water subsidies are more while household income, food subsidies are lower. It is also to be noted that in the recent years after COVID, most of the government schemes are shifted to Direct Benefit Transfer with fewer leakages.



Lorenz curve of households in study villages in Telangana



DBT beneficiaries in million households

2.6.8. Using the economic surplus method to assess economy wide impacts of CRIDA technologies/ policies

The adopters and non-adopters of dryland technologies like BBF, farm ponds, horse gram varieties and watershed programmes were studied in different states. The preliminary estimates showed that the total surplus to the economy with the adoption of improved horse gram varieties will be ranging from Rs.405 Crore to Rs.1908 Crore under different scenarios of adoption rates.

Economic surplus model results of cost-benefit analysis of horse gram improved varieties

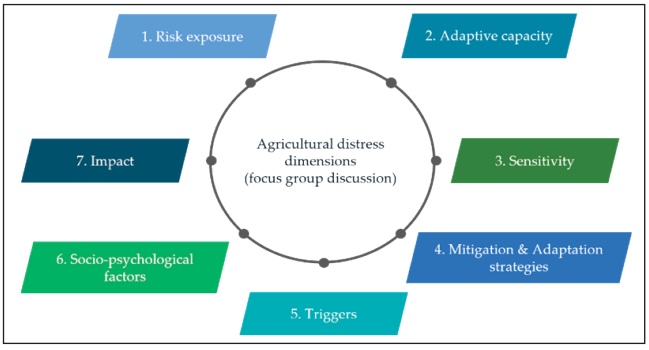
Simulation scenarios	Value of Production (TE 2017-19)	Total Surplus	Producer surplus	Consumer surplus
Yield increase (23%) Cost increase (10%) Adoption rate (50%)	800	405	157	247
Yield increase (46%) Cost increase (10%) Adoption rate (50%)		877	341	536
Yield increase (92%) Cost increase (10%) Adoption rate (50%)		1908	742	1166

2.6.9. Economic impact of livestock as means of livelihood security to resource poor dryland farmers

The study examined the spatial and temporal trends in livestock endowment in the country and its contribution to farm household income in selected semi-arid regions. The country, from 1951 to 2019, the compound annual growth rate of total bovines was 3.44 per cent while cattle it was 1.61 per cent and Buffalo had the highest growth of 8.19 per cent. The small ruminants are kept specifically in drylands for sustenance and sold as negative coping strategy. In the country the sheep population recorded a growth of 5.43 per cent and goat population of 9.5 per cent. The states under the arid and semi-arid regions of the country had major share of small ruminants.

2.6.10. Agrarian distress and PMFBY: an analysis of rainfed agriculture

To understand the impact of the different crop insurance schemes, this study probed crop condition, losses and claims from insurance in both normal year and bad year. The study also developed a Farmers Distress Index which comprises seven pillars as mentioned in the below figure to track distress at farmers level and identify sub-districts (blocks) with severe distress for intervention. All the schemes are not responding to the natural calamities like droughts, pest and diseases losses. Farmers' incomes decreased greatly during the bad year (2021-22) when compared to a normal year (2020-21). No other government or private schemes are working to alleviate distress during the bad year except crop insurance schemes like PMFBY and YSR-free crop insurance.



Dimensions of agricultural distress

2.6.11. Adaptation targeting and prioritization for climate change

An analysis of resilience of yield to drought showed considerable yield losses in soybean (7.05 q/ha) and chickpea (7.42 q/ha) during a drought year.

Adaptation technologies and yield resilience in soybean and chickpea, Ahmednagar, 2022-23

Yield resilience	Yield (Q/ha)	Yield lost (q/ha)	Resilience 1	Resilience2
Soybean				
Normal Yield	15.88			
No Adaptation	8.83	7.05	0.56	
With adaptation (Change of variety)	11.78	2.95	0.75	0.58
Chickpea				
Normal Yield	9.42			
No Adaptation	2.00	7.42	0.21	
With adaptation (Foliar spray)	6.17	4.17	0.32	0.44

Adaptation interventions viz., change of variety in soybean and foliar spray in chickpea helped reduce yield losses to 2.95 and 4.17 q/ha, respectively and enhancing yield resilience to 0.75 (0.56 with no adaptation) and 0.32 (0.21 with no adaptation) in soybean and chickpea, respectively. These adaptation technologies helped saved 58% an 44 % of avoidable yield losses in these two crops.

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

New measure was developed for assessing sustainability of treatments /practices evaluated in long term experiments as

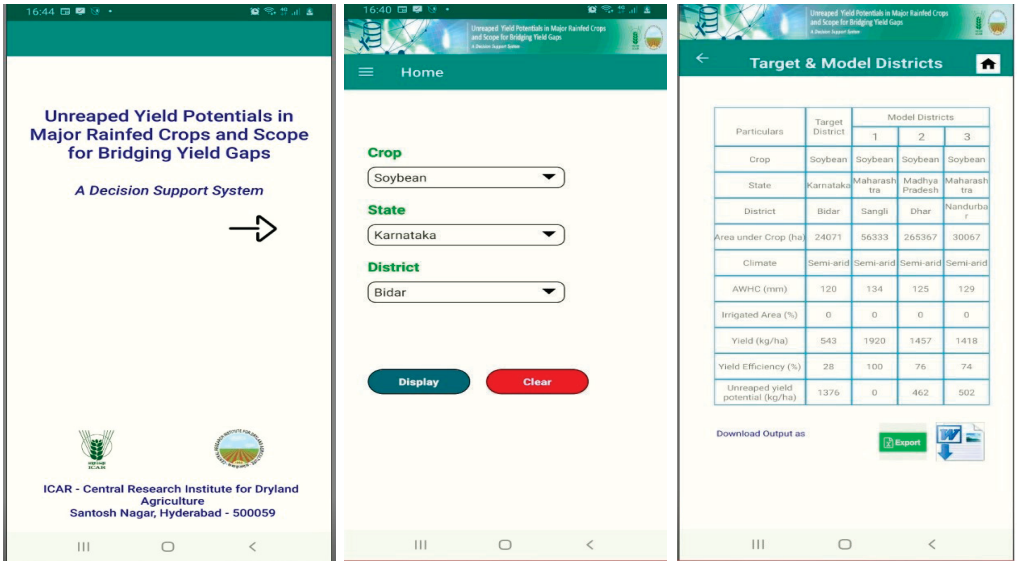
$$YSI = \frac{(\bar{Y}_{i.} - \sigma_{v_{ij}})}{Y_{max}}$$

Where $\sigma_{v_{ij}}$ is standard deviation in interaction effects of ith treatment over years; $\bar{Y}_{i.}$ is average yield of ith treatment over years, and Y_{max} is maximum yield in the experiment.

The measure was further improved by proposing two more estimators and developed a framework for assessing sustainability of treatments /practices evaluated in long term experiments. One measure was derived by regression of interaction residuals of a treatment in different years on environmental covariates such as rainfall, dry spells during the crop growing season. If adjusted R^2 is positive the model gives uncertainty estimate less than $\sigma_{v_{ij}}$. Similarly, another measure was developed by regression of interaction residuals of a treatment in different years on environmental index computed for a year as deviation of mean yield of all treatments in a year from overall mean. In this case too if adjusted R^2 is positive the model gives uncertainty estimate less than $\sigma_{v_{ij}}$. If adjusted R^2 is negative for any treatment sustainability estimate for the treatment should be based on $\sigma_{v_{ij}}$. Number of treatments with positive R^2 may be considered as a criterion to determine whether the measure to be used should be based on environmental covariates or environmental index.

2.6.13. Enabling decision makers in technology transfer in rainfed agriculture through mobile based applications

During this period, the developed mobile app unreaped yield potentials of major rainfed crops were updated accommodating 17 rainfed crops viz., rice, sorghum, pearlmillet, maize, fingermillet, chickpea, pigeonpea, blackgram, greengram, lentil, groundnut, soybean, sunflower, sesame, rapeseed, mustard, castor and cotton. The app provides climate and available water holding capacity (AWHC) of soil of the district, area under the crop and share of irrigated area and share of a particular season (in case of rice, sorghum, maize, blackgram and greengram) in area under the crop and yield of the district in the crop. It further provides yield achieved by model districts.



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

2.7 Scheduled Castes Sub Programme (SCSP)

Central Research Institute for Dryland Agriculture (CRIDA) is implementing SC Sub Plan in Kotapally mandal of Mancherial district, Telangana State and Chincholi Taluka, Kalaburagi district, Karnataka selected by NITI Aayog, Govt. of India, New Delhi.

The highlights of Salient Achievements are furnished below:

- An MoU has been signed between the Director, ICAR-CRIDA, Hyderabad and Commissioner of Rural Development, Govt. of Telangana on 25.02.2022 for the implementation of the watershed programme through District Rural Development Authority (DRDA) at Mancherial district. In this regard, during 2021-22, an amount of Rs. 40.00 lakhs was deposited on 29.03.2022 for renovations/digging of 17 percolation tanks/farm ponds/ check dam in Kondampet (5 nos.), Edagatta (5 nos.) and Nagampet (7 nos.) villages for creating rainwater harvesting to the capacity of 40,620 m^3. This water is used for supplemental irrigation to cotton and paddy crops during dry spells in *kharif*

Rejuvenation of water harvesting earthen dams by desilting

Harvested rain water in earthen dams after desilting and also for fish rearing

season and growing pulse crops during *rabi* season for doubling cropping intensity. In addition to this, these percolation tanks/farm ponds are also used for fish rearing to enhance farmers' income and nutritional security.

Awareness programme on "Balanced Fertilization for Soil Health Maintenance and Productivity Enhancement"

As a part of "*Annadata Devo Bhava*" Campaign under **AZADI KA AMRUT MAHOSTAV**, celebrating 75 years of India's Independence, an awareness programme on "Balanced Fertilization for Soil Health Maintenance and Productivity Enhancement" was organized at Mallampeta village of Kotapally mandal of Mancherial district, Telangana on 23rd April 2022. The need for rational and balanced application of mineral fertilizers for enhancing productivity and reducing cost was explained. Five kg zinc sulphate 33% bags were distributed to farmers on the occasion.

Annadata Devo Bhava Campaign at Kotapally mandal, Mancherial, Telangana

Annadata Devo Bhava campaign organized at Chindanoor village, Chincholi Taluka, Kalaburgi district, Karnataka

ICAR-CRIDA organized a special campaign on Annadata Devo Bhava at Chindanoor village, Chincholi Taluka, Kalaburgi district, Karnataka on 23rd April 2022. The theme of the special programme was to create awareness and promote natural/ organic farming. Scientists from ICAR-CRIDA along with Shri NVRN Murthy, CFAO, Shri Laxman Vittal, Sarpanch and about 50 farmers attended the programme. On this occasion, Dr. S S Balloli, Principal

Annadata Devo Bhava Campaign at Chincholi Taluka, Kalaburagi, Karnataka

Scientists educated the farmers about natural and organic farming, the components of natural farming, and the advantages/benefits of practising natural/ organic farming. Shri VRNV Murthy inaugurated vermicompost pit constructed by one of the farmers Shri Rajesh Pawar of Chindannor village. Later, Shri Murthy distributed the earthworms to farmers so that they can generate their own organic manures.

❖ Distribution of improved poultry breed

Kadaknath birds (250 nos.) along with feed material were distributed to 40 households in Bhoparam village of Kotapally mandal for backyard poultry farming. The intervention has the potential for not only income generation but also nutritional security. The farmers could able to generate additional income through the selling of birds.

❖ Distribution of tarpaulins and nutri-millet kits

A total of 2,000 tarpaulins were distributed to the beneficiaries covering 19 villages of Kotapally mandal. As a part of creating awareness about health and nutritional security, nutri millet kits (1,000 Nos.) were also distributed. A total of 750 tarpaulins were distributed to beneficiaries of Chincholi Taluka covering 11 villages.

Distribution of tarpaulins and Nutri millet kits

❖ Improved variety of red gram seed

An improved variety of red gram (PRG-176) was introduced in the cluster of eight villages of Kotapally mandal to increase the cropping intensity and soil health. To increase the area under red gram, 750 kg seeds (each 3 kg bag) distributed to 250 farmers during June 2022. Two improved varieties of redgram seed (TDRG-59 & PRG-176) were also distributed to 150 farmers of Chincholi taluka, Chindanur village.

Distribution of redgram seed to SC farmers

❖ Vegetable seed kit for kitchen gardening

Vegetable seed kits comprising Amaranths, Pumpkin, Ridge gourd, Chilli, Okra, Onion, Radish, Beans, Bottle gourd and Spinach were distributed for kitchen gardening/ backyard farming. This intervention helped them to grow organic vegetables and reduced the expenditure for household consumption. This intervention is ensuring nutritional security among the SC farmers with economic profits and they are satisfied. A total of 2000 households benefitted through this intervention.

Kitchen gardening at backyard

❖ Distribution of chickpea and safflower seed kits

An improved variety of Chickpea (BGD-103) and safflower (PBNS-12) along with vegetable seed kits to 160 farmers at Sangapur and Dharmasagar villages of Chincholi Taluka, Karnataka was distributed. Twenty five bags of chickpea and 40 bags of safflower in Kotapally mandal villages of Kondampet, Nagampet and Edagatta, for sowing during *rabi* season for efficient utilization of water harvested with newly constructed farm ponds was distributed. A total 60 SC farmers benefited.

Distributed improved variety of Chickpea and safflower

❖ Distribution of power sprayer

Four stroke petrol engine power sprayers (27 nos.) were distributed to selected villages of Kotapally namely, Kondampet, Bopparam, Alugama, kotaplly, Eddabandam, Paripally, Pinnaram, Esanvai, Saraivapeta, Shetpally, Laximipur, Repanpally and Nakkalapally under custom hiring mode.

Distribution of power sprayers

❖ **Distribution of Zinc Sulphate and Muriate of Potash (MoP)**

The soils of Kotapally mandal are deficient in zinc and the need to apply zinc through zinc sulphate for enhancing the productivity and the nutritional quality of the crops. To overcome the zinc deficiency, distributed 2,000 bags of 3 kg per bag of zinc sulphate to SC farmers in the mandal. Muriate of potash (MoP) was distributed to 400 SC farmers in Kotapally mandal of Mallampet and 150 bags in Chincholi Taluka of Chindanur village.

Distribution of Zinc Sulphate & MoP

Improved variety of green gram (MGG-347)

Farmers from Kotapally mandal keep land fallow after harvesting of paddy. To utilize the residual moisture after the harvest of paddy, an improved variety of green gram seed (MGG-347) was distributed and demonstrated in farmers' field for the first time. This variety is tolerant to thrips, stem Fly, YMV & *Cercospora* leaf spot and the maturity period is 65-70 days and suitable for soil. A total 3,000 kg seed of green gram were distributed to 500 SC farmers from five selected villages in the mandal.

Distribution of green gram seed

Distribution of Fingerlings

Three varieties of fingerlings *viz*, Rohu, Catla and Grass carp along with feed material were distributed to 17 SC beneficiaries of Kondampet, Nagampet and Edagatta villages. The fingerlings were distributed based on the size of percolation tanks/farm ponds and water availability. A total 15,000 fingerlings were released in 17 percolation tanks/farm ponds of these villages which were renovated under SCSP NRM intervention from 2020 to 2022.

Distribution and release of fingerlings to SC farmers

Capacity Building Programme

❖ **Exposure visit cum skill development programme on dryland agricultural technologies**

Under skill development cum exposure visit a total of 30 SC farmers from Kotapally mandal participated in International Conference on "Reimagining Rainfed Agroecosystems: Challenges & Opportunities" during 22-24, December 2022 at ICAR-CRIDA, Hyderabad. Farmers visited different fertilizers, pesticides, KVKs, ICAR institutes, irrigation system stalls etc., and gained knowledge about the latest and cost-effective technologies. Later, farmers visited Hayathnagar Research Farm and they were exposed to different dryland agricultural technologies. Farmers also attended National Farmer's Day known as "Kisan Diwas" on 23rd December, 2022 under Swachhta Pakhwada programme at CRIDA main office & HRF. Farmers also interacted with the scientists from CRIDA and other ICAR institutes, industry personnel, FPO people, application of drone technology in agriculture etc., which helped them in solving various problems faced by them.

SC farmers participated in skill development programme

2.8 Tribal Sub Plan (TSP)

ICAR-CRIDA is implementing Tribal Sub Plan (TSP) in the lone tribal district of Telangana i.e. Adilabad which was selected as per the guidelines by NITI Aayog, Govt. of India, New Delhi. The various intervention and activities under TSP are spread over ten villages of three mandals namely Gudihathnoor, Utnoor and Indraveli. There are total of 503 households covered under the TSP. The different interventions were planned and implemented in view of addressing 3 major aspects of crop production in rainfed ecosystem namely (1) efficient water management, (2) cultivation of improved varieties for enhanced sustainable production and (3) addressing the issues of livelihood through allied enterprises. Additionally, due emphasis was given to the aspect of climate smart farming, development institutional mechanism for equitable benefit sharing and value addition in human capital towards self-sustained livelihood security. The details of various interventions and the introduction of technologies are given in the subsequent paragraphs.

1. Development of Tribal Rural Livelihood Resource Centre (TRLRC)

ICAR-CRIDA has developed TRLRC to cater for the purpose of (i) seed and input storage and distribution, (ii) farm implements, (iii) hatchery, (iv) record keeping and office activities and (v) providing working space for

shelf help group formed under TSP. A multipurpose and versatile building premises was constructed to be used as a mini observatory for recording of rainfall, maximum and minimum temperature and relative humidity.

Tribal Rural Livelihood Resource Centre

2. Development of farm pond for surface water harvesting

An intensive field survey was carried out to select suitable sites for the development of farm ponds in different selected villages. Consequently, 40 such locations were selected based on prevailing land conditions, crops, and scope for other enterprises such as fisheries and duckery etc. These sites were geo-tagged as well. The figure below describes the locations as well as the construction of these proposed farm ponds.

Farm pond in TSP villages.

3. Participatory ground water management using rain gun irrigation system

The cumulative arable land in the village of Waijapur amounts to 75 acres distributed over 35 households. The tubewell/borewell is the only source of irrigation. Conventionally, the farmers in this region in general and this village in particular, hire the sprinkler system for irrigation in *rabi* season. The sprinkler system typically comprises 5 sprinkler nozzles and each nozzle irrigates in the radii of 5-8 meters depending on the pumping pressure. The cost of such hiring is as high as Rs 8,000 per season. In view of this, a system of participatory ground water management was devised such that each field gets an opportunity for irrigation once a week. The depth of irrigation was kept at 6 mm per irrigation.

Demonstration of raingun irrigation system

Field monitoring of Rabi crop in TSP village

4. Training and demonstration for collection of soil samples at farmers field

Training and demonstration on the true representative collection of the soil samples were conducted in different villages. Farmers were trained on the proper collection of soil samples and tagging. About 113 soil samples were collected so far from the different farmer's field and analyzed for different plant nutrient parameters at CRIDA. Farmers were educated about the use of the soil test results while applying the fertilizers.

5. Introduction of improved variety of various crops

The improved variety for various *Rabi* crops was selected based on the local climatic conditions and prevailing soil type and local preferences. Accordingly, 74.5 quintal seeds of various *Rabi* crop were procured from different ICAR institutes and SAU and introduced to the identified tribal farmers (221 nos) of Keshlapur, Arkapalli, malkapur, Waizapur, Lakshampura, Muthunoor, Sitagondhi, Nizamguda, Godhraguda and Gharkhampet villages of Gudihatnoor Indravelli and Utnoor mandals covering total area of 645 Acres. The details are as below

S No	Crop	Variety	Source	Seed Quantity (quintal)	Coverage (Acres)
1	Ground nut	K-6	ARS, Kadiri	30	65
2	Bengal gram	JAKI-9218/ JG-11	UAS, Dharwad	25	100
3	Rabi sorghum	M35-1	UAS, Dharwad	6	200
4	Green gram	MGG-351	ARS, Madira	5.5	110
5	Black gram	VBN-8	ARS, Madira	5.5	110
6	Kodo millet	JK-41	IIMR, Hyderabvad	2.5	60
Total				74.5	645

Table Introduction of Improved varieties along with good agricultural practices

Seed distribution and field monitoring of various Rabi crops

6. Livelihoods option of tribal farmers through improved variety of chicks

Backyard poultry in Adilabad is very popular and mostly undertaken by farm women as an avenue for income generation and livelihood security. ICAR-CRIDA intervened with the " dual purpose improved backyard poultry birds through TSP. These varieties thrive well under restricted feeding and limited management practices. These birds have been identified for intervention due to multiple colour plumage and fetch better price in terms of meat as well as egg in the market.

7. Capacity building

Participation in the National Seminar

About 20 farmers attended the National Seminar on "Harnessing the Potential of Panchabhutas (tatvas) for Sustainable Climate-Resilient Rainfed Agriculture" during September 28-29, 2022 at ICAR-CRIDA, Hyderabad. Farmers were provided knowledge on rainwater management, soil health management in rainfed agriculture and the importance of the Panchabhutas: Akash, Vayu, Agni, Jal, and Prithvi in sustainable agriculture. They received training on natural farming and different aspects of agricultural production.

Participation in the International Seminar

About 50 farmers from different TSP villages of Adilabad attended the International Conference on "Reimagining Rainfed Agroecosystems: Challenges and Opportunities" during December 22–24, 2022 at ICAR-CRIDA, Hyderabad. In this seminar, farmers got a clear idea about climate-resilient agricultural practices and sustainable soil management practices that will increase farmers income as well as soil health. They were exposed to exhibitions of different aspects, like drones, Nano fertilizers, polyhalite applications in agriculture, and precision irrigation management.

Participation in the National Seminar at ICAR-CRIDA

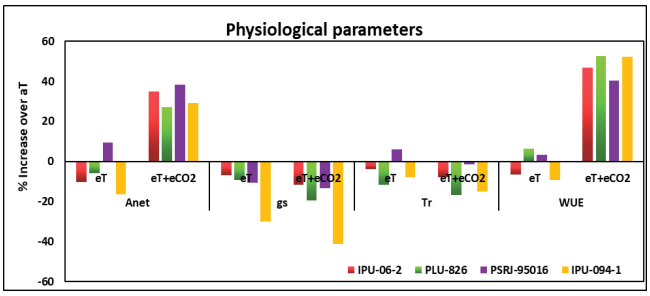
Participation in the International Conference at ICAR-CRIDA

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

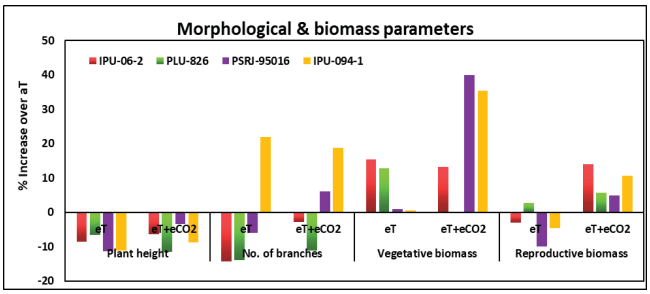
3.1.1. Productivity of rainfed crops under enhanced carbon dioxide and its interaction with water deficit and elevated temperature

The fast changes occurring in climatic parameters across the globe indicate that global warming is beginning to affect the different production systems including agriculture. A field experiment under Free Air Temperature Elevation (FATE) facility was conducted to assess the impact of elevated temperature (eT) and its interaction with elevated CO_2 (eT+eCO_2) on phenology, physiology, biomass and grain yield of four black gram (*Vigna mungo* (L.) Hepper) genotypes, IPU-06-2, PLU-826, PSRJ-95016, IPU-094-1. The eT was maintained at 3.0 ± 0.5°C above ambient canopy temperature (aT) and eCO_2 was maintained at 550 ± 50 ppm.

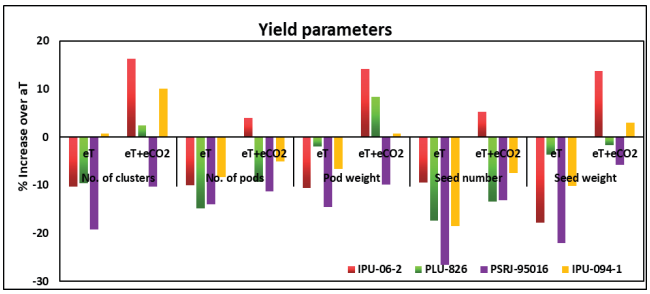
The elevated crop canopy temperature (eT) and eCO_2 along with eT (eT+eCO_2) has minimum influence on the phenology of days to 50 percent flowering of black gram genotypes, except with IPU-094-1 where an earliness of 4 days was recorded under eT+eCO_2 condition. The eT reduced photosynthetic rate, stomatal conductance and transpiration rate of all four black gram genotypes. Among the selected genotypes, IPU-06-2 registered the highest photosynthetic rate (Anet) under all three conditions. With elevated temperature (eT), the reduction in Anet ranged from nil (PSRJ-95016) to 16.55 percent (IPU-094-1), while eT+eCO_2 condition improved it to better than at aT level from 27 percent (PLU-826) to 38 percent (PSRJ-95016). The stomatal conductance and transpiration rate were reduced under both eT and eT+eCO_2 conditions, however, the magnitude of the response differed with genotype, and a higher reduction of these parameters was recorded with eT+eCO_2 than eT condition. The genotype PLU-826 registered higher WUE at both eT and eT+eCO_2 conditions due to better Anet and higher reduction in transpiration rate.



Impact of eT and eT+eCO_2 conditions on physiological parameters of four black gram genotypes



Impact of eT and eT+eCO_2 conditions on morphological and biomass parameters of four black gram genotypes



Impact of eT and eT+eCO_2 conditions on yield parameters of four black gram genotypes

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

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

temperature and CO_2 concentration in the chambers. The experiment was laid out 02-12-2022 to assess the impacts of elevated CO_2 and temperature on growth, phenology and yield at HRF under CTGC chambers.

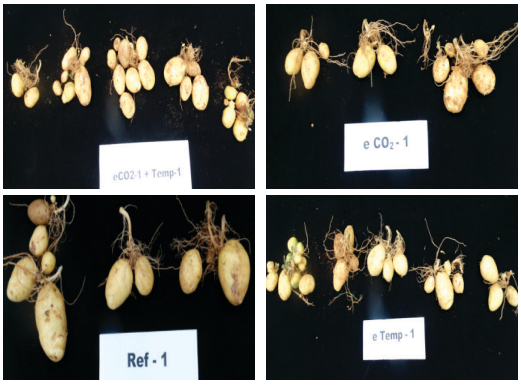
The experiment was laid out with potato variety Kufri Pukhraj variety suitable for this location in CTGC chambers at HRF with four treatments. T1 - Control (reference), T2 -Temperature gradient of 5 ± 0.5°C above reference - 'eTemp'. (three Gradients), T3 - Elevated CO_2 concentration of 550 ± 50 ppm- 'eCO_2' and T4 - interaction of eCO_2 and eTemp. Temperature gradient 5 ± 0.5°C above reference with elevated CO_2 concentration of 550 ± 50 ppm – 'eTemp + 'eCO_2. Data sets were being collected on plant height, number of branches, leaf area, biomass, photosynthesis, growth, stomatal conductance and chlorophyll concentrations, biomass, tuber yield, data on major insect pests are recorded and pest dynamics are being worked out.

Increased concentration of carbon dioxide increased rate of photosynthesis leading to more carbohydrate production and increased biomass. Increased CO_2 was also responsible for physiological processes like changed respiration, reduced stomatal conductance, reduced transpiration rates and increased water use efficiency. Subsequent morphological changes observed are increased leaf area index, dry matter and ultimately enhanced potato tuber production. Increased temperature has a negative effect on growth and yield of potato plant. If the temperature increases above the optimum temperature of the plant it will decline photosynthesis.

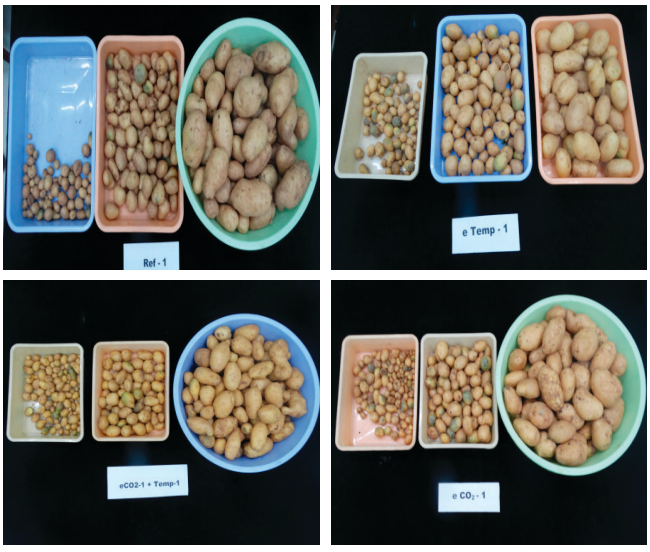
Sampling at 60 days revealed great variation in tuber formation and number of tubers per plant. The number of tubers per plant were more in combination of e temp + e CO_2 (8.5/ plant) followed by 7.60/ plant in e Temp, 5.6/plant in eCO_2 and 5.2/plant in control.

Tuber Yield: At harvest time, the tuber size, biomass, yield, and marketable yield of potatoes cultivated under varying CO_2 concentrations and temperatures were analyzed. There were significant differences in the number of small (< 30 g), medium (30–80 g), and large (> 80 g) potatoes. The tuber size was greater under eCO_2 than under the Control, eCO_2+ eTemp conditions and smallest under eTemp conditions. There was a significant difference in the total number of tubers per plant among the eCO_2, eCO_2+ eTemp, eTemp conditions but was lower at the control conditions. Biomass was significantly affected by the treatment conditions, with the highest leaf, stem, and tuber biomass achieved under CO_2 conditions.

Tubers initiation at 30 days after planting among the treatments



Tubers formation at 60 days after planting among the treatments

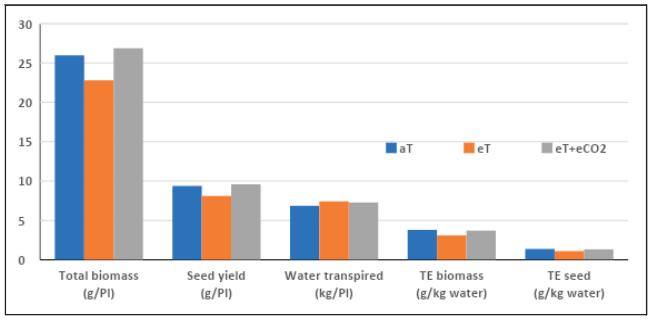


Tuber yield and marketable yields under different conditions

3.1.3. Assessment of Transpiration Efficiency (TE) of black gram genotypes under elevated CO_2 and temperature:

Black gram varieties (IPU -0602, PLU-826, PSRJ-95016, IPU-94-1) were grown under aT, eT, eT+eCO_2 in FATE facility during *rabi* to quantify the water transpired from seedling to maturity (grain harvest) and transpiration efficiency. Transpiration efficiency was determined by gravimetric method.

The average biomass produced by four genotypes of black gram grown under aT, eT and eT+CO_2 conditions was 25.9, 22.82 and 26.87g/ pl and seed yield was 9.37, 8.09 and 9.59 g/pl respectively. The average water transpired was 6.85, 7.40 and 7.27 kg/ plant under aT, eT and eT+CO_2 conditions respectively. The eT condition increased water transpired (kg/pl) and decreased the biomass and seed yield (g/pl) there by decreasing the $TE_{biomass}$ and TE_{seed} in black gram as compared with ambient conditions. Average $TE_{biomass}$ under aT, eT and eT+CO_2 were 3.79, 3.08, 3.69 g/kg and TE_{seed} was 1.36, 1.09 and 1.32 g/kg water transpired. eT+ eCO_2 improved the transpiration efficiency by decreasing transpiration and increasing $TE_{biomass}$ and TE_{seed} revealing the ameliorative response of eCO_2 in the presence of eT.



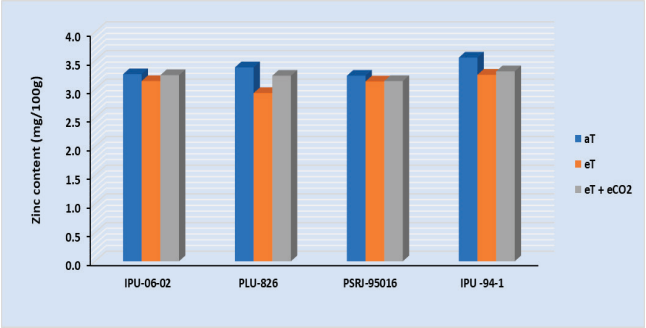
Components of transpiration efficiency (TE) in blackgram genotypes under aT, eT and eT+ eCO_2 conditions

3.1.4. Evaluation of selected genotypes of rainfed food crops for nutritional quality under eCO_2, high temperature and water deficit conditions

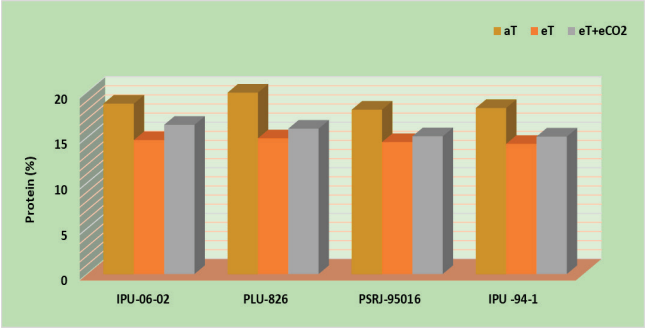
Evaluation of nutritional parameters of rainfed food crops were carried out to understand the interrelationship between the treatments and nutritional parameters of crops grown under eCO_2, high temperature (eT) or both (eT+eCO_2) at FATE facility. Collected seed samples of four black gram genotypes (BG-1 IPU-06-02, BG-2 PLU-826, BG-3 PSRJ-95016 and BG-4 IPU -94-1) grown under eT, eCO_2 and eT+CO_2 (4 replications of each genotype from three treatments) conditions of FATE facility. Processed the black gram seed samples consisting of three treatments for estimation of essential nutrients and essential minerals (Fe and Zn).

Zinc content was found to be reduced with eT treatment compared to control and the content showed slight improvement with the eT+eCO_2, presence of eCO_2 reduced the high temperature effect to some extent. Similar response trend was also observed with Iron content reduction under eT condition as compared to ambient control, however the content was further reduced with eT+eCO_2 treatment in all black gram genotypes.

Protein content (%) of seed was found to be reduced 2.5 percent in eT treatment compared to control and the content was slightly recovered with eT+eCO_2 condition in black gram genotypes. This could be due to the denaturation of protein as temperature increases. Among the black gram genotypes, PSRJ-95016 had lower protein content under ambient conditions and eT+eCO_2 as compared to the other genotypes. Zinc has direct relation with protein content, as decrease in zinc content affects protein content of black gram samples.



Zinc content (%) of black gram genotypes grown under aT, eT and eT+eCO_2 conditions

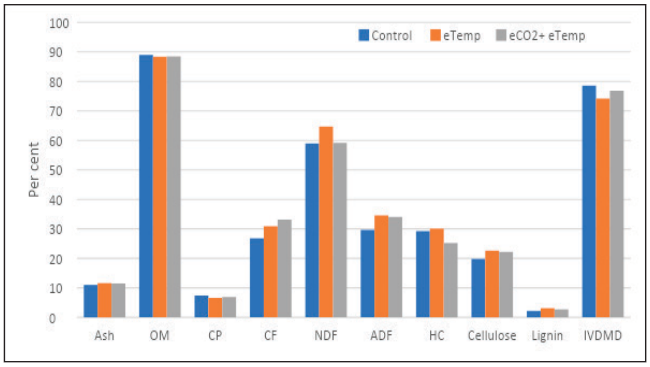


Protein content (%) of black gram genotypes grown under aT, eT and eT+eCO_2 conditions

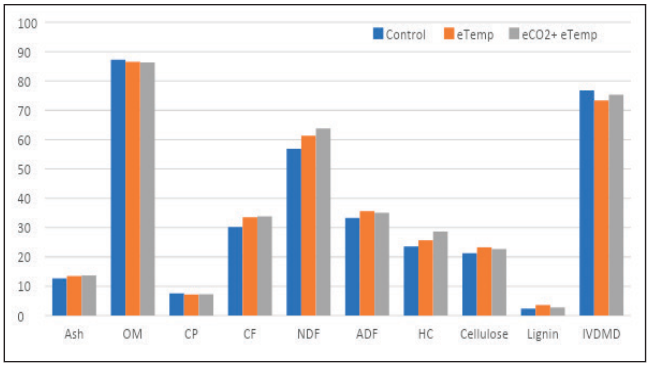
3.1.5. Impact of eCO_2 and eT on quality of crop residues as livestock feed

The projected increase in atmospheric carbon dioxide (CO_2) and climate change will have significant impacts on future fodder quality and productivity. A study was conducted to assess the impact of elevated temperature and carbon dioxide on quality, and *in vitro* digestibility of haulms of groundnut crop (K6 and Narayani varieties) grown in the FATE and FACE facility under three set of environmental conditions i.e., ambient temperature (aTemp), elevated temperature (eTemp) with 3±0.5°C and combination of eTemp and elevated CO_2 of 550± 50 ppm (eCO_2+ eTemp). Groundnut haulms were collected at 60 DAS in three replications from all the treatments and analyzed for proximate composition (organic matter, crude protein, ether extract, crude fibre), fibre fractions (NDF, ADF, cellulose, hemicellulose, lignin), minerals composition (Cu, Fe, Mn, Zn), *in vitro* dry matter digestibility (IVDMD) and metabolizable energy. Among the K6 and Narayani varieties, relatively higher ash, crude fibre (CF) crude protein (CP) was observed in Narayani, whereas higher In vitro dry matter digestibility (IVDMD) was observed in groundnut haulms of K6 variety and the differences were not significant.

Higher (P<0.05) neutral detergent fibre (NDF), acid detergent fibre (ADF), lignin per cent were found in haulms of K6 variety of groundnut crop grown under elevated temperature (eTemp) environmental conditions. Organic matter, and crude protein were found highest (P < 0.05) at the ambient (control) conditions. Growing groundnut crop under elevated carbon dioxide and temperature (eCO_2+eTemp) environmental conditions increased (P < 0.01) ash,



Quality of haulms of groundnut (K6 var.) crop grown under different environmental conditions



Quality of haulms of groundnut (Narayani var.) crop grown under different environmental conditions

crude fibre, hemicellulose and cellulose contents in haulms. *In vitro* dry matter digestibility (IVDMD) of haulms of groundnut crop grown under FATE and FACE facility differed significantly (P < 0.05) among ambient temperature (control), elevated temperature (eTemp) and elevated carbon dioxide and temperature (eCO_2+e Temp) chambers. Highest IVDMD in groundnut haulms was found in the groundnut crop grown at the ambient (78.6±0.17), whereas lowest (74.2±0.21) under eTemp environmental conditions. Among different treatments, highest metabolizable energy (ME) was found in the haulms of groundnut crop grown at the ambient, followed by eCO_2+eTemp, and eTemp environmental conditions. Except NDF and hemicellulose, a similar trend was observed in haulms of Narayani variety of groundnut crop. A non-significant difference has been observed in mineral composition in both the varieties of groundnut haulms.

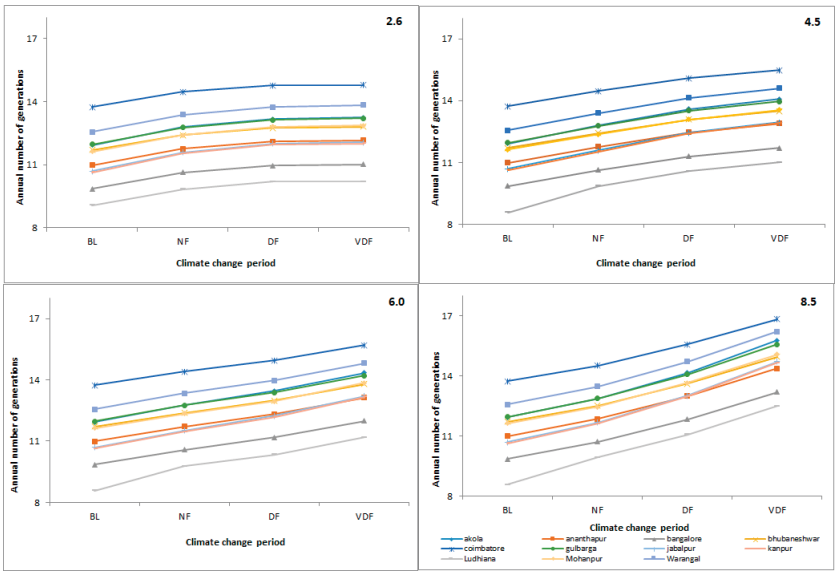
3.1.6. Pest scenario of *Helicoverpa armigera* (Hub.) on pigeon pea during future climate change periods under RCP-based projections in India

Multi-model ensemble of Maximum (Tmax) and Minimum (Tmin) temperature data of four Representative Concentration Pathways viz., RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5 of Coupled Model Inter comparison Project 5 (CMIP5) models were generated for eleven major pigeon pea growing locations of the India to predict the number of generations of *Helicoverpa armigera* (Hub.) using growing degree days approach during three future climate viz., Near (NP), Distant (DP) and Far Distant (FDP) periods and were compared over 1976-2005 baseline period (BL). The studies indicated a significant increase in both temperatures in 4 RCPs. The increases were

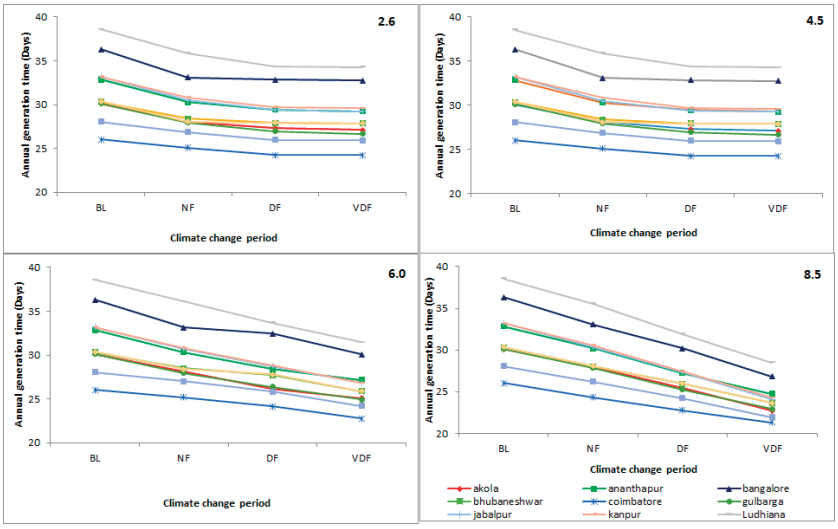
markedly higher and much evident in RCP 6.0 and RCP 8.5 during DP and FDP CCPs. It is expected that projected temperatures (Tmax and Tmin) would follow an increasing trend during 3 CCPs at 11 locations. Tmax (0.7 to 4.7°C) and Tmin (0.8 to 5.1°C) would increase considerably during NP, DP and FDP of 4 RCP scenarios. This trend was more evident in RCP 8.5 of FDP followed by 6.0 and 4.5 scenarios.

Annual number of generations and generation time

Significant ($F_{3, 3828}$ = 1768.82, P < 0.001) differences were observed in annual number of generation of *H. armigera* on pigeon pea with reduced gen. time ($F_{3, 3828}$ = 1045.33, P < 0.001) among RCPs with RCP 8.5 (16.83 ± 0.45; 21.31± 0.30) followed by RCP 6.0 (15.70 ± 0.34; 22.75 ± 0.15), RCP 4.5 (15.48 ± 0.33; 22.98 ± 0.54) over RCP 2.6 (14.79 ± 0.29; 24.25 ± 0.19). Increase in temperature causes the advancement of insect developmental stages which in turn results in reduction of duration of life cycle and thus more generations of insects may occur in shorter period of time. Our present findings showed that a greater number of annual generations of *H. armigera* on pigeon pea (6 to 38 %) would be in RCP 8.5 followed by 6.0, 4.5 over 2.6 RCPs. Shortened generation time was noticed in all four RCPs in calendar year (4-27 percent) and the trend was more evident in RCP 8.5 of FDP over BL.



Variation in annual number of generations of H. armigera during climate change periods at 11 pigeon pea growing locations of India



Variation in annual generation time of Helicoverpa armigera during climate change periods at 11 pigeon pea growing locations of India

3.1.7. Independent and interactive effects of eCO_2 and *e*Temp. on primary parameters of *Spodoptera frugiperda* (J.E. Smith) on Maize

Several experimental trials were laid out in the CTGC facility and a standard procedure was followed to conduct the feeding experiments. Insectary of ICAR-CRIDA has an insect culture of *S. frugiperda* comprising all four stages of the life cycle. The treatment associations were maintained in conducting the feeding experiments by collecting the leaves from the respective CO_2 and temperature conditions for the two successive generations. The weights of the larva, its leaf consumption, and the frass excreted were recorded. Larval life span was calculated as the period between the emergence of the larva from the egg till its pupation was considered as larval duration. Second generation feeding experiments of *S. frugiperda* were initiated using the first instar larvae hatched from the eggs laid by the first-generation female adults. The data on primary parameters viz., weights of larvae, leaf consumption, and frass excreted were measured for both generations.

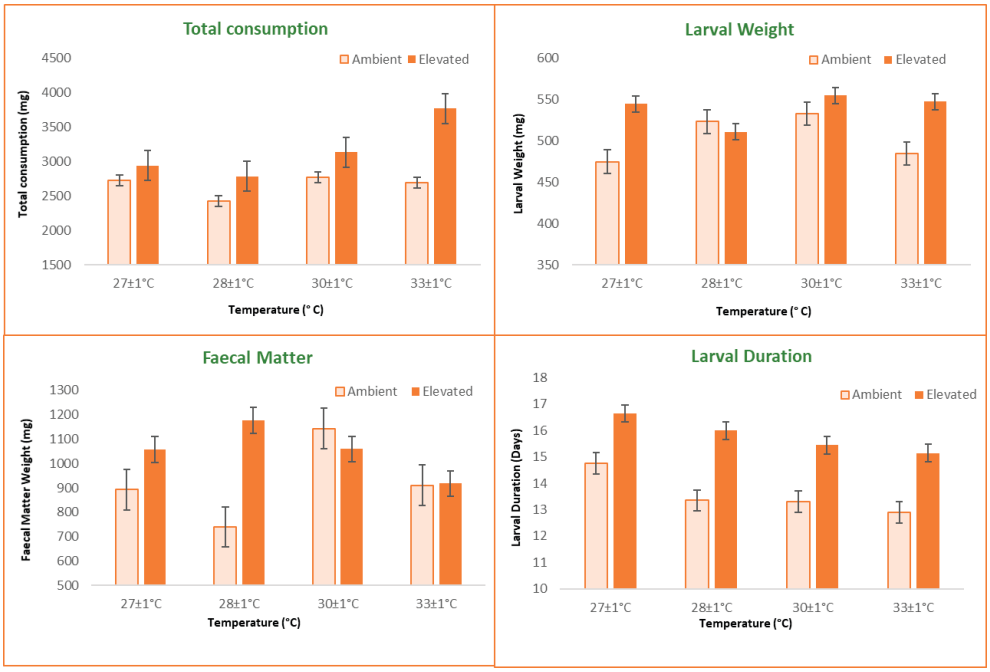
Primary parameters

Total consumption: eCO_2 ($F_{1,63}$= 44.99, P ≤ 0.01), *e*Temp ($F_{3,63}$= 6.91, P ≤ 0.01), and interactive conditions of both ($F_{3,63}$= 26.15, P ≤ 0.01) altered the total consumption of maize foliage by *S. frugiperda* larvae. Higher total consumption was at 33 ± 1^{0}C and eCO_2 (3765.5 mg ± 985 mg) against the lower at 28± 1^{0}C at *a*CO2 (2781 mg ± 482 mg).

Larval weight: Higher larval weights of *S. frugiperda* (547 ± 42 mg) were at *e*Temp (33 ± 1^{0}C) ($F_{3,63}$= 6.50, P ≤ 0.01) and eCO_2 condition ($F_{1,63}$= 18.41, P ≤ 0.01) against the least at *a*Temp + aCO_2 (474.5 ± 35 mg). The interactive mechanism of both dimensions ($F_{3,63}$= 2.82, P ≤ 0.01) also influenced the larval weights.

Fecal matter: When the mean value of the fecal matter released by the larva for two generations was observed, the increase was found to be significant at eCO_2 ($F_{1,63}$= 30.70, P ≤ 0.01), *e*Temp ($F_{3,63}$= 7.50, P ≤ 0.01) and in turn reflected in their interactive result ($F_{3,63}$= 16.56, P ≤ 0.01) also. At 28 ± 1^{0}C with eCO_2, higher (1176 mg ± 85 mg) frass was released as against the lower (740 mg ± 55 mg) at the same temperature at aCO_2.

Larval duration: Longer larval duration (16.65 ± 0.422 days) was at eCO_2, 27 ± 1^{0}C while reduced duration (12.9 ± 0.421 days) was at 33 ± 1^{0}C, aCO_2. The larval duration of *S. frugiperda* larvae was reduced at *e*Temp ($F_{3,63}$= 60.04, P ≤ 0.01) and correspondingly extended larval duration at eCO_2 ($F_{1,63}$ = 602.29, P ≤ 0.01). Interactive levels of *e*Temp and eCO_2 ($F_{3,63}$ = 2.27, P ≤ 0.05) were also noteworthy.

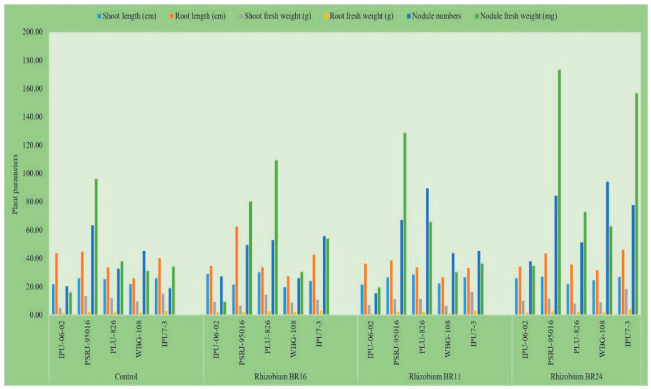


Interactive effect of eCO_2 and eTemp on insect performance indices (Mean of two generations) of S. frugiperda on maize.

3.1.8. Impact of eCO_2 and eTemp on rhizo microbiome of black gram (*Vigna mungo* L.) and characterization of efficient *Rhizobium* strain(s).

Effect of *Rhizobium* isolates on nodulation and plant growth parameters of blackgram genotypes

Rhizobium isolates such as *Rhizobium* BR11, *Rhizobium* BR16 and *Rhizobium* BR24 were tested for their effectiveness in nodulation and plant growth promotion of five black gram genotypes viz., IPU-06-02, PSRJ-95016, PLU-826, WBG-108 and IPU7-3. Inoculation of *Rhizobium* isolates was done through seed treatment. Differences in nodulation and other plant growth parameters like shoot length, root length, shoot fresh weight and root fresh weight were observed in black gram genotypes due to the inoculation of *Rhizobium* isolates. Inoculation of *Rhizobium* BR24 substantially enhanced the nodule numbers in IPU-06-02, PSRJ-95016, WBG-108 and IPU7-3 genotypes in comparison with uninoculated control. Similarly, *Rhizobium* BR11 markedly increased the nodule numbers in PLU-826 genotype.



Influence of Rhizobium isolates on nodulation and plant growth parameters of black gram genotypes

3.1.9 Impact of eCO_2 and eT on Rhizo-microbiome of black gram and characterization of efficient Rhizobium strain: Impact of eCO_2 and eT on Rooting pattern in black gram

An experiment was conducted in open top chambers with the black gram genotype PLU-826 under Elevated CO_2, ambient and open field conditions. Root samples were extracted at pod filling stage (reproductive stage 56 DAS) by digging a trench for 5 plants using black pinboards and spokes. The elevated CO_2 resulted in reduced number of laterals (10) as compared to the treatments of ambient (13) and open field conditions (16). Similar trend was observed with regard to lateral root length and root volume of black gram.

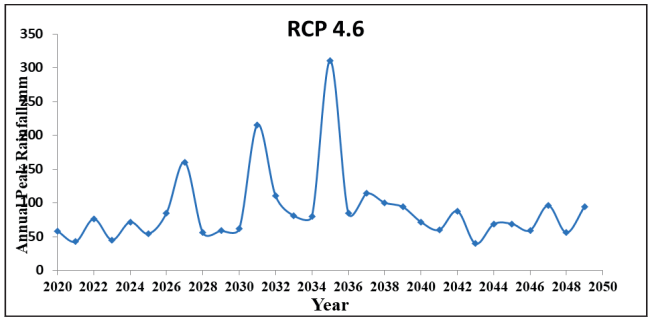
3.2. Theme II. Impact of variable rainfall on Soil and Crops

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

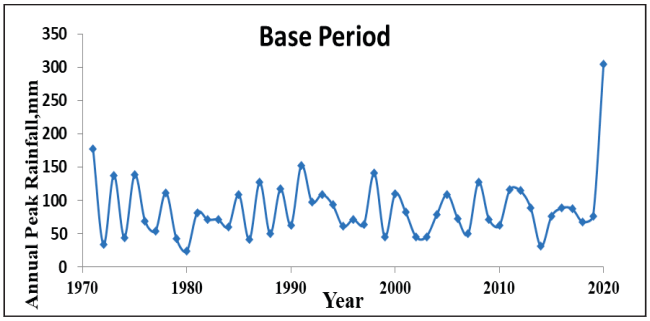
Peak Rainfall Analysis for developing Intensity-Duration-Frequency curves for RCP 4.6

The weather data for RCP 4.6 from 2020-2049 and the base data from 1971 to 2020 for Hayathnagar geo location, were analysed annual peak rainfalls to understand the behaviour of extreme rainfall patterns in the region. It was observed that during the base period of 50 years, there were common peak rainfall varying from 50 to 100 mm except in 2020 with 300 mm. However, during the period from 2020 to 2049 (30 years), there were three peaks of rainfall varying from 150 to 300mm at an increment of 5 years alternatively happening in the time series. After mid-year of RCP 4.6, the peak rainfall drastically reduced with the range of 50 to 100 mm (Fig. 1 and Fig. 2) indicating no regular pattern of peak rainfall in the region.

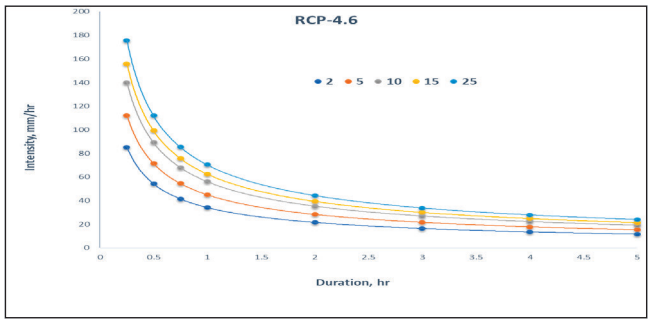
The above weather peak data were analyzed using the IMD1/3 rule, probability analysis and frequency analysis using extreme Gumbel distribution, the Intensity- Duration and Frequency curves for Hayathnagar were constructed as presented in Fig 3 and Fig 4 for understanding the extreme rainfall intensities in the region. The peak rainfall was split into intensity for different durations (0.25, 0.5, 0.75, 1.0, 2.0, 3.0, 4.0 and 5.0 hrs) for different frequencies (2, 5, 10, 15, 20, 25). The analysis indicated that the intensities are maximum at all frequencies in RCP 4.6 having an increasing trend in the intensities for all time durations. The average increase observed in RCP 4.6 was 7.93 percent over the base period intensities. However, the maximum increase was observed in lower durations of 0.25, 0.5 and1 hr.



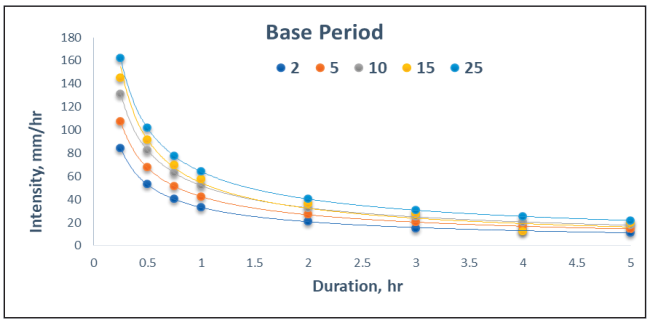
Annual peak rainfall for RCP 4.6 scenario during 2020 to 2049



Annual peak rainfall in base period during 1971 to 2020



Intensity -Duration - Frequency curves for RCP4.6 scenario



Intensity-Duration - Frequency curves for the base period

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

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

Effect of tillage, residue application and N levels on crop response and soil quality parameters in rainfed Alfisol under Sorghum-Castor system

The present study started with the hypothesis that restorative management practices such as minimum tillage, surface residue application and optimum levels of fertilizers especially N can help in providing resilience towards climate change by way of higher moisture retention, reducing soil temperature, influencing soil quality indicators and improving overall soil quality. Keeping in view of the above, a field experiment comprising of tillage {conventional (CT) and minimum (MT)}, residues {(2 t ha^{-1} dry sorghum stover (SS), 2 t ha^{-1} fresh Gliricidia lopping (GL) and no residue (NR)} and nitrogen levels {0 (N_0), 30 (N_{30}), 60 (N_{60}) and 90 (N_{90}) kg N ha^{-1}} under sorghum (*Sorghum vulgare* (L)) - castor (*Ricinus communis* (L)) system initiated in a strip split-split plot design at Hayathnagar Research Farm during 1995. During the current year (2022), castor (DCS-177) was the test crop.

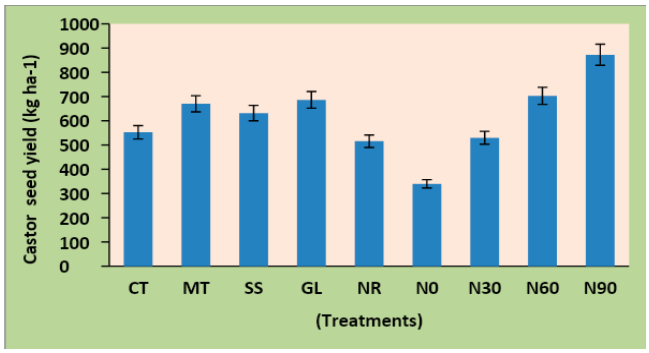
Effect of tillage, residues and N levels on castor seed yield

The castor seed yield across the treatments varied from 279 to 1061 kg ha^{-1}. Minimum tillage (670 kg ha^{-1}) recorded significantly higher mean castor seed yields (21 percent higher) compared to conventional tillage (552 kg ha^{-1}). Among the residues, application of gliricidia loppings @ 2t ha^{-1} (687 kg ha^{-1}) and sorghum stover @ 2t ha^{-1} (632 kg ha^{-1}) significantly increased the mean castor seed yield by 33 and 23 percent compared to no residue application (516 kg ha^{-1}). Application of N @ 90 kg ha^{-1} recorded significantly higher mean castor seed yield (872 kg ha^{-1}) followed by N applied @ 60 kg ha^{-1} (703 kg ha^{-1}) and @ 30 kg ha^{-1} (530 kg ha^{-1}) compared to control (340 kg ha^{-1}). The increase in castor seed yield with N applied @ 30 kg ha^{-1}, 60 kg ha^{-1} and 90 kg ha^{-1} level of nitrogen over control was tone of extent of 56, 107 and 157 percent respectively as compared to the N_0. The interactive effect of tillage x nitrogen and residue x nitrogen also found statistically significant.

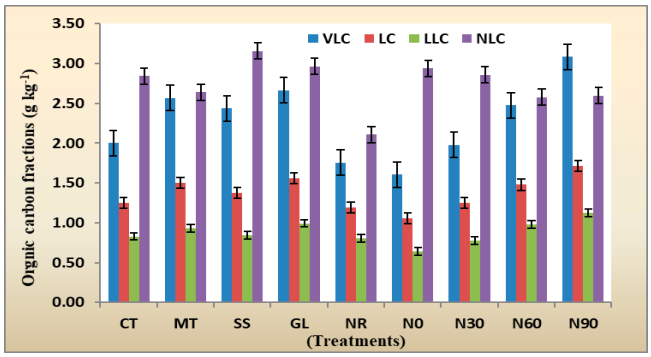
Effect of tillage, residues and N levels on carbon fractions

The results of the present study revealed that the carbon fractions content (very labile carbon, labile carbon, less labile carbon and non-labile carbon) studied. Minimum

tillage (2.57, 1.50, 0.93 g kg^{-1}) recorded significantly higher VLC, LC and LLC compared to conventional tillage (2.0, 1.25, 0.83 g kg^{-1}). Conventional tillage (2.84 g kg^{-1}) recorded significantly higher NLC compared to minimum tillage (2.64g kg^{-1}). Among the residue treatments, application of gliricidia loppings @ 2t ha^{-1} (2.66, 1.56, and 0.99 g kg^{-1}) and sorghum stover @ 2t ha^{-1} (2.44, 1.38 and 0.84 g kg^{-1}) significantly increased the VLC, LC and LLC content compared to no residue application (1.75, 1.19, and 0.80 g kg^{-1}). Sorghum stover @ 2t ha^{-1} (3.15 g kg^{-1}) and gliricidia loppings @ 2t ha^{-1} (2.96 g kg^{-1}) significantly increased the NLC content compared to no residue application (2.11 g kg^{-1}). Among the four nitrogen levels, the application of N @ 90 kg ha^{-1} recorded significantly higher VLC, LC and LLC (3.08, 1.71 and 1.12 g kg^{-1}) in soils followed by N @ 60 kg ha^{-1} (2.47, 1.48 and 0.98 g kg^{-1}) and 30 kg ha^{-1} (1.98, 1.25 and 0.77 g kg^{-1}) compared to no nitrogen application (1.61, 1.06 and 0.64 g kg^{-1}). The application of N @ 90 kg ha^{-1} recorded non-significantly decreased NLC (2.59 g kg^{-1}) in soils followed by N @ 60 kg ha^{-1} (2.58 g kg^{-1}) and 30 kg ha^{-1} (2.86 g kg^{-1}) compared to no nitrogen application (2.94 g kg^{-1}).



Effect of tillage, residue application and N levels on castor grain yield (kg ha^{-1}) in rainfed Alfisol under Sorghum-Castor system

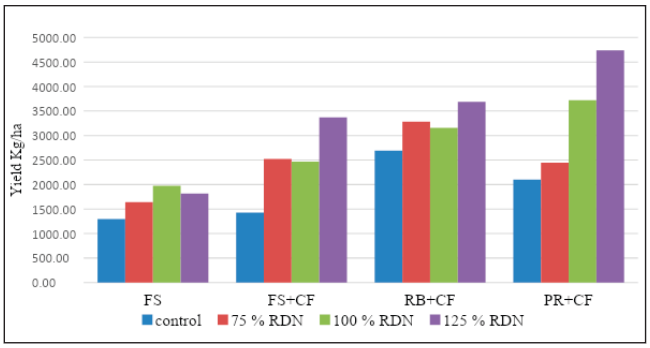


Effect of tillage, residue application and N levels on organic carbon fraction (VLC= very labile carbon, LC=labile carbon, LLC=less labile carbon and NLC=non-labile carbon) in rainfed Alfisol under sorghum-castor system.

Castor crop growth in different treatments

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

A study was initiated in Maize + Pigeon pea intercropping system in 2021 with the aim to develop sustainable intensification practices for mitigation and adaptation to climate change. The main objective of the study was to improve the profitability with low environmental impact. To achieve the target an experiment was conducted with different *in situ* moisture conservation practices and nitrogen levels.



Influence of in situ moisture conservation practices and nitrogen levels in Maize + pigeonpea intercropping systems

The maize equivalent yields were higher in *in-situ* moisture conservation as compared to no moisture conservation. Flat sowing with conservation furrow (CF), Raised beds with CF, and paired rows with CF recorded 31, 48, 48 percent higher yields over flatbed sowing without CF. Maize equivalent yields increased with an increase in nitrogen application. 125 percent RDN recorded 44 percent higher maize equivalent yields as compared to no fertilizer application. Raised beds with CF (1.22) and paired row + CF (1.24) recorded higher LER as compared flat sowing with CF (1.08) or flat sowing without CF (1.11).

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

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

Flat sowing

Conservation furrow at sowing

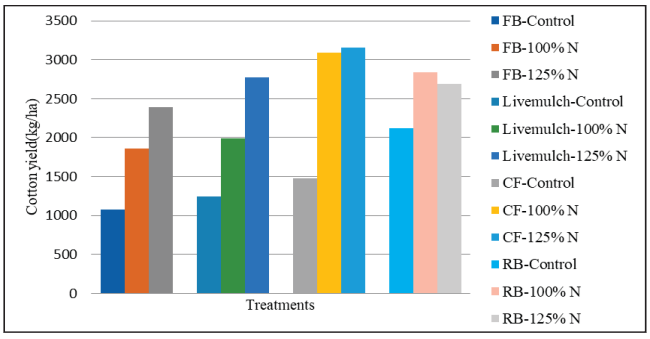
Raised bed

Flat sowing with live mulch

Conservation furrow at 30–40 DAS

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

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

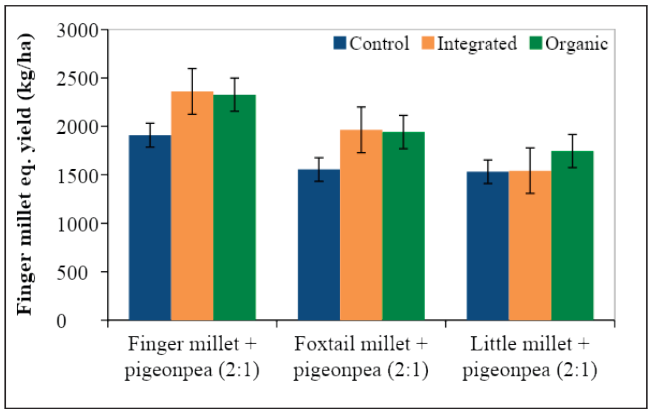


Influence of different treatments on cotton yield (kg/ha)

3.3.3. Adaptation and mitigation potential of millet based organic production systems in rainfed Alfisols

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* 2022 at GRF of the institute to evaluate the performance of finger millet (*Eleusine coracana*) + pigeon pea (*Cajanus cajan*) (2:1), foxtail millet (*Setaria italica*) + pigeon pea (2:1) and little millet (*Panicum sumatrense*) + pigeon pea (2:1) under organic, control (chemical) and integrated crop management systems. The experiment was laid out in a strip-plot design with three production systems and three intercropping systems. In the plots under organic management, gliricida (harvested from research farm) was applied on the N equivalent basis to all the three cropping systems. In the plots under integrated management, 25 percent of equivalent recommended N (10 kg/ha) was applied through gliricidia. The remaining 75 percent N (30 kg/ha) and 100 percent P (20 kg/ha) and K (20 kg/ha) was applied through chemical fertilizers. The plots under control (chemical) received recommended dose of chemical fertilizers (40:20:20 kg NPK/ha) for all the three intercropping systems. In the plots under organic management, no chemical herbicides, insecticides or fungicides were used, in keeping with organic standards. Weeds were controlled by manual weeding/hoeing using a manually operated wheel-hoe. Azadirachtin (*Azadirachta indica* based formulation) was sprayed as required during crop growth as a prophylactic measure against insect-pests. In the plots under control (chemical), crop-specific recommended herbicides and pesticides were sprayed for control of weeds, insect-pests and diseases. In the plots under integrated management, recommended integrated pest management (IPM) modules were implemented.

The crops experienced two dry spells of 14 days (9-22 August) and 10 days (12-21 September) coinciding with flowering and seed formation stages of millets



Performance of millet based intercropping systems under different production systems

Little millet + pigeonpea (2:1) intercropping system under integrated management

Foxtail millet + pigeonpea (2:1) intercropping system under organic management

Finger millet + pigeon pea (2:1) intercropping system under control (chemical)

and vegetative stage of pigeon pea. Further, pigeon pea seed yield was also less across different treatments due to occurrence of wilt and no rainfall during pod filling and maturity. In general, among the three intercropping systems, finger millet + pigeon pea (2:1) system produced 17.2 and 26.9 percent higher finger millet equivalent yield (FMEY) (2199 kg/ha) than foxtail millet + pigeon pea (2:1) and little millet + pigeon pea (2:1) systems, respectively. Among the production systems, averaged across three intercropping systems, organic and integrated management being on par with each other produced significantly higher FMEY than control (chemical). Similarly, both organic and integrated treatments produced similar but significantly higher FMEY of finger millet + pigeon pea (2:1) and foxtail millet + pigeon pea (2:1) systems compared to control. However, organic management recorded significantly higher FMEY compared to integrated management and control.

3.3.4. Genotyping of black gram for identifying diverse genetic materials

Black gram or urd bean (*Vigna mungo* L. Hepper 2n = 22), a short-duration pulse crop is cultivated mainly under rainfed conditions in India. The crop is often exposed to drought stress during crop season, drastically affecting production and productivity adversely affecting yield parameters such as pod number, seed number, seed weight, etc. Genetic enhancement for drought tolerance remains a major challenge for realizing higher productivity of this important crop for rainfed condition.

A field experiment was conducted in *kharif* 2022 with 40 black gram genotypes under well-watered and water-stressed conditions with a 2-row plot per genotype. The crop was sown with row to row distance of 45cm and, plant to plant distance of 10 cm. Data on various physiological traits were recorded under well-watered and water-stress conditions during a dry spell of 10 days which coincided with the pre-flowering stage. The parameters recorded were SPAD chlorophyll meter reading (SCMR), normalized difference vegetation index (NDVI), canopy temperature depression (CTD), relative water content (RWC), Total chlorophyll content (Tchlo), total soluble sugar (TSS) and membrane stability index (MSI). The crop did not get expose to drought stress post flowering to physiological maturity, due to regular intermittent rains. As a result, phenological and yield parameters such as days to 50 percent flowering, days to maturity, plant height (PH), branches number (BN), cluster number (CN), pod length (PL), number of seeds per pod (SPP), number of pods (PN), pod weight (PW), hundred seed weight (HSW), fodder yield per plant (FY) and seed yield per plant (SY) were recorded as non-stress conditions.

The genomic DNA was isolated from young leaves of all the 40 genotypes at vegetative stage (15-20 days seedling) for using in SSR markers genotyping work. A set of 41 genomic and 36 EST based SSRs were used for genotyping these 40 genotypes. The SSR data was used to calculate the number of alleles (Na), gene diversity (H), polymorphism information content (PIC) using PowerMarker (v.3.25) software. Phylogenetic tree was constructed with MEGA 11 using UPGMA statistical method with Nei, 1972 similarity index. Robustness of the node of the phylogenetic tree was assessed from 1000 bootstrap replicates.

The analysis of variance showed significant variances due to genotype for various yield traits such as plant height, cluster number, pod number, pod weight, hundred seed weight, seed yield/plant and fodder weight. The mean performance of the genotypes showed PDU1 as the highest yielder followed by IPU-96-7 and IPU-13-7 among genotypes evaluated. The physiological traits were significantly affected under water stress condition as compared to well-watered conditions. The combined ANOVA for all physiological traits also showed significant variances due to treatment, genotype and treatment × genotype interaction.

Among the genotypes evaluated, highest SCMR was recorded for IPU10-117 followed by IPU10-1 under well-watered while, IPU10-21 and IPU96-06 under stress conditions respectively. Similarly, for CTD, IPU11-2, IPU96-06 for well-watered; IPU9-16 and IPU99-168 under stress conditions. The highest MSI was observed IPU13-4 and IPU13-6 under well-watered, while, IPU94-1 and IPU94-4 under stress conditions. The MSI showed high variation both for well-watered (28.10 to 66.60) and stress (34.91 to 68.00) conditions. Genotypes also showed high variation for relative water content ranging from 85.63 to 94.72 percent, and 67.13 to 88.48 percent under well-watered and stress conditions respectively. The

highest RWC was recorded for genotypes IPU13-6, IPU9-16 under well-watered, while, PSRJ95016 and IPU10-16 under stress conditions.

Genotyping using SSRs revealed that all SSRs except one genomic as polymorphic. Genotyping using genic and genomic SSRs revealed 136 unique alleles with an average of 3.32 alleles per marker, while maximum seven allele were detected for genomic SSR GENSSR4 and genic SSR ESTSSR2. The the average polymorphic information content (PIC) value of 0.50 and range of 0.19 to 0.81 between genotypes. The pairwise genetic distances were used for clustering of black gram genotypes via a dendrogram with UPGMA method by using Mega 11 software which revealed four diverse clusters among 40 genotypes.

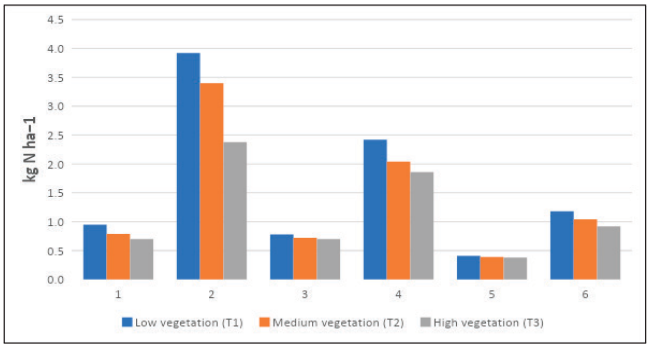
3.3.5. Assessment of nitrous oxide emissions from livestock urine deposited in grazed pastures during different seasons

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

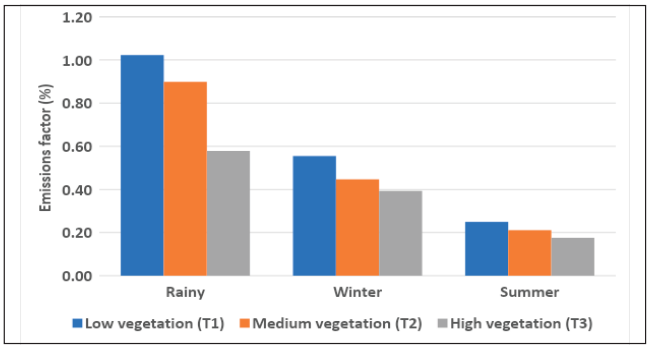
Mean daily temperature and relative humidity (RH) varied throughout the experimental period and ranged from 24.18 to 26.91 ^{O}C and 74.88 to 92.93 per cent (rainy season); 24.0 to 30.8 ^{O}C and 49.0 to 68.9 per cent (winter season); 33.1 to 38.2 ^{O}C and 34.0 to 44.0 per cent (summer season), respectively during the experimental period. The differences in mean nitrous oxide values among the different time intervals (0,15, 30 and 45 minutes) were significantly ($P<0.05$) different. Nitrous oxide emissions were significantly ($P<0.05$) higher in low pasture cover experimental plots than high pasture cover plots. Nitrous oxide (N_2O) emissions were significantly ($P<0.01$) higher in cattle urine applied experimental plots than control.

Cumulative N_2O emission flux from the urine applied plots differed significantly ($P<0.05$) and were higher under low, followed by medium and high pasture blocks of the experimental field in all the seasons. Similarly, cumulative N_2O emission flux from the control plots without urine application were 0.71, 0.63 and 0.59 kg N ha^{-1}, respectively during rainy, winter and summer seasons.

Cumulative N_2O emissions from with urine application were 3.92, 3.42 and 1.18 kg N ha^{-1}, respectively under low pasture blocks of the experimental field during rainy, winter and summer seasons. Similarly, 3.40, 2.04 and 1.04 in medium and 2.38, 1.86 and 0.92 kg N ha^{-1}, respectively under high vegetation pasture blocks of the experimental field during rainy, winter and summer seasons. Cumulative N_2O emissions from the control plots without urine application were 0.95, 0.79 and 0.70 kg N ha^{-1}, respectively under low, medium and high pasture blocks of the experimental field. Mean nitrous oxide (N_2O) emissions factor (%) of low, medium and high pasture blocks of the experimental field was 0.61, 0.52 and 0.38, respectively.



Cumulative N_2O emissions from the experimental plots



Nitrous oxide (N2O) emissions factor (%) under low, medium and high pasture conditions

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

3.4.1. Adaptation targeting and prioritization for climate change

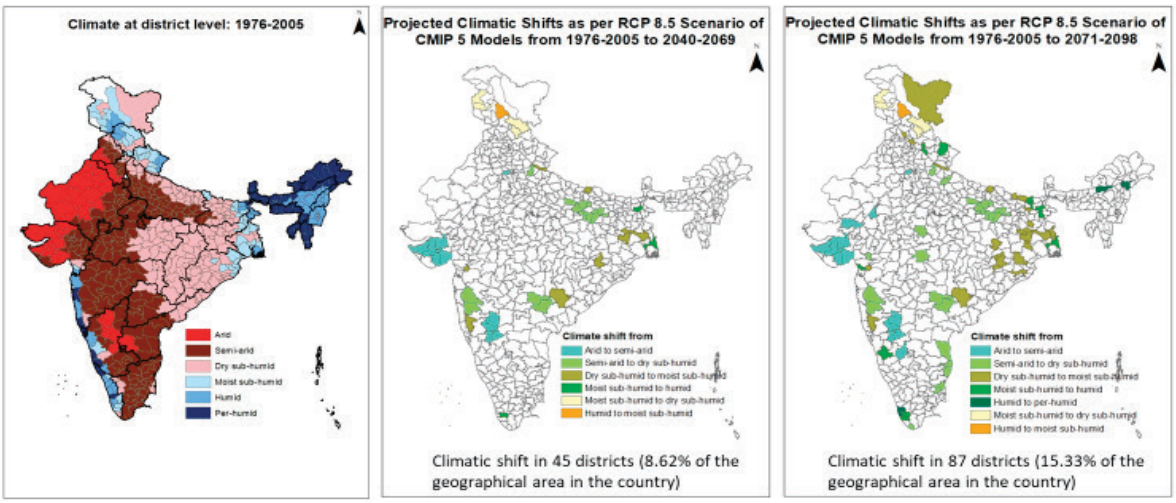
An analysis of resilience of yield to drought showed considerable yield losses in soybean (7.05 q/ha) and chickpea (7.42 q/ha) during a drought year. Adaptation interventions viz., change of variety in soybean and foliar spray in chickpea helped reduce yield losses to 2.95 and 4.17 q/ha, respectively and enhancing yield resilience to 0.75 (0.56 with no adaptation) and 0.32 (0.21 with no adaptation) in soybean and chickpea, respectively. These adaptation technologies helped saved 58 and 44 percent of avoidable yield losses in these two crops. Efforts are therefore needed to scale out adoption of such adaptation technologies.

Adaptation technologies and yield resilience in soybean and chickpea, Ahmednagar, 2022-13

Yield resilience	Yield (Q/ha)	Yield lost (q/ha)	Resilience 1	Resilience2
Soybean				
Normal Yield	15.88			
No Adaptation	8.83	7.05	0.56	
With adaptation (Change of variety)	11.78	2.95	0.75	0.58
Chickpea				
Normal Yield	9.42			
No Adaptation	2.00	7.42	0.21	
With adaptation (Foliar spray)	6.17	4.17	0.32	0.44

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

Assessed future climate at district level. Climate projections of multi-model ensemble for Precipitation, Max T and Min T at daily scale for 2050s and 2080s for RCP 8.5 scenario of CMIP 5 models at district level were used in the study. Computed Potential Evapotranspiration (PE) at district level using Hargreaves method from Max T and Min T data. These PE estimates were calibrated using FAO recommended Penman-Monteith method as standard. Computed moisture index from P and PE and assessed climate at district level (Arid, Semi-arid, Dry sub-humid, Moist sub-humid, Humid and Per humid). Compared to baseline of 1976-2005, climatic shifts are observed in 45 districts (8.62 percent of the geographical area in the country) in 2050s and 87 districts (15.33 percent of the geographical area in the country) in 2080s as per RCP 8.5.



District level climate and projected climatic shifs as RCP scenarios

Historical climate data (Precipitation, Maximum temperature and Minimum temperature) at daily scale till 2020 sourced from IMD at grid level was compiled and brought to district level. Gathered data on crop-wise nutrient use (N, P and K) and area sown under HYVs at district level for 2016-17 (Input Survey of Agricultural Census). Apportioned district level time series data of crop-wise and season-wise area sown, production and yield and crop-wise irrigated area. CMIP6 data for13 models on precipitation and Maximum temperature was compiled.

3.4.3. Adoption dynamics and institutional drivers for scaling out resilience enhancing technologies

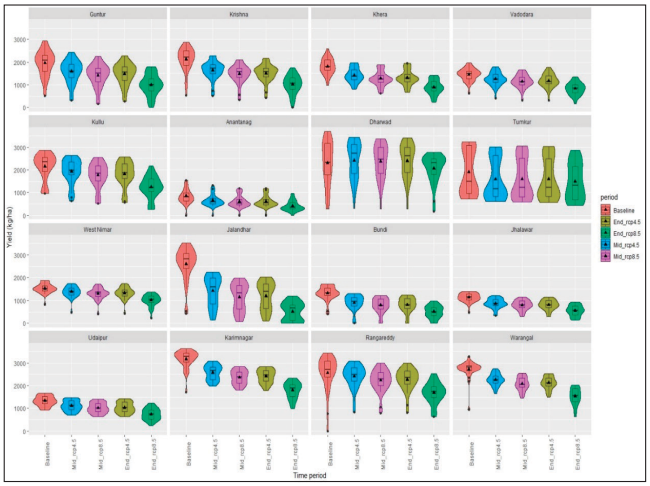
Understanding of adoption-diffusion dynamics and drivers that promote or constrain scaling up of Climate Resilient Agricultural (CRA) Technologies is essential. The study was conducted with the objective to identify the drivers that promote or constrain scaling up of CRA Technologies. Already introduced CRA technologies/ interventions across different NICRA KVKs shall be studied for assessing the Adoption dynamics and drivers. Data collected from farmers from Ahmednagar KVK villages in Maharashtra. 101 adopted and 48 non-adopted farmers form the sample of the study. The data were collected using a pre-tested interview schedule and focus group discussion guides from the farmers. Both household and village interview schedules are prepared for the purpose. Frequency, percent analysis, means, standard deviation, t-test etc. will be employed for data analysis. Data analysis and final report shall be prepared based on the interpretation of results.

Maximum adoption is observed for Silage bags to cows at 86 percent followed by Integrated Disease Management in Pomegranate at 78 percent; Change of variety in Soybean (Phule Sangam) at 75 percent, Mineral mixture to cow, sheep and goat at 73percent; and IPM (FAW) in Maize at 66 percent in that order respectively. It is obvious that with much focus on dairying and milk production in the villages surveyed, maximum adoption is observed for Silage storing in bags. Results indicate that information (as nature of support) about technology, it's availability, usage and benefits was provided at the highest level by KVK staff to the farmers in the above surveyed villages. Further, livestock related support and inputs were provided at the second highest level to the farmers by the KVK, Ahmednagar. This was followed by inputs in the form of new seed varieties, fodder varieties and poultry chick's distribution to the farmers. Data collection from another NICRA KVK to study above Adoption results shall be taken up.

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

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

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



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

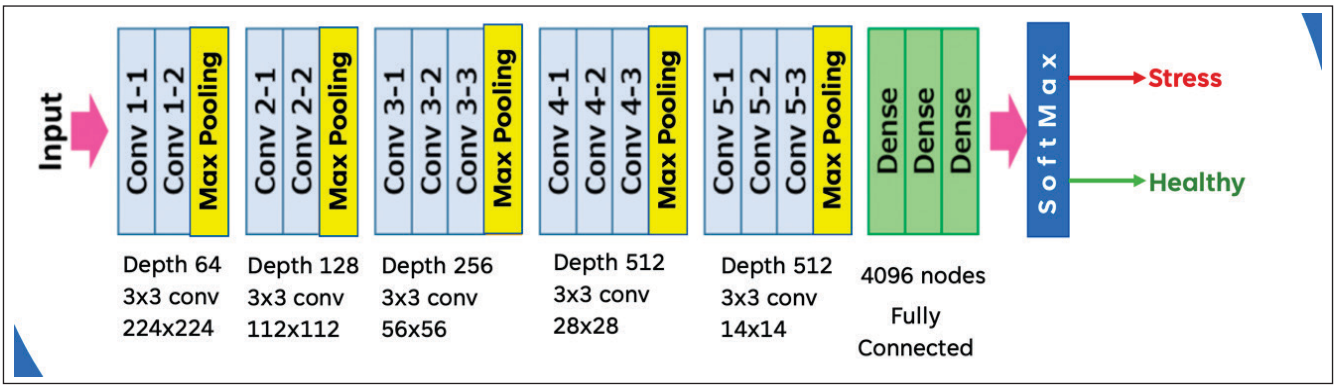
Ideal adaptation strategies for different future scenarios

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

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

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

The aim of the project is to detect the stress in different stages using AI based deep learning models. As an initial step 3000 different stress digital imageries of black gram, Cowpea, Finger millet, Fodder Sorghum, Groundnut, Horse gram Maize, pigeon pea and Sorghum were taken during the crop season in the field from HRF, GRF. Digital imageries were also taken for nitrogen deficiency symptoms in black gram and maize pot experiments grown with Hoagland Solution. Collected Maize Stress images 20,500 captured from plant phenotyping facility from. Plant photographs were taken from side view (0°), side view (90°) and top view. Captured 2000 field stress and healthy digital images. The image dataset was arranged into training, validation and testing. Pre-trained image classification model VGG-16 was used for stress images classification. The model has 13 convolutional layers, 5 pooling layers, 3 dense Layers. In all the permutations best accuracy values 56 percent was obtained with limited image dataset at image resolution 512 pixels, the optimisation algorithm is SGD, ReLU activation function and the batch size is 32.



VGG-16 Network

3.6. Technology Demonstration Component (TDC)

Technology Demonstration Component (TDC) of NICRA aims at enhancing resilience and adaptive capacity of farmers and minimizing the impact of climate variability in risk prone districts of the country. The programme also aims at building capacity of farmers and to generate awareness on climate resilient agriculture and enable communities to respond to climate stresses in a continuous manner. It is being implemented in 151 village clusters representing 28 states and 5 union territories during 2022. As part of the programme, several technologies were demonstrated for enhancing their adoption. During the year, the program was implemented in farming system perspective by

dividing the village in to different typologies and by demonstrating suitable technologies for each of the typology to minimize the impact of climatic stresses. At several locations, the predominant farming system typologies are the rainfed and irrigated systems with and without the animal component. The impact of technologies in various typologies is given below:

3.6.1. Performance of interventions

3.6.1.1. Performance of interventions in rainfed systems without animal component

In the NICRA village of Bharatpur district of Rajasthan, rainfed systems are predominant. Farmers were demonstrated with drought tolerant bajra variety HHB-299 followed by mustard variety which can be sown early. Though normal rainfall was received during the *kharif* season, but rainfall was deficit during the August month. Bajra (HHB-299) produced higher yield up to 20% and additional income of Rs. 6,500 ha^{-1} compared to non-NICRA farmers. High yielding mustard variety DRMRIJ-31 completed life cycle early and escaped the high temperatures at the time of harvesting. The variety produced an additional yield of 2.9 q ha^{-1} and net income of Rs. 17,600 ha^{-1} compared to non-NICRA farmers.

Drought tolerant varieties of bajra and mustard in NICRA village of Bharatpur district

During the year 2022, deficit rainfall of 78% in June, 51% in July and 35% in August was received in NICRA village of Tenar, Garhwa district of Jharkhand. An amount of 553 mm (38% deficit) rainfall was received during *kharif* season in 43 rainy days. Delayed onset of monsoon was observed in the NICRA village delaying the sowing of *kharif* crops. To overcome the situation, drought tolerant rice variety IR64 (DRT-1), finger millet variety A-404 and niger variety Birsa Niger-3 were demonstrated to farmers. The drought tolerant varieties produced higher yields up to 39% with additional net income of Rs. 7,376-14,544 ha^{-1} compared to non-NICRA farmers.

Drought tolerant varieties of rice and finger millet in Tenar village of Garhwa district of Jharkhand

In lowlands of Sadanandapur NICRA village of Buxar district of Bihar, rainfall received during *kharif* season was 885 mm of which 369 mm received during June month (60% excess) with high rainfall events of 42, 63 and 107 mm rainy days. To reduce the impact of water logging in lowlands, KVK demonstrated flood tolerant variety swarna sub-1. The variety experienced submergence conditions at the time of sowing and tillering stage. The flood tolerant variety produced higher yield of 56.6 q ha^{-1} compared to the farmers' variety (42.5 q ha^{-1}) with higher net income.

Flood tolerant rice variety in Sadanandapur NICRA village of Buxar district of Bihar

3.6.1.2. Performance of interventions in rainfed systems with animal component

Based on the constraints and resources available in the NICRA villages, suitable interventions were identified for rainfed systems with animal component. Under this typology, focus was on crops and animal related interventions which can minimize the yield loss due to climate stress. For example, in Dholikhera NICRA village of Bhilwara district of Rajasthan, which is frequently prone to drought, *kharif* season received 800 mm rainfall of which 46% was deficit during the June month and a dry spell of 12 days in the September month coinciding with grain filling stage of the crop was observed. Drought tolerant and short duration varieties of maize (DHM-121), blackgram (PU-01), sorghum (CSV-15) and intercropping systems of maize + blackgram (DHM-121 + PU-01) in 2:2 ratio were demonstrated. The varieties produced higher yield up to 42% compared to local varieties and obtained net income of Rs. 21,000 to 40,000 ha^{-1}. The intercropping system obtained higher yields up to 35% compared to sole crop of maize crop with local variety.

Drought tolerant and short duration varieties of maize (DHM-121), blackgram (PU-01), sorghum (CSV-15) demonstrated in NICRA village of Bhilwara district of Rajasthan

In case of animals, backyard poultry breed, Pratapdhan was introduced which can produce more number of eggs per year with high meat production. Additional income of Rs. 40,000 was obtained from Pratapdhan breed compared to Marwari local bird.

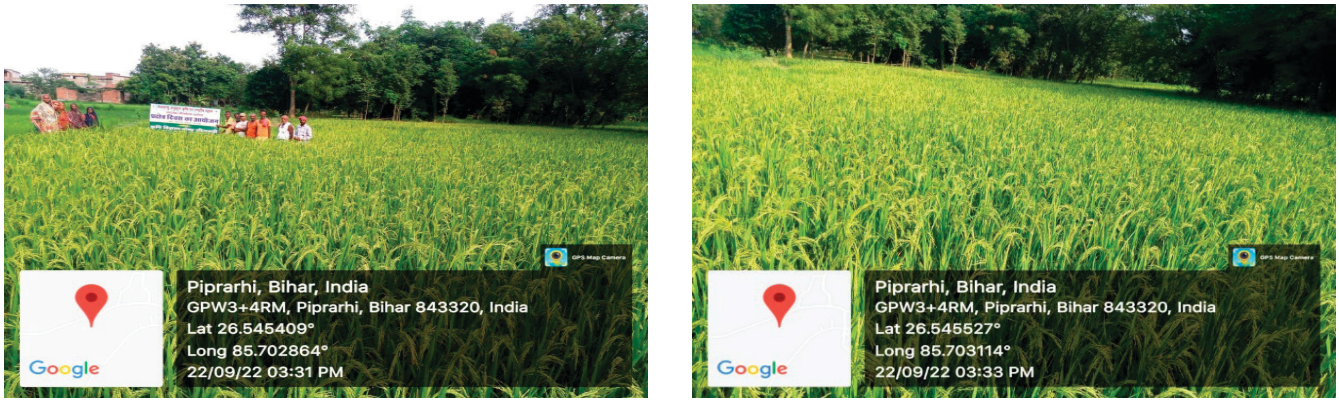
In Chandauna village of Darbhanga district of Bihar, 226 mm rainfall was received during *kharif* season of which 39 mm was received during June, 53 mm in July and 70 mm in August. Direct seeding of rice (DSR) method was demonstrated for taking up timely sowing as the district received deficient rainfall during the year. The soaked seeds were directly sown in the field without nursery raising and water saving. Demonstrations were taken up in 40 farmer's fields. The DSR resulted in 15% higher yield and 38% higher net returns over transplanting method in comparison to non-NICRA farmers. To improve the productivity in animals, pusa mineral mixture was demonstrated. Mineral mixture demonstration was taken up involving 20 cow rearing farmers and 27 goat rearing farmers. Cow feeding with pusa mineral mixture @ 50g/day resulted in 23% higher milk productivity with additional net income of Rs. 30,000. Whereas, goat feeding with mineral mixture supplementing with vitamins and minerals has produced 8% higher meat productivity resulting in higher net income of Rs. 3,300 /animal.

Demonstration of Pratapdhan chicks in Dholikhera village, Bhilwara district of Rajasthan

DSR method of rice cultivation and mineral mixture for goat in Chandauana village of Darbhanga district

3.6.1.3. Performance of interventions in irrigated systems with animal component

Recurrent flood situation is experienced in Piprarhi NICRA village of Sitamarhi district of Bihar. During the year 2022, an amount of 968 mm rain was received during *kharif* season, about 33% excess rainfall was received during June. Flood situation prevailed in the month of July and August. To minimize the impact of flood situation, submergence tolerant variety Swarna Sub-1 was demonstrated to the farmers. The variety produced higher yield up to 38.2 q ha^{-1} compared to local rice variety 35.5q ha^{-1}, an additional net income of Rs. 10,000 ha^{-1} was realized form the variety.



Submergence tolerant rice variety (Swarna Sub-1) in Piprarhi NICRA village of Sitamarhi district of Bihar

Terminal heat is a major climatic stress encountered in many areas of Punjab in 2022, which has a significant effect on wheat production. Maximum temperatures were higher by 4-5°C during the third and fourth weeks of March 2022, and warmer temperatures persisted for two weeks. The introduction of resilient technologies such as direct seeded rice with short duration varieties followed by wheat sowing in time, adoption of happy seeder and super seeder, *in-situ* rice residue management has improved the wheat yield upto 12% with additional net income of Rs. 25,000 ha^{-1} and had greatly reduced the effect of heat stress.

Timely sowing of wheat crop using happy seeder in Bathinda district of Punjab

3.6.1.4. Performance of interventions in irrigated systems with animal component

Creation of new water harvesting structures in convergence with the developmental programmes was taken up in Juna patrasar NICRA village of Barmer district of Rajasthan for harvesting the rain water. The harvested water was utilized for irrigating the *rabi* and summer crops contributing to cropping intensification

Water harvesting and providing supplemental irrigation to cumin crop and napier grass in NICRA village of Barmer district of Rajasthan

in rainfed areas. *Rabi* crop cumin variety (GC-4) was introduced in the NICRA village which is having wilt tolerant ability and also high yielding. The variety is demonstrated in 20 farmers' field covering 10 ha area. About 2-3 irrigations were provided from the harvested water to the cumin crop. To enhance the animal productivity green fodder variety of napier grass i.e., Rajka bajri was demonstrated under irrigated conditions. Higher yields upto 6 q ha^{-1} and net income of Rs. 1,03,746 ha^{-1} was realized due to cumin and higher green fodder production of 163 q ha^{-1} with net income of Rs. 5,437 ha^{-1} was realized compared to non-NICRA farmers.

Khanabari NICRA village of Kishanganj district of Bihar, generally experience flood situations in lowland and medium land conditions. During 2022, June month received higher rainfall with intense rainfall events of 35-132 mm/day leading to water logging conditions of fields. Submergence tolerant rice variety Sabour Sampann was demonstrated to reduce the impact of flooding and for timely transplanting. The variety tolerates the submergence conditions and matures early in 75 days to escape the flooding at the time of harvesting. The variety recorded higher yield up to 11% with additional income up to Rs. 7,500 ha^{-1}. To provide additional income to the household backyard poultry was introduced with Kadaknath chicks. Introduction of improved breeds helped to obtain additional body weight by 1.5 kg per bird and also increased the egg production by 41 per bird per year compared to local breeds.

Demonstration of submergence tolerant rice variety Sabour Sampann and Kadaknath chicks for backyard poultry in NICRA village of Kishanganj district of Bihar

During the year 2022, terminal heat stress prevailed over several parts of Uttar Pradesh. During the third and fourth week of March 2022 maximum temperatures were higher by 3-4°C over the normal temperature which impacted yields of wheat. To minimize the impact of heat stress technologies such as mulching in sugarcane, zero till sowing of wheat enabled timely sowing, heat tolerant wheat variety DBW 173, Raj 4120 and Raj 4079 were demonstrated in NICRA villages of Gonda, Kushinagar and Jhansi districts. The technologies have contributed to 94-95% of normal yields and minimized the yield loss. In livestock, feeding with green fodder, concentrates and mineral mixture @ 50 g/day along with providing shade has reduced the impact of heat stress on animals and minimized the loss in milk yield compared to farmers' practice.

Demonstration of heat tolerant wheat variety Raj-4079 and Low cost animal shelter to protect from heat stress in NICRA villages of Uttar Pradesh

3.6.2. Capacity building of the farmers

3.6.2.1. Training programme conducted in NICRA KVK villages

During the year 2022, about 1381 capacity building programs were conducted involving 39395 farmers. Trainings were conducted on various aspects of climatic change, impact and adaptation of climate change, natural resource management for enhancing the adaptive capacity, efficient cultivars and cropping systems, nutrient management, IPM practices, breed improvement, feed and fodder management, fish and goat farming, poultry, horticulture, kitchen gardening, nursery raising, vermicompost preparation, value addition etc. in NICRA villages.

Training Programme in various NICRA KVK Villages

3.6.2.1. Capacity Building Programme organized at CRIDA, Hyderabad

TDC- NICRA has organized a capacity building programs on "Technology demonstrations for enhancing resilience" to various KVKs in three phases during 24-25 July, 2022, 13-14 August, 2022 and 22-23 August, 2022 at CRIDA, Hyderabad. About 329 personnel from 151 KVKs involved in TDC Programme participated in these workshops. Training was imparted on various aspects, such as farming system typologies and impact assessments of NICRA interventions.

3.6.3. Launch and review workshops organized

During the year, review and launch workshops were organized during January to July, 2022 involving all the ATARIs. During the workshops, the progress of the work done was reviewed and the action plans for the next year was thoroughly discussed and finalized. During the program, KVKs were guided to plan and implement the program in farming system typology so as to make the program more comprehensive for enhancing resilience at household level in the NICRA villages encompassing various farming systems.

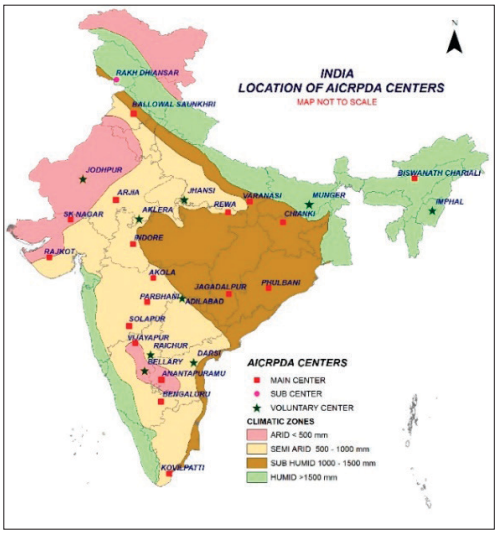
Launch and review workshops organized

Coordinated / Network Projects

4

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

The All India Coordinated Research Project for Dryland Agriculture (AICRPDA) has the mandate to generate agro-ecology specific technologies through on-station in the thematic areas of rainwater management, cropping systems, nutrient management, energy management, alternate land use and integrated farming systems. On-farm research (OFR) focus on rainfed IFS research and technology assessment/refinement. AICRPDA has a network of 28 centers located in diverse rainfed agro-ecologies in the country. Under NICRA, resilient practices and real-time contingency measures are being demonstrated in the farmers' fields. The salient achievements are given below. During 2021-22, 189 on-station experiments were conducted (44 on rainwater management, 55 on cropping systems, 48 on nutrient management; 19 on energy management and 23 on alternate land use).



Location of AICRPDA centres

4.1.1 On-station research

Rainwater management

In-situ moisture conservation

- In semiarid Vertisols at Arjia, tillage with vibro chisel plough recorded the highest grain yield (3145 kg/ha) with higher net returns (Rs.50771/ha), B:C ratio (2.62) and rainwater use efficiency (RWUE) (4.30 kg/ha-mm) along with the lowest soil loss of 14.2 t/ha, whereas tillage with cultivator recorded highest soil loss (18.6 t/ha) and maximum energy use efficiency (18.6 MJ/ha).

- In subhumid Alfisols at Phulbani (subhumid Alfisols), finger millet (5 rows) in sunken bed + okra (2 rows) in raised bed with organic mulching was a very effective method for inter-plot water harvesting and gave higher finger millet equivalent yield (2873 kg/ha), net returns (Rs.50559/ha), B:C ratio (2.14) and RWUE (3.02 kg/ha-mm).

Finger millet (5) in sunken bed + okra (2) in raised bed

Ex-situ rainwater management

- At Akola, in semiarid Vertisols, 13 runoff causing rainfall in the catchment area of 5ha of farm pond was 617.8mm which helped in the accumulation of 3151.6m^3 runoff in the farm pond. Out of the harvested rainwater, 1210 cum was used for irrigation and other purposes while 360 cum and 330 cum were lost through evaporation and other losses. The storage end of the season was 850 cum. Supplemental/protective irrigation was not given

to rainfed crops due to adequate soil moisture conditions. During *rabi* season 2022-23, chickpea was sown the second week of November. The protective irrigations of 50mm depth were given to chickpeas (0.8 ha) and also as supplemental irrigation to vegetable crops (0.1 ha viz. coriander, fenugreek, spinach, brinjal, okra, cowpea, bottle gourd and cluster bean) with micro-irrigation systems (in-line drip and micro-sprinklers). The water use efficiency in the vegetable crops was from 1.88 to 3.33kg/m^3 and the net income was Rs. 6410.

- At Jagdalpur, the application of two supplemental irrigations of 5 cm each (sprinkler) from harvested rainwater to chickpea gave significantly higher seed yield (1498 kg/ha) with higher net returns (Rs.60440/ha) and B:C ratio (2.75) compared to one irrigation (1168 kg/ha).

Chick pea under supplemental irrigation

Cropping systems

Alternate crops: In semiarid Vertisols at Kovilpatti, in the evaluation of alternative crops to cotton under semiarid Vertisols, radish recorded significantly higher cotton equivalent yield (3053 kg/ha), net returns (Rs110645 kg/ha), B:C ration (5.14) and RWUE (26.90 kg/ha-mm) followed by cluster bean (2721 kg/ha) and field bean (1798 kg/ha).

Pre-monsoon cropping systems: In semiarid Alfisols at Bangalore, with bi-modal rainfall distribution, among different crops evaluated during pre-monsoon period, field bean recorded significantly higher seed yield and rainwater use efficiency (1176 kg/ha, & 1.79 kg/ha-mm, respectively) as compared to greengram (1113 kg/ha, & 1.69 kg/ha-mm) and sesame (441 kg/ha & 0.67 kg/ha-mm). However, green gram recorded higher net returns (Rs. 50183/ha) and B:C ratio (2.39) as compared to field bean and sesame.

Crop diversification/intensification

Rainfed coarse cereals based cropping systems: In semiarid Inceptisols at Rakhdhiansar, significantly higher maize equivalent yield (MEY) of 3703 kg/ha was obtained with maize + cowpea (1:1) with the corresponding highest values of net returns, LER, B:C ratio and RWUE of Rs. 50663/ha, 1.24, 2.88 and 10.9 kg/ha-mm, respectively;

- At Ballowal Saunkhri, in semiarid Inceptisols, maize 6 m strip and black gram 2.4 m strip recorded higher maize equivalent yield (MEY) (3808 kg/ha), with the highest LER (1.19), and RWUE (5.62 kg/ha-mm). However, higher net returns (Rs.44935/ha) and B:C ratio (2.63) was obtained with maize strip 3 m and black gram strip width 4.8 m.

Strip cropping of maize 6 m + blackgram 2.4 m – Ballowal Saunkhri

Rainfed millet based cropping systems: In semiarid Vertisols at Kovilpatti, significantly highest pigeon pea equivalent yield (833 kg/ha), net returns (Rs.20863/ha), LER (1.11), B:C ratio (1.84) and RWUE (1.56 kg/ha-mm) was recorded with pigeon pea + kodo millet (2:6) intercropping system; In semiarid Alfisols at Bengaluru, finger millet + pigeon pea (8:2) intercropping system recorded significantly higher finger millet equivalent yield (FMEY) (2578 kg/ha), net returns (Rs 51802/ha), B:C ratio (2.5) and RWUE (2.34 kg/ha-mm)

Pigeonpea + kodo millet (2:6) - Kovilpatti

Rainfed oilseeds based cropping systems: At Rajkot, **in s**emiarid Vertisols significantly higher groundnut pod equivalent yield (3997 kg/ha) net returns (Rs 187573 / ha) B:C ratio (3.5) and RWUE (3.5 kg/ha-mm) was recorded with paired row planting of groundnut with sweet corn; at Akola, **in s**emiarid Vertisols, soybean + foxtail millet (4:4) intercropping system recorded significantly higher soybean equivalent yield (2540 kg/ha), net returns (Rs 71928/ha), B:C ratio (3.59) and RWUE (2.31 kg/ha-mm); at Indore, **in s**emiarid Vertisols significantly higher soybean equivalent yield (6359 kg/ha), net returns (Rs.236150/ha) and B:C ratio (5.72) was recorded in soybean + cowpea (4:2) - berseem double cropping sequence; at Jagdalpur, groundnut-mustard double cropping system recorded significantly highest main crop (groundnut) equivalent yield (2777 kg/ha); net returns (Rs.115835/ha) and B:C ratio (1.79)

Paired row planting of groundnut with sweet corn - Rajkot

Mustard - Jagdalpur

Rainfed pulses based cropping systems: At S.K Nagar, pigeon pea + green gram (1:1) system recorded significantly higher pigeon pea equivalent yield (625kg/ha), net returns (Rs.30237/ha) and RWUE (2.30 kg/ha-mm); at Kovilpatti, significantly higher pigeon pea equivalent yield (1234 kg/ha), net returns (Rs.31575/ha), LER (1.53), B:C ratio (1.87) and RWUE (2.32 kg/ha-mm) were recorded with pigeon pea + groundnut (2:6) intercropping system; at Arjia, sowing of mustard at 2.7 m interval across chickpea crop recorded significantly higher chickpea seed equivalent yield (2224 kg/ha), compared to sole chickpea (1739 kg/ha); at Biswanath Chariali, significantly higher yield (1217 kg/ha) and B:C ratio (2.67) was recorded in rajmah-sesamum-soybean sequence.

Pigeonpea + greengram (1:1) – SK Nagar

Pigeonpea + groundnut (2:6) – Kovilpatti

Fodder systems: At Anantapur, in an exploratory trial for round the year supply of green fodder to small ruminants, higher green fodder yield was recorded with fodder cowpea (22433 kg/ha) followed by fodder bajra (20391 kg/ha), Rhodes grass (19929 kg/ha) and stylo grass (19195 kg/ha).

Green fodder crops fodder cowpea and fodder bajra - Anantapuramu

Nutrient management

Permanent manurial trials (PMTs)

At, Ballowal Saunkhri, in a PMT initiated in 2009, during *kharif*, significantly higher yield of maize (3711 kg/ha) was recorded with application of NPK (100% RDF) + FYM 10 t/ha but it was at par with all other treatments (100% NPK (DAP), 100% NPK+ S (SSP),100% NPK+ZnSO4, 50% NPK + FYM 10 t/ha, 150% NPK, 100%N through FYM and 100%N through FYM+ biofertilizers except control. The highest net returns (Rs.47335/ha), B:C ratio (2.59) and water use efficiency (6.25 kg/ha/mm) was also recorded with the application of 100% NPK + FYM 10 t/ha. Application of NPK (100% RDF) + FYM 10 t/ha recorded higher moisture content (14.51 %), OC content (0.56%). Whereas the application of NPK (100% RDF) (DAP) recorded higher available N (234.7 kg/ha), NPK (150% RDF) recorded higher available P (31.3%) and available K (159.7) when compared to other treatments.

Integrated nutrient management

- At Indore, in a soybean-chickpea system, application of FYM 6 t/ha + N20 P13 kg/ha produced higher soybean seed yield (1080 kg/ha) with higher net returns (Rs.28100/ha), B:C ratio (2.37) and RWUE (1.35 kg/ha-mm).
- At Vijayapura, 100% recommended NPK and spraying of Nano-N + Nano-Zn (twice) gave significantly higher rabi sorghum seed yield (1604 kg/ha), net returns (Rs.37682/ha), B:C ratio (2.73) and RWUE (27.1 kg/ ha/mm) compared to 100% NPK (1381 kg/ha).

Energy management/Farm mechanization

- Semiarid Vertisols at Solapur, reduced tillage (RT) recorded significantly higher sorghum grain (1750 kg/ha) and stover yield (3818 kg/ha), net returns (Rs.38642/ha), B:C ratio (2.02) and RWUE (29.17 kg/ha-mm) compared to conventional and zero tillage (1681 kg/ha). Among residue management treatments, black gram green manuring recorded significantly higher grain (1798 kg/ha) and stover yield (3884 kg/ha) than the rest of the residue management treatment
- Subhumid Inceptisols at Ballowal Saunkhri, significantly higher maize grain yield was recorded with complete mechanization (3967 kg/ha) as compared to farmer's practice (3262 kg/ha) but was on par with partial mechanization (3763 kg/ha). The WUE 6.68 kg/ha-mm, net returns (Rs.43906/ ha) and benefit-cost ratio (2.15) were found higher under complete mechanization

Alternate land use systems

- In semiarid Vertisols/Alfisols at Raichur, in *Melia dubia* based Silvi-agriculture system in shallow black soils, *Melia dubia* planted at a spacing of 5 m x 5 m recorded maximum height, maximum branches per tree, girth and canopy spread as compared to 5m x 4m and 5m x 3m planting geometry. Pigeonpea recorded higher grain yield irrespective of the spacings of *Melia dubia* as compared to the pearl millet and foxtail millet. *Melia dubia* planting geometry at 5 m x 5m and pigeon pea as intercrop were found best practice.
- In semiarid Vertisols at Parbhani, among different species of bamboo, *Bambusa balcooa* recorded significantly superior girth (10.6 cm) whereas *Dendrocalamus strictus* recorded significantly higher plant height (11.6 m) and number of tiller (29/ plant). The spacing of 5.0 m x 5.0 m was found significantly superior and performed better with mean plant girth, height and number of tillers of 9.03 cm, 5.71 m and 22.29, respectively during the second year of plantation;

- In semiarid Inceptisols at Rakh Dhiansar, among agri-horti-silvi-pastoral system with guava + *Melia* + *Setaria* sp.+ maize-gobhi sarson, higher maize equivalent yield (2961 kg/ha) was obtained (grass - 2570; grain-2690 and stover- 5326 kga/ha) with net returns of Rs. 41627/ha; BC ratio of 2.65 and RWUE of 8.72 kg/ha-mm.

Maize sown in between alleys

- In subhumid Inseptisols at Chianki, in aonla and *kharif* crops based agri-horti system, aonla + black gram gave significantly higher aonla equivalent yield (AEY) (8.88 t/ha) followed by aonla + groundnut (8.72 t/ha) whereas, in sole crop aonla gave (8.2 t/ha). Similarly, maximum net returns (Rs.183100/ha) and RWUE (9.74 kg/ha-mm) were recorded in aonla + black system. Whereas, B:C ratio was recorded higher (4.81) in aonla + groundnut system.
- In sub-humid Inceptisols at Ballowal Saunkhri, in agri-horti-silvi-pasture model, *Grewia optiva* at 3 m x 3m+ Setaria grass + black gram wheat system resulted in the highest system productivity (5029 kg/ha) followed by guava at 6 m x 6 m + Setaria grass + black gram-wheat system sole. However, blackgram wheat recorded higher net returns (Rs.104950/ha) and B:C ratio (2.80) .
- In semiarid Vertisols at Indore, horti-pasture system with guava, pomegranate, phalsa and drumstick and MP Chari, Hy. Bajra, *Stylo Scabra and Stylo hamata, t*he mean higher fodder yield was obtained with hybrid bajra (14001 kg/ha) followed by *Stylosanthes hamata* (12667 kg/ha), *Stylosanthes scabra* (11067 kg/ha).

Drumstick/Phalas+ Hybrid bajra

4.1.2 On-farm research

On-farm participatory Rainfed Integrated Farming Systems Research

The interventions are being implemented under seven modules (as per the need) viz. NRM, crop, livestock, perennial tree, fodder, specific/optional module (interventions specific to individual farmers' needs) and capacity building. The results are briefed below:

Ananthapuramu centre (Semiarid Alfisols)

Under rainfed situation, for marginal farmer (0.8 ha) with crop + small ruminants based RIFS, different interventions implemented for improving the existing farming system were *in-situ* moisture conservation with conservation furrows; improved varieties of groundnut (K-9), pigeon pea (LRG-52) and fodder sorghum (SSG-998); groundnut + pigeon pea intercropping system (15:1); improved nutrition (RSMM @ 5 g/dat + licking of mineral block + sorghum/maize grain) and healthcare (deworming, deticking and vaccination against Enterotoxemia) of ramlambs. Different interventions resulted in higher groundnut equivalent yield (2237 kg), net returns (Rs 74651) and employment generation (282 man-days/year) compared to the existing farming system (1700 kg). The improved farming system gave additional returns of Rs 33593/year over the existing farming system.

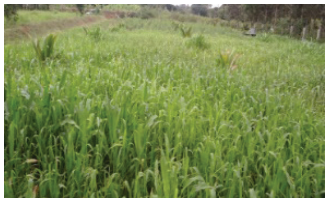
Bengaluru centre (Semiarid Alfisols)

Under rainfed situation, for marginal farmer (0.8 ha) with crop + large ruminants (CB-HF cows) based RIFS, interventions on NRM practices (contour cultivation, use of bullock drawn seed drill, and mulching); improved varieties of groundnut (KCG-6), finger millet (MR-1), pigeonpea (BRG-5), field bean (HA-4) and fodder maize (SA Tall); intercropping systems such as groundnut + pigeonpea (8:2) and pigeonpea + field bean (1:1); *ex-situ* rainwater harvesting through excavation of farm pond; introduction of chilli cultivation; improved nutrition (green fodder, concentrates and mineral mixtures) and healthcare (deworming) of large ruminants in marginal farmers category with 0.8 ha land area under crops + large ruminants (CLR) farming system recorded higher finger millet equivalent yield (7439 kg), net returns (Rs. 1,38,261) and employment generation (357 man days) as compared to existing farming system (3365 kg system productivity with net returns of Rs. 48,461 and employment generation of 296 man-days).

Under rainfed situation, for marginal farmer (2.0 ha) with crop + large ruminants (CB-HF cows) based RIFS, interventions such as contour cultivation; use of bullock drawn seed drill; mulching; improved varieties of groundnut (Kadiri Lepakshi), finger millet (MR-1), pigeonpea (BRG-5), field bean (HA-4); introduction of fodder sorghum and hybrid napier; intercropping of groundnut + pigeonpea (8:2); introduction of vegetable cultivation (bottle gourd, ridge gourd and cucumber); improved nutrition (green fodder, concentrates and mineral mixtures) and healthcare (deworming) of large ruminants in small farmers category with 2.0 ha land area under crops + large ruminants (CLR) farming system recorded 128% higher finger millet equivalent yield (9733 kg) with higher net returns (Rs. 114159) and employment generation (409 man days) as compared to existing farming system (4268 kg system productivity with net returns of Rs. 38379 and employment generation of 330 man-days).

Farm pond

Perennial component



Finger millet

Groundnut + Pigeonpea

Weeding by Cycle weeder

Napier cuttings (CO-5)

Improved groundnut variety (K-1812)

Interventions under rainfed condition - Bengaluru

4.1.3 Technology assessment

In an on-farm assessment of subsoiling on the productivity of groundnut + pigeon pea intercropping system by Anantapuramu centre, 10% higher groundnut equivalent yield (1135 kg/ha) with higher net returns (Rs. 41,380 /ha) and B:C ratio (2.37) were recorded with deep tillage with chisel plough compared to farmers' practice (1035 kg/ha). Assessment of balanced nutrition in finger millet by Bangalore centre revealed that application of a recommended dose of NPK + $ZnSO_4$ @ 12.5 kg/ha + Borax @ 10 kg/ha recorded higher grain yield (2823 kg/ha), net returns (Rs. 41548/ ha) and B:C ratio (2.51) followed by the recommended dose of fertilizer (2613 kg/ha) as compared to farmers' practice (1577 kg/ha).

Collaborative Research

Collaboration with CRIDA

Effect of foliar application of different nanofertilizers on the performance of rainfed crops was conducted at 3 AICRPDA centres (Bengaluru, Vijayapura and Jagdalpur) to assess the effect of nano-N and nano-Zn on growth and yield of rainfed crops. At Bengaluru, significantly higher finger millet grain and straw yield (3545 and 5088 kg/ha) was obtained with the application of 100% NPK + spraying of nano-N and nano-Zn twice and was on par with the application of 75% N + recommended PK + spraying of nano-N and Nano-Zn twice (3493 kg/ha and 5048 kg/ha, respectively).

Microbial consortia (Consortia-1- *Pseudomonas putida* P7 + *Bacillus subtilis* B30 and Consortia-2, *Pseudomonas putida* P45 + *Bacillus amyloliquefaciens* B17) for drought tolerance in rainfed crops. Seed treatment + soil application of Consortia 1 gave a higher grain yield (2550 kg/ha) of *kharif* sorghum at Parbhani and grain yield (1295 kg/ha) of *rabi* sorghum at Vijayapura. Seed treatment + soil application of consortia 1 recorded significantly the highest proline content (1.30 µg/g) in sorghum leaf at harvest (at Parbhani) and also higher soil moisture content at all the stages of the crop.

CRP CA-Developing Conservation agriculture strategies in rainfed production systems: In semiarid Alfisols at Bengaluru, in finger millet + pigeon pea (8:2) intercropping system, conventional tillage recorded higher grain yield, gross returns and RWUE (974 kg/ ha, 58413 Rs./ha and 0.82 kg/ha-mm) compared to zero tillage but statistically on par with reduced tillage, however significantly higher net returns and B:C ratio (Rs. 28915/ha, 2.05) was recorded with reduced tillage.

Collaboration with AICRPAM: Realtime monitoring and management of agricultural drought in major rainfed crop**.** At Akola, management of crop during dry spell (opening of furrow and two foliar sprays of urea and KNO_3) recorded higher seed cotton yield (1111 kg/ ha) with higher net returns (Rs.32127/ha), B:C ratio (1.53) and RWUE (1.15 kg/ha-mm) compared to no real-time intervention (1019 kg/ha).

Collaboration with Agricultural Research Stations within domain ACZ of AICRPDA Centres: The rainfed agriculture research base was expanded by conducting experiments at 15 Agricultural Research Stations within the domain Agro-climatic Zone of each by 14 AICRPDA centres. At ARS, Buldana (Maharashtra), in soybean-chickpea sequence, sowing on BBF and opening of furrow after every three rows at 30-35 DAS gave higher soybean equivalent yield (3804 kg/ha), net returns (Rs.107280/ha) and RWUE (3.61 kg/ha-mm); at Regional Research and Technology Transfer Station, G. Udayagiri, (Odisha), intercropping of maize + yam gave higher maize equivalent yield (4630 kg/ha) followed by maize + sweet potato (4536 kg/ha).

4.1.4 AICRPDA- NICRA

Under National Innovations in Climate Resilient Agriculture (NICRA), on-station and on-farm demonstrations/trials are being conducted by 23 AICRPDA centres with a focus on real-time contingency plan (RTCP)implementation and preparedness to cope with weather aberrations. During 2020-21, the interventions to cope with the delayed onset of monsoon and seasonal drought (early, mid-season and terminal) were demonstrated in more than 1709 farmers' fields in 23 village clusters (55 villages) in 24 districts across 15 states.

On-station

Delayed onset of monsoon: At SK Nagar, under the delayed onset of monsoon by 15 days, castor cv. GCH 7 (1269 kg/ha), pearlmillet cv. GHB 558 (1345 kg/ha), maize cv. GDYMH 101 (1703 kg/ha), greengram cv. GM 4 (524 kg/ha), black gram cv.GU 1(470 kg/ha), clusterbean cv. GG 2 (425 kg/ha), fodder sorghum cv. GJ 43(4596 kg/ha) gave higher yields.

Castor var. GCH 7

Maize var. GDYMH 101

Evaluation of groundnut verities for wet spells: In Semiarid Alfisols, scarcity zone of Andhra Pradesh (Anantapuramu), 3 wet spells of 93.2 mm, 56.2 mm and 34.4 mm occurred during 23-25 August, 6-9 October, 12-14 November at pegging, pod development to maturity and harvest stages of groundnut crop. Among eight groundnut varieties viz. K-6, Kadiri Lepakshi, TCGS-1694, GJG-32, Harithandhra, Amaravathi, Dharani, K-9, evaluated for wet spells/high rainfall, Kadiri Lepakshi recorded higher pod yield (1920 kg ha^{-1}) and haulm yield (2500 kg ha^{-1})

Mid-season drought: At Rakh Dhiansar, a dry spell of 11 days during 29 August – 8 September occurred at the tasseling stage of maize. Foliar spray of water-soluble complex fertilizer (19:19:19) @ 0.5 % + $ZnSO_4$ @ 0.5% during dry spell gave significantly higher grain yield (3200 kg/ha).

Foliar spray of water soluble complex fertilizer (19:19:19) @ 0.5 % + recommended dose of Zinc (STB) in maize

On-farm validation of RTCPs in AICRPDA-NICRA adopted villages

Delayed onset of monsoon: At Kalimati/Dholiya, Ganghu and Dhanpura villages (SK Nagar), the onset of monsoon was delayed by 16 days. Castor var. GCH 7 (1150 kg/ha), pearlmillet var. GHB 1129 (1240 kg/ha), maize var. GDYMH 101 (1692 kg/ha), and black gram variety GU 1 (441 kg/ha) recorded significantly higher grain yield.

Castor var. GCH 7

Pearlmillat var. GHB 1129

Coping with early season drought: At Kavalagi/Honnutagi villages (Bijapur district, Karnataka), a dry spell of 19 days occurred during 7-25 June coinciding with germination and vegetative stage of *kharif* crops. Weeding and inter cultivation with bullock drawn hoe increased the yield of pigeon pea by 16% (1029 kg/ha) with higher net returns (Rs.46259/ha), B:C ratio (3.49) and RWUE (2.31 kg/ha-mm) as compared to farmers' practice of no weeding and inter cultivation. At Babhulgaon village (Parbhani district, Maharashtra), a dry spell of 22 days (25 July to 15 August) occurred at the vegetative stage of crops. *In-situ* moisture conservation through the opening of furrow after every 4 rows in soybean and after every 2 rows in pigeon pea at 30 to 35 DAS enhanced yield by 34.6% and 21.35%, respectively, with higher net returns (Rs.36144 and Rs.45395/ha), B:C ratio (2.64 and 2.62) and RWUE (1.85 and 1.46 kg/ha-mm).

Meetings/seminars organized

ICAR-CRIDA organises 27th Biennial Workshop of AICRPDA, 9th Annual Review Workshop of NICRA-AICRPDA and 10th Annual Review Workshop of NICRA-AICRPAM

The "27th Biennial Workshop of AICRPDA, 9th Annual Review Workshop of NICRA-AICRPDA and 10th Annual Review Workshop of NICRA- AICRPAM" organized by the ICAR-Central Institute for Dryland Agriculture, Hyderabad from 2nd to 4th June 2022.

On the occasion, the *Best Dryland Farmers* from various parts of the country and the *Best Researchers* were felicitated with Awards for their outstanding contributions in the field of dryland agriculture and publications from AICRPDA centres and AICRPMA was released.

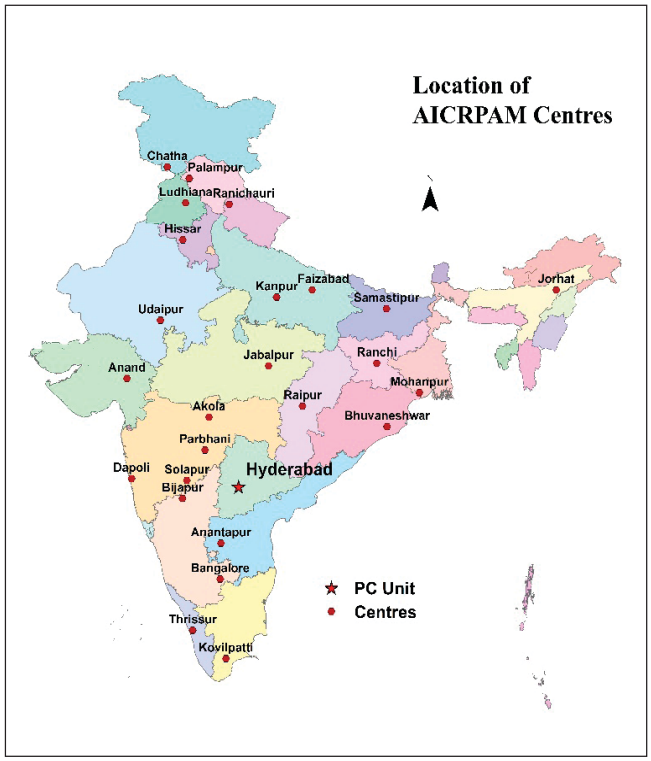
Brainstorming session on Water Policy for Rainfed Agriculture on 4 June 2022

A brainstorming session on Water Policy for Rainfed Agriculture was jointly organised in hybrid mode by ICAR-CRIDA and the Indian Society of Dryland Agriculture (ISDA) on 4th June 2022

The major recommendations to include in water policy for rainfed agriculture framework were identified as data driven and water balanced based and landscape level development planning, location specific water policy, needs of area-recharge calculations, aquifer mapping, individual farmer oriented small storage structures in central region.

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

The All India Coordinated Research Project on Agrometeorology (AICRPAM) was initiated by ICAR in May 1983 with the establishment of a coordinating cell at the Central Research Institute for Dryland Agriculture, Hyderabad with 12 Cooperating Centres at various State Agricultural Universities. After a detailed review and evaluation of the progress made by the project and realizing the importance of agrometeorological research support for enhancing food production, ICAR enhanced the Cooperating Centres to additional 13 Agricultural Universities of the country w.e.f. April 1995. The 25 Cooperating Centres of the AICRPAM network are Akola, Ananthapuramu, Anand, Bengaluru, Bhubaneswar, Chatha, Dapoli, Faizabad, Hisar, Jabalpur, Jorhat, Kanpur, Kovilpatti, Ludhiana, Mohanpur, Palampur, Parbhani, Raipur, Ranchi, Ranichauri, Samastipur, Solapur, Thrissur, Udaipur and Vijayapura. The Quinquennial Review Team has reviewed the research progress of the project in 1992, 1998-99, 2006, 2011 and 2017. In the last QRT Report, the performance of AICRPAM was adjudged as Very Good.

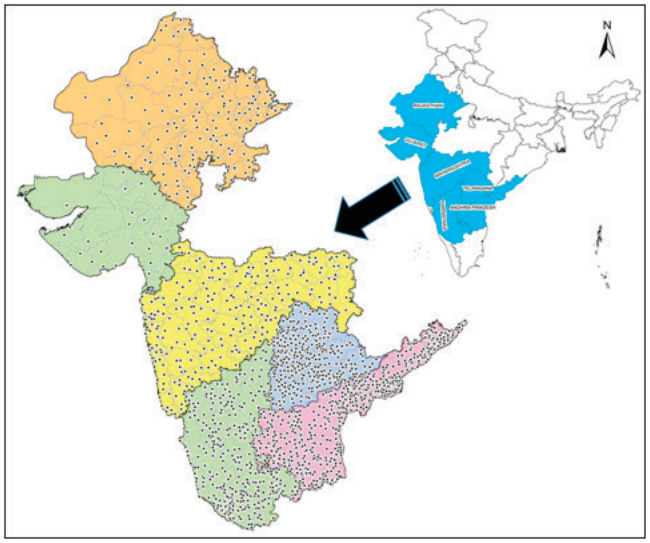


Location map of 25 Cooperating centers and Project Coordinating Unit of AICRPAM

4.2.1. Research activities at Project Coordinating Unit

Dry Spell Index (DSI)

The dry spells within the crop season, along with cumulative rainfall deficit, play a vital role in determining the productivity of various rainfed crops in India. A new index named Dry Spell Index (DSI) was developed to quantify the cumulative impact of dry spells during the *kharif* season (Jun-Sep) on major rainfed crops of India. District-wise spatial variability and trends of DSI were analyzed across major arid and semi-arid regions of the country using observed rainfall data from 1636 stations over six states of India. A comparison of DSI with the Standardized Precipitation Index (SPI), hitherto, a widely used drought index was also carried out to assess the comparative performance of DSI over SPI.



Rainfall stations (indicates as dots) across the study area

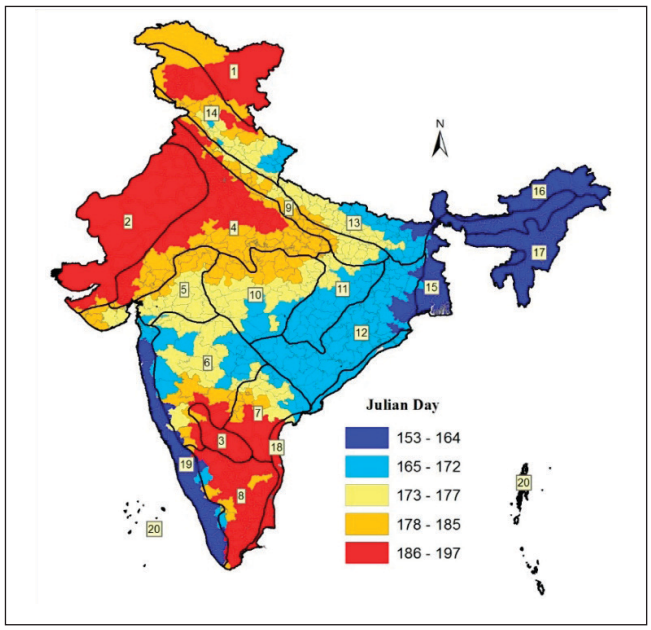
The results revealed that regions especially central and eastern Karnataka, northern Rajasthan and western Gujarat are becoming wetter in terms of total seasonal rainfall as indicated by SPI, and simultaneously becoming drier in terms of total dry spell duration within the season as per DSI.

The impact of DSI on the yield of major rainfed crops viz., cotton, groundnut, maize, pearl millet, pigeon pea and sorghum was estimated by employing appropriate statistical methods. From the correlation analysis of DSI and SPI, it was observed that the impact of the number and duration of dry spells integrated in the form of DSI was higher in comparison to the influence

of total rainfall indicated by SPI on the yield of six major rainfed crops in India. Groundnut and pearl millet crops were found to be experiencing a higher duration of dry spells in comparison to other crops. It was also noticed that districts with higher DSI showed lower productivity in all the crops compared to the districts with lower values of DSI having better productivity levels.

Agroclimatic onset of crop growing season in various agro-ecological regions of India

The success of rainfed crop production is highly dependent on timely sowing/planting decisions. Information on the optimum crop sowing window for the season will facilitate crop planning by farmers and other stakeholders. Daily rainfall data of 0.25° x 0.25° grid resolution from India Meteorological Department for the period 1951-2019 was used for the present study and gridded data was converted into area weighted daily rainfall data for 680 districts using the Thiessen polygon method. To determine the onset of crop growing season, three methods viz., Soil Water Balance, Depth and modified Morris and Zandesta were evaluated to identify the most suitable method. Soil Water Balance (SWB) method was found to be the most suitable based on validating with observed crop sown status, a false start and a number of undefined onset years criteria. The onset dates determined by MTC and SWB methods were statistically compared and subsequently appropriate threshold values were identified to find the onset in 19 AERs of India.



Mean onset of the growing season determined by Modified Threshold Combination method

This study revealed that the onset is not influenced by threshold combinations in the per-humid, humid and sub-humid regions, whereas, in semi-arid and arid regions, the critical evaluation of criteria for determining onset is vital to avoid false starts and undefined onset years.

4.3. Theme-wise salient research findings from cooperating centres

4.3.1. Agro-climatic characterization

- A study on vegetation responses to meteorological drought in agricultural fields at different stations of Gujarat indicated that no significant association exist between SPEI and NDVI at Anand. This suggests crop conditions have a low dependency on monsoon wetness. However, at Bhuj, the vegetation condition of crop fields was found to be significantly responsive to the wetness of September (SPEII and SPEI2) and agricultural crop conditions during *kharif* and *rabi* seasons near Bhuj, largely dependent on the wetness of August and September months.
- A comprehensive drought analysis based on the Standardized Precipitation Evapotranspiration Index (SPEI) was carried out to find out its spatial variability over three dry zones of south Karnataka. Results showed that, the districts like Mandya, Tumkuru, Ramanagara, Davanagere and Chitradurga, drought events with higher magnitude (SPEI 2.05, 1.65, 1.54, 1.54 and 1.18, respectively) compared to other districts.
- Changes in the area under different *kharif* and *rabi* crops and climatic parameters in the Punjab state during two major periods viz. green revolution period (1971-1990) and post green revolution period (1991-2018) were carried out. The study indicates no significant change in maximum temperature during pre- and post- green revolution time scales. But, increase and decrease in annual, *kharif* and *rabi* season minimum temperature and rainfall was evident during post green revolution period.

- At Mohanpur Center, an attempt was made to find the accuracy and reliability of Hargreaves-Samani, Turc and Makkink PET methods against the FAO Penman- Monteith method. The Makkink method could efficiently estimate PET with the least error and deviation compared to the other two methods.
- At Samastipur, short (5-7 days) as well as long (11-15 days) dry spells during June-September months were found to increase in the recent period (1998-2018) at Pusa, Samastipur, Purnia, Bhagalpur and Patna compared to earlier period (1979-1998).
- A significant increase in rainy days was observed in the districts like Dhule, Ahmednagar, Satara and Kolhapur districts while a significant decreasing trend was noticed in Nandurbar, Pune and Solapur districts. The remaining districts did not show any significant change during the period June-September.

4.3.2. Crop weather relationship studies

- At Mohanpur, Among the growing environments, the crop transplanted on 23 June recorded the highest grain yield and RUE, followed by the crop transplanted on 20 July. Among the varieties, the highest yield and RUE was recorded by Nayanmani followed by Satabdi and Swarna.
- The relationship of seasonal rainfall, available soil moisture with pear millet yield (2018-2021) at Anand indicated that seasonal rainfall of about 700-800 mm and 65-70% available moisture are optimum for maximum productivity. Rainfall higher than 800 mm during the season and more than 70% of mean available moisture reduced the production of pearl millet drastically.
- A study on the effect of growing environments and cultivars on Leaf Area Index (LAI) at Hisar revealed that the crop attained maximum LAI at 35 DAS at the flag leaf stage and decreased thereafter. The maximum LAI was recorded by crop sown on 23 July (5.68) followed by that of 15 July (5.51). Among varieties, the maximum LAI was recorded by HHB-272 (5.50) followed by GHB-558 (5.38).
- At Solapur, a pooled analysis to assess the effects of growing environments on radiation use efficiency (RUE) was studied using experimental data conducted during 2016-2021. Among the treatments, Dhanshakti sown during the second fortnight of July recorded the highest RUE at 50% flowering (2.4 g MJ^{-1}), followed by Mahyco hybrid (2.3 g MJ^{-1}).
- At Ananthapuramu, BRG-1 recorded a significantly higher pod yield (644.8 kg ha^{-1}) as compared to BRG-2, BRG-5 and PRG-176 (568.1, 426.5 and 398.9 kg ha^{-1}, respectively).
- A similar correlation study conducted at Jabalpur indicated a negative correlation exhibited between maximum and minimum temperatures and bright sunshine hours with seed yield at the vegetative stage and pod development stages.
- Bt cotton Balwan recorded a significantly higher seed cotton yield (1019 kg ha^{-1}) than hirsutum cotton AKH 081 (859.50 kg ha^{-1}) and arboreum cotton AKA 7 (767 kg ha^{-1}) at Akola. Thermal use efficiency was found to be higher for monsoon-sown crop (28 June) with respect to both seed cotton and biomass production and it decreased in subsequent late sowing.
- The crop sown on 06 November recorded the highest RUE (1.08 g MJ^{-1} m-2) than on 22 November (0.96 g MJ^{-1} m^{-2}) and 06 December (0.71 g MJ^{-1} m^{-2}) sown crop at 120 days after sowing at Chatha. Among the varieties, RUE increased from 30 to 120 DAS and the variety HD-2967 recorded the highest RUE (1.04 g MJ^{-1} m^{-2}) followed by RSP-561 (0.88 g MJ^{-1} m^{-2}) at 120 DAS.
- The impact of growing environments (01 Nov, 10 Nov, 20 Nov, 30 Nov and 10 Dec) and spacing (60 x 20 cm, 75 x 20 cm and 45 x 20 cm) on absorbed PAR of rabi maize was studied during rabi 2021-22 at Samastipur. Silking stage of the crop absorbed the highest PAR (931.2 µm m^{-2} sec^{-1}), followed by tasselling stage (867.0 µm m^{-2} sec^{-1}). The highest absorption was recorded by the crop sown on 30 November and the lowest by 1 November sown crop.
- The effect of minimum temperature during the grain development stage and minimum temperature during the vegetative stage on the grain yield of rabi sorghum at Kovilpatti was studied. An increase in minimum temperature (>21.4 °C) during the grain development stage ultimately increases the grain yield of sorghum.

- At Akola, crop sown on 02 November (D1) recorded higher heat use efficiency (0.99 kg ha-1 °C day^{-1}) with respect to both seed and biomass production. Amongst the varieties, heat use efficiency with respect to grain yield and biomass production was higher in V1 (JAKI-9218).
- Among the three microclimatic regimes studied (sown on 20 Sept., 25 Sept. and 30 Sept. 2021) at Jorhat, the highest yield was recorded under MR-I (889.7 kg ha^{-1}) followed by MR-II (811.3 kg ha^{-1}) and least in MR-III (791.1 kg ha^{-1}). A decrease in seed yield was observed when sowing was done during the last week of September month.
- At Mohanpur, the highest seasonal evapotranspiration was recorded for crop sown on 07 October, which might have reduced the water use efficiency of the varieties. The highest water use efficiency was recorded by cv. Meha sown on 25 September, followed by PM-05 sown on 25 September.
- Effect of growing environments (D1: 16 Nov., D2: 22 Nov., D3: 30 Nov. and D4: 7 Dec. 2021) on chlorophyll content index (CCI) of potato varieties (V1: Kufri Bahar, V2: Kufri Pushkar and V3: Kufri Lima) was studied at Hisar. Among the different growing environments, the highest CCI was recorded by early planted crop i.e. D1 (96.9) and lower by subsequent plantings. Among the varieties, Kufri Pushkar recorded the highest CCI value (92.3) followed by Kufri Lime (91.3) and lowest by Kufri Bahar (86.1).
- The impact of weather parameters on the yield of Alphonso mango at different locations of Maharashtra was undertaken by the Dapoli centre. During vegetative stages, evening relative humidity showed a significant positive relation with fruit yield. During fruiting, Tmax, BSS and pan evaporation showed a significant positive correlation and both morning and evening relative humidity showed negative relation.
- Correlation of fruit yield and quality parameters of guava variety Hisar-Safeda with weather parameter under Hisar condition (pooled data analysis, 2013-14 to 2021-22) indicated that average fruit yield/plant showed a significant positive correlation with saturation vapour pressure (both morning and evening) and negative correlation with seasonal rainfall. Total soluble solids (TSS) showed a significant positive correlation with relative humidity (morning and evening) and water use efficiency. The acid content of the fruit showed a significant negative correlation with morning and evening relative humidity and seasonal rainfall.

4.3.3. Crop growth modelling

- The soybean model in DSSAT CSM was calibrated and validated for new soybean cultivars (JS-335, JS-9305 and AMS-1001) by the Akola centre. The impact of protective irrigation (60 cm) during long-dry spells on the yield of soybean was simulated and the yield gain through simulated protective irrigation was of greater magnitude in late sown soybean and more so at the reproductive development stage of pod formation to seed development across all sowings.
- Crop simulation model CERES-millet was calibrated using 2017 experimental crop and weather data at Anand and validated with four years of field data of 2018, 2019, 2020 and 2021. The model is predicting the phenology, biomass yield and final grain yields well within the limits. The D-index values showed for anthesis, maturity days, LAI, grain yield and above-ground biomass were 0.97, 0.99, 0.99, 0.91 and 0.91, respectively.
- Seven years of weather data of different parameters and crop experimental data sets (*rabi* 2015-16 to 2021-22) were collected and analyzed at Chatham centgre, Jammu to develop the wheat yield prediction model. Step-wise regression model indicated that the step 3 regression model with weather parameters at different growth stages (Tmax, Tmin, RH-II, sunshine hours and evaporation) improved the accuracy of prediction up to 56 per cent.

4.3.4. Weather effects on pests and diseases

- The relationship between weather and the incidence of spotted pod borer (*Maruca vitrata*) on red gram during 2019, 2020 and 2021 was studied at the Ananthapuramu centre. The correlation analysis for the rainfed crop indicated that there was a significant negative correlation between no. of webs per square meter and live larvae per square meter with rainfall, maximum temperature, minimum

temperature, wind speed and evaporation and a significant positive correlation with morning relative humidity.

- A simple weather-based disease prediction model for cotton leaf curl virus disease was developed by the Hisar centre. The optimum range of weather parameters with the progression of maximum PDI value from 22 to 45 SMWs was analyzed and found to be 32.3 to 36.3 °C (maximum temperature), 24.5 to 29.6 °C (minimum temperature) and 73.2 to 86.7.0 per cent (morning relative humidity) and 7.0 to 9.1 hrs (bright sunshine hours).
- An investigation was undertaken on the occurrence of haemo-protozoan disease especially Theileriosis, Babesiosis, Anaplasmosis and viral disease Foot and Mouth Disease (FMD) in livestock at Ranchi district by using the retrospective data from the period 2012-2020. The average percentage disease incidence of Theileriosis and Babesiosis in cattle was significantly highest in monsoon (44.8% and 45.3%) followed by summer (32.8% and 36.5%) and lowest in winter (22.4% and 18.2%), respectively. Prevalence of Anaplasmosis was significantly highest in summer (47.9%) followed by monsoon (33.5%) and lowest in winter (18.6%). Cattle was more susceptible to FMD in the winter season during which, the average percentage of disease incidence was 42.8% followed by monsoon (32.8%) and lowest in the summer season (24.4%).

4.3.5. Agromet advisory services

- AICRPAM with the help of its cooperating centres across the country is involved in issuing AAS bulletins twice a week, both in English and vernacular languages.
- The Dynamic Crop Weather Calendar (DCWC), a decision support system developed by AICRPAM has been validated for 75 districts in the country for major crops grown in the respective districts
- A new mobile application 'CSAU Weather Forecast' was developed by AICRPAM-Kanpur centre. CSAU Weather Forecast provides detailed local and weather worldwide forecasts. This app provides the current temperature in Celsius and Fahrenheit, sunrise and sunset time according to city time zone, atmospheric pressure, weather conditions, visibility distance, relative humidity, precipitation, wind speed and direction, in addition to five days in future and per day weather forecast.

Krishi Vigyan Kendra - Ranga Reddy District

5

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

5.1. On-Farm Testing (OFT)

Assessed 12 technologies on varietal, ICM, horticulture, agricultural engineering and livestock management were assessed in the adopted villages during 2022.

Agronomy and Horticulture

Technology	No. of Trials	Yield (t/ha)		Net returns (Rs.)	B:C Ratio
		Farmers Practice	Improved Practice		
Assessment of chilli hybrids Arka khyati and Arka Shweta in comparison with local hybrid	5	12.5	15.2	186420	2.28
Introduction of Okra var. Arka Nikita (F1 hybrid) & Arka Abhay	5	12.5	18.5	168800	2.50
Integrated pest management for *Tuta absoluta* in Tomato	5	24.4	36.1	186500	2.30
Assessment of French bean varieties Arka Sharath & Arka Arjun	5	13.2	16.5	80300	2.06
Assessment of coriander multi cut variety Arka Isha	5	7.85	11.2	101000	2.78
Integrated crop management in Tomato	5	21.5	36.2	169950	2.10

Animal Science

Technology	No. of Trials	Thematic area	Farmers Practice	Improved Practice	Results
Efficacy of coated vitamin and chelated minerals in dairy animals	5	Reproductive management	Natural grazing with paddy straw feeding	Natural grazing + complete balanced ration with supplementation of coated vitamins, chelated minerals	Higher (61%) conception rate
Assessment of area specific mineral mixture in dairy cattle	20	Nutritional management	Natural grazing with dry roughage feeding	Natural grazing + complete balanced ration with area-specific mineral mixtures	The quantity of milk and fat was enhanced by 24% and 68%
Assessment of supplementation of Sodium bicarbonate and yeast in cross bred cattle	8	Production management	Natural grazing with imbalanced concentrate mixture feeding	Supplementation of Yeast and or Sodium bicarbonate along with a balanced ration	Increased milk yield (20-24%) and fat % (1.6-1.9).
Assessment of ethno veterinary practices on parasitic infestation in calves	5	Health management	Neem oil only	Custard Apple, Neem, Eucalyptus leaf, Turmeric powder extract diluted up to 50% in vegetable oil base	Controlled ticks, lice, mite problem in livestock

Agricultural Engineering

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

5.2. Front Line Demonstrations (FLDs)

Four hundred and ninety FLDs were conducted on 19 technologies on field crops, vegetables, fruit crops, livestock, farm mechanization, soil and water conservation and drudgery reduction.

Agronomy and Horticulture

Crop	Technology	Demos	Yield (kg/ha)		% Increase
			Farmers Practice	Improved Practice	
Pigeon pea	Cluster Frontline demonstrations on pigeon pea variety PRG176 with production technologies	25	1015	1420	39.9
Dolichos bean	Demonstration of Dolichos beans variety Arka Soumya in comparison with local variety	10 (4ha)	14500	18500	21.6
Field bean	Demonstration of Field bean (TFB-2) as a contingency crop	10	12400	15400	19.4
Mango	Integrated crop management in mango	10	12800	16200	20.9
Bitter gourd	IPM for fruit fly control in bitter gourd	10	19300	26700	27.7
Chilly	Plastic mulching in chilly	10	11000	14800	25.7
Guava	Control of fruit fly in guava through mass trapping with fruit fly traps	10 (4ha)	21800	25300	23.6

Animal Science

Intervention	Farmers Practice	Improved Practice	Increase over FP
Demonstration of perennial fodder variety Super Napier (10 demos)	Yield: 55 t/ha	Yield: Co-5 168 t/ha	Three times more green fodder yield
Demonstration of mineral licks for grazing sheep and goat (16 demos)	17 kg live weight	20 kg live weight	17.6% more weight gain
Demonstration of Total Mixed Ration (TMR) feeding to milch animals (12 demos)	Feeding of agricultural byproducts with grazing and no supplementation of minerals	Balanced ration with supplementation of minerals and vitamins	8.5 % increase in milk yield
Demonstration of model fodder block as a package – (10 demos)	Single cut sorghum, green fodder yield	Multicut fodder sorghum (CO-FS-29, Perennial legume (Hedge lucerne), Fodder legume tree (Moringa)	74% more protein rich green fodder for supplementation
Demonstration of artificial insemination with sexed semen in dairy cows (15 demos)	Low female calves	More female calves	12 female calves born,
Demonstration of improved backyard poultry birds var. Rajasri as sustainable livelihood income (290 demos)	Low egg and meat production	Increased egg and meat production	Increased income by 78.4%

Agricultural Engineering

Technology	No of Demos	Yield (t/ha)		Net Returns (Rs. /ha)	B:C Ratio
		Farmer Practice	Improved Practice		
Demonstration of CRIDA Designed Nine Row planter for different crops.	25	1.5	2.5	Rs.50000/ ha	3.21
Demonstration of Multipurpose Plastic Mulch sheet laying machine for Vegetables (Tomato, Brinjal, Mirchi, Ladies finger and others).	5	23	41	Rs.222200/ ha	3.82
Demonstration of Paddy Baler Machine for balling of harvested paddy stalk	10	Paddy straw saved 20 to 30%	Paddy straw saved 80 to 90%	Rs.40000/ ha	3.13
Demonstration of Rain pipe for different types of vegetables	4	Saved water 30 to 40%	Saved water 70 to 80%	Rs.15000/ ha	2.81
Demonstration of Power Operated weeder for Rainfed crops	5	Manual weeding, crop saved 30 to 40%	Mechanized weeding crop saved 60 to 70%	Rs.10000/ ha	2.22
Demonstration of Drones for Spray Application	3	Organized a live demonstration to get the awareness on spray application to various height crops, attended around 467 farmers.			

5.3. Training Programmes

Organized 78 need-based and skill-oriented training programmes on various aspects of improved technologies to 3197 clientele farmers, farm women, rural youth and field level extension workers.

Clientele	No. of Courses	Male	Female	Total participants
Farmers & farm women/Rural Youth	**52**	**1914**	**286**	**2224**
Extension functionaries	**14**	**452**	**84**	**536**
Sponsored Trainings	**12**	**402**	**35**	**437**
Total	**78**	**2768**	**405**	**3197**

5.4. TV/radio talks/shows

S.No	Date	Activity	Media
G. Sri Krishna	26-4-2022	Situational advisories in Mango cultivation https://youtu.be/eJ1QRUqft08	HMTV
G. Sri Krishna	14-5-2022	Measures to be taken at Fruit Development and harvesting stage https://youtu.be/GHGwxp7QJbk	ABN
G. Sri Krishna	21-5-2022	Measures to be taken at Fruit Development and harvesting stage, storage https://youtu.be/c9aJ20NReZM	ABN
G. Sri Krishna	23-5-2022	Live -Cultivation practices in horticulture crops during monsoon https://youtu.be/JwGp1Kms83U	HMTV
G. Sri Krishna	26-5-2022	Seed production & Availability in KVK https://youtu.be/AaOBz9rGal4	HMTV
G. Sri Krishna	28-5-2022	Quality seed in KVK https://youtu.be/9dKxr8Jx6WA	ABN
G. Sri Krishna	29-5-2022	Seed production & Availability in KVK https://youtu.be/9eYpzkfXzI8	DD Yadagiri
G. Sri Krishna	30-5-2022	Seed & Planting material production in KVK https://youtu.be/xTVr_WJJhec	10 TV
G. Sri Krishna	10-11-2022	Production technology of chrysanthemum https://youtu.be/WLenik3unIE	HMTV
D. Sudheer		https://youtu.be/STh_76l--vU Aim to provide skills to famers	HMTV
D. Sudheer		https://youtu.be/STh_76l--vU Scientific sheep and goat rearing	HMTV
D. Sudheer		https://youtu.be/W8fWdpAWWo0 Empowerment of women SHGs through backyard poultry farming	HMTV

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

SMS	Topic	Period	Venue
G. Sri Krishna	Action plan meeting of KVKs Conducted jointly ATARI Zine X and PJTSAU.	18-19 April 2022	Online
G. Sri Krishna	ZREAC meeting conducted by SKLTSHU at Mulugu Siddipet district.	10-5-2022	SKLTSHU
G. Sri Krishna	Participated in 12th Biennial National conference of Krishi Vigyan Kendras	01-06-2022 to 02-06 2022	Dr YSPUHF, Nauni, Solan HP
G. Sri Krishna	Annual Zonal workshop of KVKs under ATARI Zone X (AP, Telangana, Tamilnadu and Puducherry)	12-07-2022 to 14-07-2022	Kanha Shanthi Vanam, Chegur
G. Sri Krishna	National seminar on "Harnessing the potential of panchabhutas (tatvas) for sustainable climate resilient rainfed agriculture	28-09-2022 to 29-09-2022	ICAR- CRIDA, Hyderabad
G. Sri Krishna	International Conference on "Reimagining Rainfed Agro-ecosystems Challenges & Opportunities	22-12-2022 to 24-12-2022	ICAR- CRIDA, Hyderabad

5.6. Seed Hub

During 2022 under Seed Hub project, About 52.34q of Redgram PRG 176 , 0.95q of Horsegram (CRHG-4 and CRIDA-18 R, CRGH 22) and 5.01q of Greengram (WGG 42) seed was supplied to the farmers. Till today 22q of Redgram PRG 176 certified seed was produced in this season. Approximately 7.43 lakhs (through Seed sales)revenue will be generated through sales of Seed.

Participants of the training programme

Soil Testing – Details of samples analyzed during 2021-22

No. of Soil samples analyzed	No. of Water samples analyzed	No. villages	No of Farmers benefitted and cards distributed
118	-	2	95

5.7. Major events organized by KVK, CRIDA

Krishi Vigyan Kedra- Ranga Reddy, ICAR-CRIDA organized World Soil Day Campaign on 05.12.2022 at Krishi Vigyan Kedra, Hayathnagar Research Farm, Hayathnagar, Hyderabad. About 66 farmers and farm women along with KVK staff and students participated in the event. Demonstration of chrysanthemum varieties, solar-based micro irrigation systems, fodder block, horticulture block and red gram crop grown on raised bed with modified furrow system along with KVK team was done.

World Soil Day cerebrations at KVK CRIDA

Parthenium week

Krishi Vigyan Kendra-Ranga Reddy district, ICAR-CRIDA conducted Parthenium awareness programme on 19th August 2022 at KVK, Hayathnagar Research Farm (HRF). KVK staff and RAWE students participated in the programme.

Parthenium awareness programme

Poshan Vatika Abhiyan and Tree Plantation

Krishi Vigyan Kendra - Ranga Reddy district, ICAR-CRIDA has organized 'Kisan Mela cum awareness training programme at KVK, Hayathnagar Research Farm on 29.07.2022 to create awareness on "Water conservation" under "Jal Shakti Abhiyan" programme of Ministry of Jal Shakti, Govt. of India. Farmers from 10 villages in Yacharam and Machal mandals of Ranga Reddy district participated in the programme.

Kisan Mela cum awareness training programme at KVK

Awareness programme and Kisan Mela on Natural Farming

KVK Ranga Reddy District, ICAR-CRIDA organized an Awareness programme on Natural farming and Kisna Mela on 12th December 2022 at KVK farm. Sri Nagaratnam Naidu, a Natural farmer shared his experience of how to convert agricultural lands from toxic chemicals to healthy organic with the adoption of Natural farming concepts. Farmers visited the exhibition arranged at the venue, KVK demonstrations viz. Demonstration of chrysanthemum varieties, solar based micro irrigation systems, and newly initiated natural farming block along with KVK team.

Natural farming and Kisan Mela

Training cum distribution of Rajasri variety backyard poultry chicks in KVK adopted village for the empowerment of rural women.

Krishi Vigyan Kendra, Ranga Reddy District, ICAR-CRIDA, Hyderabad organized training on backyard poultry in KVK adopted village (Konapur and Shettipalli) of Amangal Mandal, Ranga Reddy district in the forenoon of 15th September, 2022.

National Campaign on Poshan Abhiyan and Tree Plantation

Krishi Vigyan Kendra, Ranga Reddy District, ICAR-CRIDA organized the "National Campaign on Poshan Abhiyan and Tree Plantation" on 17 September 2022 at KVK farm. The message of Honourable Union Agriculture Minister Sh. N S Tomar Ji on Poshan Abhiyan was telecast to participants.

National Campaign on Poshan Abhiyan and Tree Plantation at KVK

Special campaign (Swachhata (cleanliness) and reducing pendency in government) 2.0

Krishi Vigyan Kendra, Ranga Reddy District, ICAR-CRIDA organized " Agricultural Waste Management and cleanliness " activity under Special Campaign (Swachhata (cleanliness) and reducing pendency in government) 2.0 on 02.10.2022 at KVK-Ranga Reddy, HRF, Hayathnagar. Dr. DBV Ramana, OIC, KVK welcomed the RAWE students and highlighted the importance of Agricultural Waste Management and cleanliness in day to day life and how it will help in mitigating pollution and efficient use of available resources for soil fertility improvement. Collected waste/ residue materials from farm produce and demonstrated composting using microbial consortia after separation of decomposable materials for composting and non-decomposable materials for disposal in safe place.

Krishi Vigyan Kendra, Ranga Reddy District, ICAR- CRIDA organized the "Cleaning of campus and demonstration of technologies on waste and wealth" activity under Special Campaign (Swachhata (cleanliness) and reducing pendency in government) 2.0 on 03.10.2022 at KVK-Ranga Reddy, HRF, Hayathnagar. Dr. K Sammi Reddy, Head (DRM) welcomed the KVK & HRF staff and highlighted the importance of cleaning of campus in the prevention of seasonal diseases and the importance of converting waste as useful compost. Application of Microbial

Special campaign on Swachhata

mixture, adoption of organic farming practices, use of crop residues for composting to create waste to wealth, preparation of vermicomposting beds and demonstration of vermicompost were also shown to the staff. Later staff cleaned the campus and all the decomposed agricultural waste collected was placed in vermicompost bins for making compost.

Krishi Vigyan Kendra, Ranga Reddy District, ICAR- CRIDA organized " Cleaning of offices and campus" activity under Special Campaign (Swachhata (cleanliness) and reducing pendency in government) 2.0 on 05.10.2022 at KVK-Ranga Reddy, HRF, Hayathnagar. All the staff of KVK-Ranga Reddy cleaned their office rooms and arranged all the files in proper order. During programme, a rally was conducted with school children of the upper primary class. Awareness on effective utilization of agricultural byproducts, the importance of microbial consortia in agricultural activities, and available agricultural waste to make compost, so that application of compost will enhance soil fertility and result in higher production/ income.

Review of swachhata special campaign 2.0 activities

Sri V. Srinivas, IAS, Secretary, DARPG and DPPW, Govt of India reviewed the progress of Swachhata Special Campaign 2.0 activities at KVK, Ranga Reddy District which is under administrative control of ICAR-CRIDA, Hyderabad on 8th October 2022.

Interstate exposure visit and training of farmers on dryland agriculture technologies at KVK and Hayathnagar Research Farm, CRIDA

An Interstate Exposure Visit and training of Farmers on Dryland Agriculture technologies was organized at KVK & Hayathnagar Research Farm, CRIDA and coordinated by TOT Section on December 1, 2022. Nearly 20 farmers from Cuddalore district, Tamil Nadu participated the in the programme. Dr.K.Nagasree , Principal Scientist welcomed the farmers and gave introductory remarks. Dr.DBV.Ramana, Head KVK gave orientation towards dryland technologies of KVK. Dr.D.Sudheer, a livestock expert explained about 21 species of fodder cultivation and prospects of fodder use for enhanced milk productivity. Dr.G.Srikrshna, Horticulture expert, KVK explained the production

Farmers exposure visit and training programme at KVK

technology of Chrysanthemum crop. Er.S.Vijaya Kumar, Farm machinery engineer explained farm ponds usage, Water harvesting structures, and micro irrigation practical demonstration to farmers. Drs.K.Nagasree, K.RaviShankar, Anshida Beevi, and Jagriti Rohit facilitated field visit.

Training on natural farming at KVK- Ranga Reddy, ICAR-CRIDA

KVK- Ranga Reddy, ICAR-CRIDA conducted two days training programme on "Natural farming" under the project Out scaling of Natural Farming through Krishi Vigyan Kendras, 2022-23 from 14-15 November, 2022. Dr. DBV Ramana, OIC, KVK explained about the origin of Natural farming and its role in present human life and that it is important for every individual needs to follow nature for future sustainability. Sri Manohara Chari, a practising Natural farmer from Padmaram village shared the experiences with farmers and highlighted the importance of Dashaparni Kashaya, Panchagavya,, Jeevamruth, Agniastra, Bramhastra in natural farming. Mr. G. Sri Krishna, SMS (Horticulture) educated farmers on integrated pest and disease management and concepts of organic farming in vegetable crops with special reference to low cost and high net returns. Important measures to be taken to combat the present crisis in high cost of cultivation Viz., use of organic manures, use of bio-fertilizers, sticky and pheromone traps, boarder, trap crops, inter crops, mixed crops, neem oil, neem cakes, green manuring, green leaf manuring, foliar sprays of organic micro nutrients and market linkages. Er. S. Vijaya Kumar, SMS (Agril Eng.) briefed about the possibility of mechanization and Soil, and water conservation measures in natural farming. Dr.D.Sudheer, SMS (Vety.Sci.) explained about fodder production and animal health management in natural Farming. Farmers visited KVK demonstrations viz. Demonstration of chrysanthemum varieties, solar-based micro irrigation systems, and newly initiated natural farming block along with KVK team. Second day field visit was organized at Padmaram village, Choudarigudem mandal and demonstrated the preparation methods of Panchagavya,, Jeevamruth, Agniastra, Bramhastra, Dashaparni Kashaya, etc, participants learnt practically and interacted with farmers. Mr.P. Ramakrishna, Technical Officer, Sri. Narayana, Sri.Vishnuvardan Reddy (Practicing natural farmers) and 42 farmers participated in this programme.

Farmers training programme on Natural Farming

Exposure visit cum training on dryland agriculture production technologies for input dealers

Krishi Vigyan Kendra Ranga Reddy, ICAR- CRIDA organized one day exposure visit cum training on Dryland production technologies in Agriculture, Horticulture and livestock components on 11th August, 2022 for Diploma in Agricultural Extension Services for Input Dealers (DAESI) trainees from Medchal Malkajigiri District. About 40 input dealers attended the programme.

Diagnostic field visits and monitoring of demonstrations in KVK villages

KVK Team along with Officers from Department of Horticulture and Agriculture, Govt. of Telangana participated in the diagnostic field visits and monitoring of demonstrations in KVK adopted villages in Amangal, Kadthal, Yacharam, Ibrahimpatnan mandals of Rangareddy district during 21-22nd July, 2022. The main crops which are adversely affected due to incessant rains are tomato, bhendi, and guava. Suggested amelioration measures to the farmers. Blossom end rot observed in Tomato. Early sown tomato crop (which has completed 4-5 harvests) damaged through the incidence of early blight and fruit rot. Sucking pests like Jassids, and mites were observed in Bhendi crop. Tea mosquito bug damage is observed in Guava along with nematode infestation.

Interventions related to on-farm trials on improved varieties in chilly (Arka Kyathi, Arka Swetha), french bean (Arka Sharath, Arka Arjun) and front-line demonstrations on field bean (TFB-2) and Integrated crop management in tomato have been taken up in KVK adopted villages and all these fields were visited & necessary suggestions were given to the farmers in light of incessant rains. Guava rejuvenation was demonstrated in the farmer's field and fertilizer recommendation, irrigation schedule was also given along with integrated pest and disease management. Farmers were encouraged to adopt organic farming in vegetable crops for sustainable income using dhasapatra kashayam.

Diagnostic field visits by KVK team

Fish seed release in KVK farm ponds

Fish seed (fingerlings) Catla (*Catla catla*), Rohu (*Labeo rohita*), *Mrigal* (*Cirrhinus mrigala*) and yearlings of Murrel (*Channa striata*) were procured from hatcheries located at Warangal. For transportation from Warnagal to Hyderabad, fish seed in water was packed in polyethylene covers and filled totally with saturated Oxygen. Murrel has been released in a lined KVK farm pond at solar based micro-irrigation system and whereas other common corps (Catla, Rohu and Mrigal) were released in an unlined farm pond at IFS model unit in Hayathnagar Research Farm, ICAR-CRIDA on 28.07.2022.

Health camp for the staff and contractual service employees of the Hayathnagar Research Farm

ICAR-Central Research Institute for Dryland Agriculture organized Health camp for the staff and contractual service employees of the Hayathnagar Research Farm (HRF) on 18.08.2022 with the help of Maxvision Eye Hospitals and Clove Dental Hospitals, Vanastalipuram, Hyderabad. Dr. Vinod Kumar Singh, Director, ICAR-CRIDA inaugurated the health camp and explained about the importance of good health for a peaceful happy life. In this health camp, eye and oral cavity testing for any problems including the descaling of teeth along with blood sugar and blood pressure testing was done. Dr. I. Sreenivas, Dr.DBV Ramana other Farm and KVK staff participated in the inauguration along with Mr. Balaji, Manager, Maxvision, Dr. Swathy, Clove dental and their staff. About 80 contractual service employees, 15 permanent staff of CRIDA and also 10 security personal utilized the services.

Field visit and monitoring of cluster Front Line Demonstrations Pulses (Redgram) in KVK villages

Field visits on CFLD on pulses were organised by KVK RangaReddy CRIDA on 30-11-2022. Dr. D.B.V. Ramana, O.I.C., KVK & Nodal Officer (CFLD) along with KVK Team Dr. D Sudheer, Sri G. Sri Krishna, Shri. P. Ramakrishna, Technical Officer, visited Demo plots and explained about input usage in Production technology.

Exposure visit of international trainees to ICAR CRIDA KVK adopted NICRA village

International Training Program on "Climate Resilient Agriculture for Extension Professionals–Indian Experience" sponsored by the Ministry of External Affairs, GoI under Indian Technical and Economic Cooperation (ITEC), scheduled from 01 - 14th November 2022 at MANAGE, Hyderabad. The training was coordinated by Er S Vijaya Kumar (SMS-Agriculture Engineering), Sri G Srikrishna (SMS-Horticulture) and Dr D Sudheere (SMS-Live Stock), 20 international delegates were attended from various countries like Tanzania, Sudan, Kenya, Ethiopia, Georgia, Tajikistan, Madagascar, Mozambique and Malaysia participated in the programme, the delegates visited CRIDA NICRA project developed Farm Mechanization Custom Hiring Centre (CHC)

International Training programme in KVK

Awareness training cum demonstration on rice transplanter

ICAR-CRIDA, KVK-Ranga Reddy demonstrated the rice transplanter in Chintalapalli village, Amanagal Mandal, Rangareddy District on 04 August 2022. Rice transplanter was demonstrated in progressive farmer Sri. Laxma Reddy's field in the village.

Rice Transplanter demonstration

Training and Capacity Building

6

6.1. Participation in trainings

Name	Title	Duration	Venue
Pushpanjali	Training Programme on "Analysis of Experimental Data"	January 17-22, 2022.	ICAR-NAARM, Hyderabad
Josily Samuel, Pushpanjali Jagriti Rohit	Online International Workshop on "Advance Statistical Data Analysis using SPSS"	January 21-27, 2022	Science Tech Institute, Lucknow, UP
Josily, Samuel, Jagriti Rohit,	21 days winter school "Advances in Social Science Research and Evaluation"	January 25 - February 14, 2022.	NAARM, Hyderabad
K.Nagasree	Online Training Program on "Competency Enhancement programme for Effective Implementation of Training Functions by HRD Nodal Officers of ICAR"	February 21-23, 2022.	Online
Anshida Beevi CN	21 days online training program under SC-SP scheme on "Analytical Techniques for Decision Making in Agriculture"	February 5-25, 2022.	ICAR-NAIP, New Delhi
Suvana S	Hyperspectral Remote Sensing	April 25-29, 2022	NRSC, Hyderabad
HB Santosh	Hands-on training program on CRISPR/Cas9 Gene Editing Technologies in Plants	October 10-14, 2022	ICRISAT, Hyderabad
Bhargavi Bussa	Farming System Design Training Workshop	November 7-12, 2022	ICRISAT, Hyderabad
HB Santosh	Training Programme on "New Crop Breeding Technologies"	November 21-December 11, 2022	ICRISAT, Hyderabad

6.2. Post graduate research (On-going)

Scientist	Student	Degree	Discipline	Institute/University
K.A. Gopinath	B. Sunitha	M.Sc.	Agronomy	PJTSAU, Hyderabad
DBV Ramana	A. Chandrakanth	MVSc	Livestock Production & Management	PVNRTSUVAFS, Rajendranagar
G. Pratibha	E. Anusha	Ph.D.	Agronomy	PJTSAU, Hyderabad
G. Pratibha	V. Soujanya	Ph.D.	Agronomy	SVAC, Tirupati
G. Pratibha	M. Niharika	M.Sc.	Agronomy	ANGRAU, Bapatla
K S Reddy	Ranjit Kumar	M. Tech	Soil and water Engineering	PJTSAU, Hyderabad
K Nagasree	K Priyanka	M.Sc.	Agricultural Extension	PJTSAU, Hyderabad
K Ravishankar	M. Sampreetha	M.Sc.	Agricultural Extension	PJTSAU, Hyderabad
Basudeb Sarkar	K. Padmalatha,	PDF (DST)	Molecular biology	DST Women Scientist Scheme-A
N. Jyothi Lakshmi	Laxmi Swetha	M. Sc.	Plant Physiology	PJTSAU, Hyderabad
N. Jyothi Lakshmi	N. Pavithra,	Ph.D.	Plant Physiology	ANGRAU, Bapatla
M. Manjunath	B. Himaja,	M. Sc.	Agricultural Microbiology	PJTSAU, Hyderabad
M. Vanaja	P. Sathish-	Ph.D.	Genetics	OU, Hyderabad
M. Vanaja	P. Shobharani-	Ph.D.	Genetics	OU, Hyderabad
Srinivasa Rao M	D.V. Sravan Kumar	Ph.D.	Agril. Entomology	ANGRAU, Bapatla
Salini	T.Priyanka	M.Sc.	Plant Breeding	PJTSAU, Hyderabad
B.Sanjeeva Reddy	Sravan Kumar Chintha	Ph.D.	Farm Machinery and Power Engineering	UAS-R, Raichur

6.3. Human resource development (HRD)

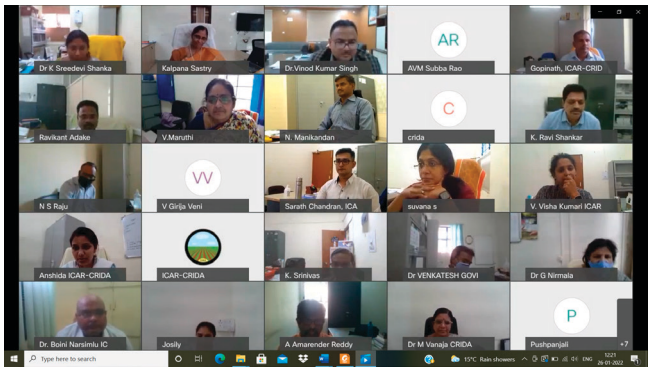
Category	Attended trainings (No.)
Scientists	15
Technical staff	5
Administrative & Finance staff	2
Total	22

Women in Agriculture

7

7.1 National Girl Child Day

ICAR-CRIDA celebrated National Girl Child Day on January 24, 2022 to create awareness about the rights of the girl child, the importance of girl's education and the health of girl child. On this occasion, an online lecture was organized for the staff of ICAR-CRIDA. The chief guest of the programme was Dr. R. Kalpana Sastry, Former Joint Director, ICAR-NAARM & Managing Director, AgHub Foundation, Centre for Innovation and Agri-Entrepreneurship, PJTSAU, Hyderabad. Dr V.K Singh, Director, in his opening remarks explained about the relevance of celebrating National Girl Child Day. Later, the chief guest, Dr. R. Kalpana Sastry delivered a talk on "National Girl Child Day - Its significance for National Agricultural Research System (NARS)". She specifically pointed out how do we as part of the national agricultural system plan to value this concept and mainstream it into our institutional working strategies.



Celebration of National Girl Child Day at ICAR-CRIDA

7.2 International Women's Day

ICAR-CRIDA, Hyderabad celebrated International Women's Day on March 8, 2022. Ms. K. Nirmala, IAS, Secretary, Public Enterprises, Govt. of Telangana was the chief guest of the programme. Dr. V. K Singh, Director, ICAR-CRIDA welcomed all and highlighted the role of women in agriculture and allied sector. He also appreciated the efforts of women scientists and women staff of CRIDA. Ms. K. Nirmala, IAS in her presidential address talked about gender equality and women empowerment. She gave examples of women's contribution from different spheres of life. She also

Celebration of International Women's Day at ICAR-CRIDA

emphasized that women efforts should be appreciated as it will motivate them to work even better. She urged that training should be provided to women in value addition.

7.3 A training-cum-demonstration on "Processing and Value Addition of Millets for Farm Women"

ICAR-CRIDA organized a series of events as a part of Campaign on Annadata Devo Bhava under Azadi Ka Amruth Mahotsav on April 23, 2022. On this occasion, a training-cum-demonstration was organized on the theme Processing and Value Addition of Millets for Farm Women at Hayathnagar Research Farm of ICAR-CRIDA. Around 35 farm women participated in the campaign. Initially, Dr. K. Sreedevi Shankar, interacted with the farm women on the importance of millets in food and nutritional security and explained about value-added products. Later, demonstration was carried on the preparation of millet-based products

Participants of the training programme

Farm women participating in Hands-on experience with millets preparations

followed by the participant themselves prepared the same.

7.4 Training cum distribution of Rajasri variety backyard poultry chicks

Krishi Vignan Kendra, Ranga Reddy District, ICAR-CRIDA, Hyderabad organized training on backyard poultry in KVK adopted villages (Konapur and Shettipalli) of Amangal Mandal, Ranga Reddy district on September 15, 2022. Later, Rajasri variety chicks were distributed to 140 identified SC beneficiaries under SC subplan. Sri. Yadaiah Sapranch, Konapur and Sri.Venkataiah Deputy sarpanch of Shettipally of Amangal division also participated in the programme and urged the women farmers for careful management of the chicks. Dr. D Sudheer, SMS (Veterinary Science) explained the importance of the Backyard poultry farming for nutritional security and empowerment of rural women.

Training cum distribution of Rajasri variety backyard poultry chicks in KVK adopted villages

7.5 National Campaign on Poshan Abhiyan and Tree Plantation

Krishi Vignan Kendra, Ranga Reddy District, ICAR-CRIDA organized "National Campaign on Poshan Abhiyan and Tree Plantation" on September 17, 2022 at KVK farm. Dr. DBV Ramana, OIC, KVK welcomed the farmers and farm women and highlighted importance of nutrition in human health, nutri-cereals and their role in substitution of vitamins, minerals including iron, magnesium, Calcium and Potassium. On this occasion, Honourable Union Agriculture Minister Sh. N S Tomar Ji message on Poshan Abhiyan was telecasted to participants. Sh. G. Sri Krishna, SMS (Horticulture) explained about Bio-fortified varieties

Honourable Union Agriculture Minister Sh. N S Tomar Ji message on Poshan Abhiyan

Distribution of saplings to farmers and farm women

Participants of the training programme

released in India in different crops like Rice, Maize, Pearl millet, wheat, Lentil, mustard, sweet potato, cauliflower, pomegranate, etc and nutrition status of fortified varieties. Smt.A.Vidhaadhari shared the experience of health and nutrition with farm women. Saplings of medicinal plants, Drumstick seedlings, Mango, Guava grafts, Dragon fruit plants and also 100 vegetable seed kits supplied by IFFCO were distributed to the farmers and farm women.

Awards and Recognition

8

8.1. Awards/Recognition from Professional Societies and other organizations

The Rajrishi Rajbhasha Tandan award was awarded to ICAR - CRIDA in recognition of its best performance in implementation of the Official Language Policy of the Government of India in the ICAR Institutes situated in Region 'C' on 16th July, 2022. Dr. Vinod Kumar Singh, Director, CRIDA received the Shield as a First Prize and Dr. Sant Ram Yadav, Assistant Director (OL) received the Certificates.

Dr. J.V.N.S. Prasad, Principal Scientist, ICAR-CRIDA and along with Dr. V.K. Singh, Director, ICAR-CRIDA, Dr. U.N. Tank, Dr. R.K.S. Tomar, Dr. Lakhan Singh and Dr. S.R.K. Singh were conferred the Vasantrao Naik Award for Research and Application in Dryland Farming Systems for 2021.

Dr. A.G.K. Reddy received best popular article award on the article titled 'Mealy bug infestation and management in custard apple in dryland areas' on the occasion of ICAR-CRIDA 38th foundation day 2022.

Dr. G. Pratibha received best poster award for *In-situ* moisture conservation and nutrient management strategies on yield of cotton in rainfed Semi- Arid regions. E. Anusha, Dr. G. Pratibha, M. Madhavi, K. Srinivas, B. M. K. Raju, I. Srinivas and K.V. Rao. National seminar on Harnessing the Potential of Panchabhutas (Tatvas) for Sustainable Climate Resilient Rainfed Agriculture.

Dr. Jagriti R received best oral presentation award for presentation on Perceived attributes leading to the adoption of agromet advisories by dryland farmers in India in International Conference on Reimagining Rainfed Agro-ecosystem: Challenges and Opportunities at ICAR-CRIDA, Hyderabad during 22-24 December, 2022

Dr. Kundu S received the best oral presentation award for presenting a research paper "Effect of conservation agriculture and balanced nutrition on system productivity, profitability and mitigating GHGs emission in maize-horsegram sequence in rainfed Alfisols. International Conference- ICRA 2022. Reimagining Rainfed Agroecosystems: Challenges and Opportunities, 22-24 December 2022.

Dr. Kundu S received the best oral presentation award for presenting a research paper "Increasing Cropping Intensity through Conservation Agriculture in Rainfed Pearlmillet based Cropping System in Alfisols of Semi-arid Southern India. National Conference on Agro-Ecology based Agri-Food Transformation Systems, 27-28 January, 2023.

Dr. M. Manjunath, received best oral presentation for presentation on 'Soil moisture stress alters the abundance of maize root associated bacteria" in the International Conference- ICRA 2022. Reimagining Rainfed Agroecosystems: Challenges and Opportunities, 22-24 December 2022.

Dr. M. Srinivasa Rao, awarded Fellow of Telangana Academy of Sciences (TAS), April 2022

Dr. Pushpanjali received the best oral presentation in National Seminar on "Managing Soils in a Changing Climate" held at ICAR-NBSS&LUP Campus, Nagpur during March 24-26, 2022 on "A systematic approach to study soil preferential flow in semi-arid India".

Dr. Santhosh H B received the *Best Oral Presentation Award* for presentation on 'Samrat Bt – a new, early maturing Bt cotton variety for stress resilience and multiple cropping in rainfed agro-ecologies of south India' in International Conference on Reimagining Rainfed Agro-ecosystems: Challenges & Opportunities held at ICAR-CRIDA, Hyderabad during 22-24, December, 2022.

Dr. Sarath Chandran, M.A received the best oral presentation award for presentation on ' Sorghum yield response to future climate in a semi-arid environment' during international conference on 'Reimagining rainfed agro-ecosystems: challenges & opportunities (ICRA-2022) organized by ISDA and ICAR-CRIDA during 22-24 December 2022

Dr. V. Visha Kamari, received best oral presentation award for the research paper "Livelihood sustainability of rainfed farmers: Impact of various fodder based cropping system in rainfed regions of Telangana "at International conference on "Reimaging rainfed agro-ecosystem: Challenges and opportunities at ICAR-CRIDA, Hyderabad from 22nd to 24th December 2022.

Dr. V. Visha Kamari, received ISDA Best Ph.D. thesis award, 2021-22 for the research "Effect of Foliar Spray of Fe, Zn and B in Mitigating Terminal Heat and Moisture Stress in Lentil (*Lens culinaris* Medik.)", during the ICRA-2022 held at ICAR-Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad, India, from 22-24 December 2022.

Dr.V. Visha Kumari, received the best research paper award for the paper titled "The response of Lentil (*Lens culinaris* Medik) to soil moisture and heat stress under different dates of sowing and foliar application of micronutrients during 38th ICAR-CRIDA foundation day on 12th April 2022.

Mr. Dhimate Ashish received the best poster award on 'Energy efficient harvesting of safflower with brush cutter : An alternative approach for timely harvesting' in the National Seminar on Harnessing the potential of Panchabhutas for sustainable climate resilient rainfed agriculture 28-29 Sept 2022 at ICAR-CRIDA, Hyderabad.

8.2 Chief Editor/ Editor of NAAS rated Journals.

Dr. A.K. Shanker is the Academic Editor in *Plos One*, *Frontiers in Plant Sciences and Scientific Reports.*

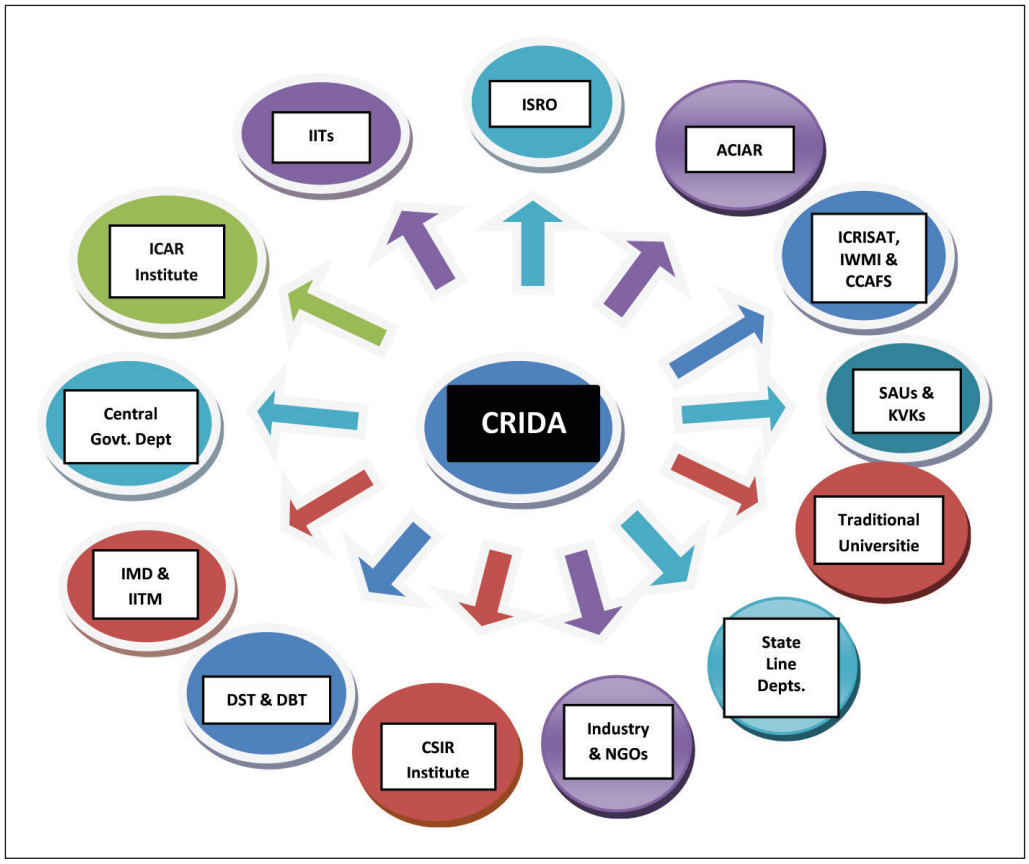
Dr. Rejani is the editor of *Indian Journal of Soil Conservation, (IASWC), Dehradun (2022)*

Dr. Rejani is the editor of *Indian Journal of Dryland Agricultural Research and Development, (IJARD), (2022)*

Linkage and Collaborations

9

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



Linkages and Co- operations of ICAR- CRIDA

Publications 10

10.1. Research papers

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Ongoing Projects- 2022

11

S. No.	Institute code no	Title of the Project	Investigators	Year of Start-Close
Division of Resource Management				
Institute Projects				
1	RM/AF/58	Evaluation of multipurpose tree species based agroforestry systems	**G. Venkatesh**, G. Ravindra Chary, K.A. Gopinath, J.V.N.S. Prasad, K. Sammi Reddy, I. Srinivas, K.V. Rao, Basudeb Sarkar, Arun Kumar Shanker, D.B.V. Ramana, B.M.K. Raju & K. B. Sridhar	2019-25
2	RM/AF/59	Evaluation of bamboo species suitable for Southern Telangana region	**G. Venkatesh**, K. Sammi Reddy, K.A. Gopinath & V.K. Singh	2021-23
3	RM/FM/39	Development and performance evaluation of self-propelled reaper for harvesting of short and bushy crops.	**Dhimate Ashish** Satish, I. Srinivas, R. V. Adake, B. Sanjeeva Reddy & G. Pratibha	2018-21
4	RM/FM/49	Development of solar powered mechanization package for small farm holders in rainfed system	**R. V. Adake**, I. Srinivas, B. Sanjeeva Reddy, Dhimate Ashish Satish, Manoranjan Kumar, K. Sammi Reddy, G. Pratibha, A. Amarender Reddy, V. Maruthi & A.G.K. Reddy	2019-24
5	RM/FM/50	Development and performance evaluation of Intra Row Weeder cum Basin Lister for tree based dryland horticultural crops	**B. Sanjeeva Reddy**, K.A. Gopinath, Dhimate Ashish Satish & A.G.K. Reddy	2019-22
6	RM/RM/54	Potential role of *in situ* moisture conservation and nutrient management strategies for sustainable production and resource use efficiency in rainfed areas	**G. Pratibha**, K. Srinivas, K.V. Rao, I.Srinivas, B.M.K. Raju, M.Srinivas Rao & Arun.K. Shanker	2021-24
7	RM/RM/52	Design and development of sub-surface water harvesting and recycling system for augmentation of farm pond in dryland agriculture	**Manoranjan Kumar**, K.V. Rao, R.V. Adake, B. Narsimlu & A K Indoria	2019-24
8	RM/RM/54	Effect of Ca-bentonite on soil moisture dynamics and availability of nutrients in semi-arid rainfed Alfisols	**A.K. Indoria**, K. Sammi Reddy, K. Srinivas, S. Kundu, M. Manjunath & V. K. Singh	2021-25
9	RM/RM/38	Assessment of soil quality and development of indices for predominant rainfed areas of Karnataka falling in AESR-6.2 under different crops and cropping systems	**A.K. Indoria**, K. Srinivas, K.L. Sharma, K. Sammi Reddy & Pushpanjali	2018-21

S. No.	Institute code no	Title of the Project	Investigators	Year of Start-Close
10	RM/NM/35	Estimating the carbon sequestration potential of semiarid soils using carbon saturation concept	**K. Srinivas** , A.K. Indoria & S.S. Balloli	2018-23
11	RM/SS/53	Characterizing preferential flow in soils of semiarid Telangana	**Pushpanjali, G**. Ravindra Chary, K. Sammi Reddy, K.L. Sharma, K.S. Reddy, Manoranjan Kumar, Dhimate Ashish Satish & N. Ravi Kumar	2019-23
12	NRMACRIDASIL 202200500005	Evaluation of natural farming practices to sustain soil health and crop productivity in rainfed areas	**Pushpanjali**, K. Sammi Reddy, S. Kundu, M. Manjunath, P.K. Pankaj, K.S. Reddy, Josily Samuel, A.G. Reddy & V.K. Singh	2022-26
13	RM/RM/53	Soil water dynamics in raised bed with modified furrow system and supplemental irrigation in Alfisols	**R. Rejani**, KV Rao, I. Srinivas, G.Pratibha, A.K.Indoria, K Srinivasa Reddy, K. Srinivas, Ashish Dhimate & K Sammi Reddy	2021-25
14	RM/SS/54	Enhancing the bio-availability of rock phosphate P through the application of natural zeolite	**V. GirijaVeni**, K. Sammi Reddy, K. Srinivas & Manjunath	2021-24
15	NRMACRIDASIL 202200100001	Effect of *in-situ* soil moisture conservation and INM with nanonitrogen application on nitrogen transformations and yield of maize in a rainfed alfisol	**Suvana S.,** K. Sammi Reddy, G. Pratibha, K.V. Rao, K.A. Gopinath, M. Manjunath, Jyothilakshmi, A.K. Shankar, Visha Kumari, Ashish Dhimate, V. Girijia Veni & V.K. Singh	2022-25
Division of Crop Sciences (DCS)				
16	CS/EN/42	Predicting climate change impact on insect pests of dryland crops using phenology modelling	**T. V. Prasad**, M. Srinivasa Rao, S.K. Bal & K.V. Rao	2018-23
17	CS/Horti. /44	Collection and evaluation of tamarind *(Tamarindus indicaL.)* germplasm from rainfed areas of Deccan and Bastar Plateau.	**A.G.K. Reddy**, M. Osman, S.K. Yadav, N. Jyothi Lakshmi, S.K. Bal, T.V. Prasad, Pushpanjali, K. Salini & K. Sreedevi Shankar	2018-23
18	CS/FN/02	Nutritional profiling of major rainfed crops from diverse agro ecologies	K. Sreedevi Shankar, G Ravindra Chary, S K Yadav & V GirijaVeni	2021-24
19	CS/MB/4 4	Rhizo-microbiome of rainfed crops under semi-arid region of India	**M. Manjunath**, S. K. Yadav, N. Jyotilakshmi, Arun Kumar Shanker, G. Pratibha, K A Gopinath & A.K. Indoria	2021-24
20	CS/CP/42	Genetic enhancement for nutritionally rich high yielding horse gram varieties suitable for rainfed conditions	**K. Salini**, Basudeb Sarkar, S.K. Yadav, M. Vanaja, V. Maruthi, N. Jyothilakshmi & K. Sreedevi Shankar	2021-24

S. No.	Institute code no	Title of the Project	Investigators	Year of Start-Close
21	CS/EN/43	Evaluation of low-cost approaches for management of FAW, Spodoptera frugiperda in maize	**M. Srinivasa Rao**, TV Prasad, K Srinivas & G Pratibha	2021-23
22	CS/CP/43	Genetic enhancement for abiotic stress tolerance in maize	**Basudeb Sarkar**, M. Vanaja, K Salini, SK Yadav, N. Jyothi Lakshmi & Arun Shanker	2021-23
23	CS/CP/44	Mitigation of water Stress in pearl millet *(Pennisetum glaucum)* by Zn nano particle action on photosystem II, electron transport and pigment complex	**A. K. Shanker** , M. Jyothilakshmi, V. Visha Kumari, S. Suvana & M. Manjunath	2021-23
24	CS/CP/41	Assessing the potential of mechanized strip intercropping systems for crop intensification as a climate adaptive strategy in rainfed agriculture	**V. Maruthi**, K. S. Reddy, I. Srinivas, K. Srinivas, P. K. Pankaj, Ashish Dhimate & M.Vanaja	2021-24
25	CS/EN/44	Bioclimatic thresholds and thermal constants for aphid, *Melanaphis sacchari* (Homoptera: Aphidida) on *Sorghum bicolor*	**M. Prabhakar** & N. Ravi Kumar	2021-23
26	CS/CP/45	Individual and interactive effects of moisture deficit and elevated temperature on physiological efficiency of C3 and C4 rainfed crops	**M. Vanaja**, S.K. Yadav, B. Sarkar , N. Jyothi Lakshmi, Arun Shanker, V. Maruthi & K. Srinivas	2021-23
27	NRMACRI DASIL202 200200002	Development of climate resilient double cropping system for resource conservation and sustainability in rainfed alfisols	**V. Visha Kumari**, S. Suvana, Manoranjan Kumar, Sarath Chandran, A.K. Shankar, B.M.K. Raju, K.A. Gopinath & V.K. Singh	2022-26
Section of Design and Analysis (SDA)				
28	D&A/CA /46	Harnessing statistical tools for informed decision making towards sustainable rainfed agriculture	B.M.K. Raju, C.A. Rama Rao & G. Ravindra Chary	2021-25
29	D&A/AE/ 56	Using the economic surplus method to assess economy wide impacts of CRIDA technologies/policies	A. Amarender Reddy, I. Srinivas, Basudeb Sarkar, K.V. Rao & Boini Narsimlu	2021-24
30	D&A/AE/ 57	Economic impact of livestock as means of livelihood security to resource poor dryland farmers	Josily Samuel, C A Rama Rao, B M K Raju, P K Pankaj, Pushpanjali & Jagriti Rohit	2021-24
Section of Transfer of Technology (ToT)				
31	TOT/AE/ 50	Development of strategic framework for upscaling of proven technologies in rainfed areas	K. Nagasree, JVNS Prasad, Jagriti Rohit & Anshida Beevi	2021-23
32	TOT/AE/ 51	Assessment of adoption potential and constraints for popularizing/upscaling raised bed planter (RBP) and broad bed & furrow planter (BBF) in unreached Areas	K. Ravi Shankar, I. Srinivas, G. Nirmala, K. Nagasree, B.M.K. Raju, Ashish Dhimate, Jagriti Rohit & C.N. Anshida Beevi	2021-24

S. No.	Institute code no	Title of the Project	Investigators	Year of Start-Close
33	TOT/AE/ 52	Multi-dimensional study on wellbeing outcomes in relation to agricultural interventions: evidences from Semi Arid regions of India	Jagriti Rohit, K. Nagasree, K. Ravi Shankar, AnshidaBeevi C.N, Josily Samuel & B.M.K Raju	2021-24
34	TOT/LM/ 57	Dry fortified Total Mixed Ration (TMR) for indigenous sheep	P. K. Pankaj, D.B.V. Ramana, V. Maruthi, Sreedevi Shankar, G. Nirmala & R. Nagarjuna Kumar	2021-24
35	TOT/AE/ 53	Livelihood diversification strategies in rainfed areas of Telangana State	G. Nirmala, P. K. Pankaj, K. Ravi Shanker & A. Amarender Reddy	2021-24
36	NRMACRI DASIL202 200300003	Bridging the digital divide for dfficient ICTled extension in rainfed areas	Anshida Beevi, G. Nirmala, K. Nagasree, K. Ravi Shankar, B.M.K. Raju & R. Nagarjuna Kumar	2022-25
All India Coordinated Research Project on Dryland Agriculture (AICRPDA)				
37	PC(D)/06	Water resources development and livelihood improvements of farmers in rainfed areasan on-farm research	Boini Narsimlu, G. Ravindra Chary, K.S. Reddy, A.G.K. Reddy, S.S. Balloli, K.B Sridhar, P.K. Pankaj, T.V. Prasad & M. Osman	2021-23
38	PC(D)/07	Quantification and valuation of ecosystem services from agroforestry systemsin rainfed agroecological regions	K. B. Sridhar, G. Ravindra Chary, C.A. Rama Rao, G. Venkatesh, K.A Gopinath, B. Narsimlu, M.S. Shirahatti, Mudlagiriappa & M R Umesh	2020-22
39	NRMACRI DASIL202 200400004	Adaptation and mitigation potential of millet based organic production systems in rainfed Alfisols	K.A. Gopinath	2022-27
All India Coordinated Research Project on Agrometeorology (AICRPAM)				
40	Inter organizatio nal AICRPAM (ICAR) & IMD (MoES)	Developing a criteriabased decision support system and standalone software for supporting the crop-specific district wise Agromet Advisory Services in India	**Santanu Kumar Bal**, A.V.M. Subba Rao M.A. , Sarath Chandran & N. Manikandan S. D. Attri, Priyanka Singh & V.M. Sandeep	2021-26
PME Cell				
41	RM/SS/55	Evaluation of universal soil extractants for rapid soil testing	**S.S. Balloli**, K. Sammi Reddy, K. Srinivas & B.M.K. Raju	2021-23

LIST OF EXTERNALLY FUNDED PROJECTS

S. No.	Institute code no	Title of the Project	Investigators	Year of Start-Close
1	EF068	Effect of Polyhalite application on maize yield, nutrient use efficiency and GHGs emission under rainfed condition	**Sumanta Kundu**, K. A. Gopinath, G. Pratibha, JVNS Prasad, A.K. Shanker, A.K. Indoria, K. Sammi Reddy & V.K. Singh	2021-2023
2	EF060 (DAC)	Updation of District Agriculture Contingency Plans	**K.V. Rao**, J.V.N.S. Prasad, G. Ravindra Chary, P. Vijay Kumar, D.B.V. Ramana, M. Osman, S.S. Balloli, K.A. Gopinath, A.V.M. Subba Rao, Josily Samuel, I. Srinivas, B.M.K. Raju, N. Ravi Kumar, P.K. Pankaj & B. Sarkar	2016-22
3	EF061 (IWMI)	Drought Monitoring, Planning and Management: Improving food security and resilience of the drought affected states in India	**K.V. Rao**, J.V.N.S. Prasad, G. Pratibha, A.V.M. Subba Rao, S.S. Balloli, K. Srinivas & K. Sammi Reddy	2016-22
4	EF	Sealing out climate – smart agriculture for resilient farming in India	**K.V Rao**	2021-25
5	EF	Resource management strategies for agricultural systems sustainability in Odisha	**K.V. Rao**	2022-25
6	EF046 (CROPSAP Govt. of Maharashtra)	Crop Pest Surveillance and Advisory project (CROPSAP) in Maharashtra.	**M. Prabhakar**, A.V.M Subba Rao & N. Ravi Kumar	2022-23
7	CS/EF/070	Comparative assessment of Aldor (30-00-05+7S) as an alternative to Urea on yield and nutrient use efficiency of rainfed maize in Telangana, Andhra Pradesh and Karnataka	**V. Visha Kumari**, K.A. Gopinath, V.K. Singh, G. Ravindra Chary, S. Suvana & A.K. Shankar	2022-26
8	EP063	KRISHI – Knowledge based Resources Information Systems Hub for Innovations in Agriculture	**N.S Raju**	
9	EF065 (NABARD)	Agrarian distress and PMFBY: An analysis of rainfed agriculture	**A. Amarender Reddy**	2022-23
10	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. Narsimlu, B. Sanjeeva Reddy, P. K. Pankaj, K. Ravi Shankar, A. Gopal Krishna Reddy, AnshidaBeevi C. N.& Jagriti Rohit	2016-2025
11	EF060	Behavioural surveillance of farmers in the wake of COVID 19: A Psychosocial Study	**Jagriti Rohit**, G. Nirmala & K. Nagasree	2021

S. No.	Institute code no	Title of the Project	Investigators	Year of Start-Close
12	EF066	Effect of Polyhalite on yield and quality of rainfed groundnut and on soil properties in Telangana and Andhra Pradesh	**K.A. Gopinath**, V.K. Singh, V. Visha Kumari & S. Suvana	2021-23
13	EF067	Effect of foliar application of different Nano fertilizers on nutrient use efficiency, drought stress tolerance, productivity and economics of rainfed crops	**K. A. Gopinath**, K. Sammi Reddy, V.K. Singh, G. Ravindra Chary, A.K. Shanker, S. Kundu & V. VishaKumari	2021-23
14	EF065	Innovative & contextual Agromet advisor services for climatic smart agriculture.	**A.V.M. Subba Rao**, S.K. Bal, Anthony Whitbread & R. K. Mishra	2018-22
15	EF	Consortium for Scaling-up Climate Smart Agriculture in South Asia (C-SUCSeS)	**J.V.N.S Prasad**	2022-24
16	Consultancy/01	Preparation of Third Biennial Update Report: Mitigation actions and other information related to agriculture sector	**J.V.N.S. Prasad**, K.V. Rao, D.B.V. Ramana, C.A. Rama Rao, B.M.K. Raju, G. Venkatesh, V. Girija Veni, Sumanta Kundu & B.Ramakrishna	2016-2022
17	Consultancy/02	Soil and moisture conservation plan of mining area of JSW steels in Narayan and Dharma Ore Mines in Ballary and Bhomman Ore Mine in Chitradurga districts of Karnataka	**Manoranjan** Kumar, M. Osman, K.B. Sridhar & V.K. Singh	2021-2022
18	Consultancy/03	Agro-ecology based feasibility of agricultural production systems and associated vulnabarities	**K.V. Rao**, C.A. Rama Rao, B.M.K. Raju, S.K. Bal, A.V.M. Subba Rao, G. Ravindra Chary & N. Ravi Kumar	2021 – 2023

List of NICRA-Projects

Theme 1: Impact of elevated carbon dioxide and temperature on crops, pests, diseases, weeds, soil, microbes and livestock in rainfed ecosystem (PI: S.K. Yadav)

S. No.	Institute code no	Title of the Project	Investigators	Year of Start-Close
1	NICRA/T heme-1/1	Impact of elevated CO2 and elevated temperature on phenology, physiology, growth and yield of major rainfed crops Sub-Projects: Effect of elevated CO2 and elevated temperature on: i. Photosynthetic trait dissection in black gram ii. Soil nutrient dynamics iii. GHG emissions iv. Nutritional profiling of crops v. Quality of crop residues	M Vanaja, B Sarkar, AK Shanker, N Jyothi Lakshmi K. Sreedevi Shankar, DBV Ramana, K. Srinivas, G. Pratibha & S.K.Yadav	2021-26
2	NICRA/T heme-1/2	Impact of eCO2 and eT on Rhizomicrobiome of black gram and characterization of efficient Rhizobium strain(s) Sub-project: Rooting behaviour in Rhizobium inoculated plants in black gram	M Manjunath, V Maruthi, M Vanaja & P C Latha (IIRR)	2021-26

S. No.	Institute code no	Title of the Project	Investigators	Year of Start-Close
3	NICRA/T heme-1/3	Impact of eCO2 & eT on growth, phenology, physiology and yield of potato	AGK Reddy, M Vanaja, N Jyothi Lakshmi, TV Prasad, M S Rao & S K Yadav	2021-26
4	NICRA/T heme-1/4	Quantification of impacts of eCO2 & eT on pest dynamics of major rainfed crops	M.S. Rao, T.V. Prasad & M. Prabhakar	2021-26

Theme 2: Impact of variable rainfall and eCO2 and eT on crop, soil resources (PI: Dr. K.S. Reddy)

S. No.	Institute code no	Title of the Project	Investigators	Year of Start-Close
1	NICRA/ Theme2/1	Soil Plant Water dynamics modelling under eCO2 and eTemp and varying rainfall intensities for rainfed crops (LWME and Agromet):	KS Reddy, M Kumar, N Manikandan and B Narasimlu	2021-26
2	NICRA/Theme 2/2	Soil nutrient leaching and carbon pool study under elevated CO2 , eT and varying rainfall intensities (Soil Science:)	Pushpanjali	2021-26
3	NICRA/ Theme2/3	Physiological traits contributing to change in crop co coefficients/crop water requirements under elevated CO2 and temp and varying intensities of rainfall (Physiology)	M.Vanaja	2021-26

Theme 3: Adaptation and mitigation technologies for minimizing impact of climate change in rainfed farming systems (PI: Dr. K. Sammi Reddy)

S. No.	Institute code no	Title of the Project	Investigators	Year of Start-Close
1	NICRA/ Theme3/1	Adaptation and mitigation of climate change through effective resource management practices in rainfed agriculture	K. Sammi Reddy, M. Manjunath, A.K. Indoria, K. Srinivas, V. Girijia Veni, S. Kundu, AVM Subba Rao, M.A. Sharat Chandran & V.K. Singh	2021-26
2	NICRA/ Theme3/2	Development of sustainable intensification practices for adaptation to climate change and mitigation co-benefits	G. Pratibha, KV Rao, K. Srinivas, M. Manjunath, Arun K Shankar, M S Rao & BMK Raju	2022-26
3	NICRA/ Theme3/3	Prioritized water conservation options and design considerations under climate change scenario	K. V. Rao, R. Rejani & G. Pratibha	2022-26
4	NICRA/ Theme3/4	Quantification of Greenhouse gas emissions from rainfed systems and important developmental programmes implemented in rainfed regions of the country	JVNS Prasad & V. Girija Veni	2022-26
5	NICRA/ Theme3/5	Genetic enhancement for drought tolerance in black gram	B. Sarkar, M. Vanaja, K. Salini, N. Jyothi Lakshmi & SK Yadav	2022-26
6	NICRA/ Theme3/6	Assessment of nitrous oxide emissions from livestock urine deposited in grazed pastures during different seasons	DBV Ramana, PK Pankaj, KV Rao, G. Pratibha & BMK Raju	2022-26

Theme 4: Bio-physical and socio-economic aspects of climate resilient technologies (PI: C.A. Rama Rao)

S. No.	Institute code no	Title of the Project	Investigators	Year of Start-Close
1	NICRA/Theme 4/1	Adaptation targeting and prioritization for climate change	C A Rama Rao, B.M.K. Raju, A.V.M. Subba Rao, K.V. Rao, R. Nagarjuna Kumar, A. Amarender Reddy & K. Nagasree	2021-26
2	NICRA/Theme 4/2	Assessing impact of climate change on major rainfed crops and constructing agro-climatic analogues for adaptation	B M K Raju, C. A. Rama Rao, K.V. Rao, G. Ravindra Chary, Dr. G. Pratibha, Josily Samuel, R. Nagarjuna Kumar & A.V.M. Subba Rao	2021-26
3	NICRA/Theme 4/3	Adoption dynamics and institutional drivers for scaling out resilience enhancing technologies	K Nagasree, Jagriti Rohit, K. Ravi Shankar, C.N. Anshida Beevi, JVNS Prasad, B M K Raju & C A Rama Rao	2021-26

Theme 5: Development of IT based Tools for Climate Change Research (PI: S.K. Bal)

S. No.	Institute code no	Title of the Project	Investigators	Year of Start-Close
1	NICRA/Theme 5/1	Assessing spatiotemporal yield variability of pearl millet, pigeon pea and groundnut in India under projected climates: A simulation approach	Sarath Chandran M.A., Santanu Kumar Bal, A.V.M. Subba Rao, N. Manikandan, K.V. Rao, V. Visha Kumari & K. Srinivas	2021-26
2	NICRA/Theme 5/2	Integrated assessment of climate change on water availability & demand and development of adaptation strategies in Krishna basin	K.V. Rao, R. Rejani, A.V.M. Subba Rao, S.K. Bal , C.A. Rama Rao, B.M.K. Raju, N. Ravi Kumar, D.B.V. Ramana, J.V.N.S. Prasad, G. Ravindra Chary & Adlul Islam	2021-26
3	NICRA/Theme 5/3	Real-time Extreme Weather Event Monitoring Network	A.V.M. Subba Rao, R. Nagarjuna Kumar, N. Manikandan, Sarath Chandran M.A., J.V.N.S. Prasad, K.A. Gopinath, K.V. Rao, M. Prabhakar & S.K. Bal	2021-26
4	NICRA/Theme 5/4	Deep Learning based AI models for Plant Recognition and Stress Detection from Plant Digital Imageries	N. Ravi Kumar, N. Jyothilakshmi , K. Srinivas, V. Visha Kumari & V. K. Singh	2021-24
5	NICRA-AICRPAM	Development of Strategies for improved agromet advisories at micro-level by integrating Climate Impacts and Weather Extremes	**S.K. Bal** AVM Subba Rao Sarath Chandran M.A. N. Manikandan	2021-26

RAC and IRC Meetings

12

12.1. XXX Research Advisory Committee (RAC) meeting

The XXX Research Advisory Committee (RAC) Meeting of ICAR-CRIDA was held during 25- 27 April 2022 at ICAR-CRIDA in a hybrid mode under the Chairmanship of Dr. Gurbachan Singh, Former Chairman, ASRB. The members, Dr. M. A. Shankar, Former Director of Research, Dr. H. K. Senapati, Former Dean, and Dr. M. Maheswari, Former In-Charge Director, ICAR-CRIDA participated in the meeting in physical mode. Other members Dr. V. Geethalakshmi, Director (Crop Management), Dr. K. Vijaya Raghavan, Ex-Joint Director, Extension, Dr. S. Bhaskar, ADG (Agron. AF & CC), joined online and contributed to the proceedings.

Dr. V. K. Singh, Director, ICAR-CRIDA, Dr. M. Srinivasa Rao, Member Secretary and Project Coordinators, AICRPDA and AICRPAM, Heads of Divisions /Sections, and other invited scientists participated in the meeting. On 25th April 2022, Member Secretary presented the Action Taken Report (ATR) on the recommendations of the previous meeting (XXIX RAC), and the same was accepted by the RAC. Director, ICAR-CRIDA presented the contributions of CRIDA in dryland agriculture and explained the significant outputs of the institute. At the outset, the Chairman of RAC appreciated the contributions of ICAR-CRIDA, AICRPDA, and AICRPAM, and emphasized the focused research in view of changing climate and emerging problems

RAC team interacting with scientists

RAC team visit to NICRA research complex and farm machinery workshop at Hayathnagar Research farm

in dryland agriculture. In the fore noon of 26th April 2022, RAC members along with the Director, Project Coordinators, Heads, and scientists of CRIDA visited field experiments, Climate Change Research Complex, KVK, and the Farm Mechanization workshop at Hayathnagar Research Farm. In the afternoon session, the salient achievements of Divisions, Sections, AICRPDA, AICRPAM, and NICRA were presented by respective heads and PI and Co-PI of National Innovations in Climate Resilient Agriculture (NICRA). On 27th April 2022, the entire team of RAC visited the Agri-horticultural block, farm ponds, fodder systems, conservation agriculture block, etc of Gunegal Research farm and interacted with the scientists. In the afternoon, an open house interactive session of RAC with all scientists of CRIDA was conducted. The Chairman and members of RAC interacted affirmatively on various research issues raised by the scientists. Some of the recommendations that emerged out of the deliberations include the Development of protocols for Natural Farming in rainfed ecologies, the Development of the "Agroclimatic atlas of India", the Development of crop cafeteria, and the Assessment of GHGs and carbon footprints under integrated farming systems.

12.2. Institute Research Council (IRC).

The IRC meeting was held on 23rd May, 4th, 7th, 8th, 11th and 13th July 2022. Project Coordinators, Heads of Divisions/Sections/Units and institute Scientists participated in the meeting. The meeting was chaired by Dr. V. K. Singh Director, ICAR-CRIDA. In his opening remarks he advised all the participants for constructive criticism in the interest of improvement in quality of research. The director also briefed about the changing priorities in rainfed agriculture, ongoing programmes and salient achievements and new initiatives. The Principal Investigators of the project presented the progress made in their research projects. The IRC reviewed the progress made under various research projects for the year 2020-21 and the mid term corrections were proposed by the IRC in the research projects and finalized the technical programmes of the ongoing research projects for the year 2021-22.

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

13

Workshop/meetings /attended by Dr. Vinod Kumar Singh, Director, ICAR-CRIDA

Scientist	Details of program	Duration	Venue
Dr. Vinod Kumar Singh	Valedictory Address as Chief Guest in closing ceremony of High End workshop on Remote Sensing and digital image processing of satellite data for eco-system monitoring	January 23, 2022	Virtual
	Delivered invited lecture on "Precision Agriculture for Sustainable Food System– NICRA experiences in the 21 days ICAR sponsored Winter School on Climate Smart Agriculture for sustainable production	April 3, 2022	Virtual, RPCAU, Pusa, Bihar
	Consultation meeting on Glue Grant by the Secy, Min of Education, Govt. of India	May 2, 2022	Virtual
	17th NICRA Expert Committee Meeting to be held at ICAR-CRIDA, Hyderabad	May 2, 2022	ICAR-CRIDA, Hyderabad
	Physical meeting at Oral evidence before the standing committee on chemicals and fertilizers	May 4, 2022	Parliament House, New Delhi
	1st Research Council Meeting-2022 of Directorate of Research, Banda University of Agriculture and Technology (BUAT), UP	May 5, 2022	Banda, UP
	Invited Lecture at Rani Lakshmi Bai Central Agricultural University, Jhansi, International Conference on Agriculture science and technology: Challenges and prospects (AST-2022)	May 5, 2022	Jhansi, UP
	Executive Development Programme on Leadership Development for newly recruited Research Managers (RMPs)	May 09-14, 22	ICAR-NAARM, Hyderabad
	Attended meeting with DG, ICAR as Member of Judging Committee of Best Institute Award - Vasant Rao Naik	May 27, 2022	New Delhi
	Brainstorming Workshop on organic farming scheduled on 10th June 2022 at	June 10, 2022	ICAR-NAARM, Hyderabad.
	19th Research Council meeting as Eminent External Expert (Physical) MPUA&T, Rajasthan	June 6, 2022	Udaipur, Rajasthan
	Meeting on Crops Situation under the Chairmanship of Secretary (DA&FW), Ministry of Agriculture and Farmers Welfare	July 30, 2022	Virtual
	Expert Consultation on Scaling CSA at ICRISAT, Hyderabad as a part of ongoing collaboration between CIMMYT-Dr. Reddy's Foundation and ICRISAT	September 20, 2022	ICRISAT, Hyderabad
	ISDA-CRIDA International Conference on "Reimaging Rainfed Agro-ecosystems- Challenges & Opportunities"- Technical Programming Committee Meeting at	September 22, 2022	ICAR-CRIDA, Hyderabad
	Re-interaction Meet on Energy – Water – Food Nexus. Challenges Ahead – Climate change, IPCC Report at VIP circuit House Annexe, Sahibagh, as speaker on "Energy – Water – Food Nexus Challenges Ahead	October 7, 2022	Ahmadabad, Gujarat
	Anglo-American Crop Nutrients (AACN) in collaboration with CRIDA organized Annual Co-operators' Conference	October 17-18, 2022	ICAR-CRIDA, Hyderabad

Scientist	Details of program	Duration	Venue
Dr. Vinod Kumar Singh	Kisan Samman Sammelan of Hon'ble PM in respect of KVKs/SAUs and ICAR institutions	October 17, 2022	Virtual
	National meeting on Crop Diversification	October 31, 2022	IIWM, Bhubaneswar
	International Training Program on Climate Resilient Agriculture for Extension Professionals – Indian Experience organized by MANAGE – visit to CRIDA on 03.11.2022 – address by director	November 3, 2022	Virtual
	Foreign deputation to Sharm-El-Sheikh, Egypt under COP-27, UNFCCC	November 6-18, 2022	Sharm-El-Sheikh, Egypt
	Attended Kharif review and rabi planning workshop of NICRA TDC of ATARI Zone IV	November 25-26, 2022	Gumla, Jharkhand
	Visited AICRPDA centre, Bengaluru to review on-station and on-farm activities under AICRPDA, NICRA, OFR and SCSP.	November 27-28, 2022	Bengaluru, Karnataka
	International Conference on Reimagining Rainfed Agro-ecosystems: Challenges & Opportunities	December 22-24, 2022	ICAR-CRIDA, Hyderabad
	AINP-of 17th Annual Group meeting, Modipuram	December 28-30, 2022	Modipuram, UP

Workshop/meetings /attended by Scientists.

Scientist	Programme Name	Duration	Venue
K Ravishankar, Anshida Beevi CN, Jagriti Rohit	Webinar on "Emerging Approaches and Trends in Extension Research: A Social Change Perspective"	January 28, 2022	EEI, Hyderabad
DBV Ramana	Launch workshop of new KVKs and review of existing KVKs of Technology Demonstration Component of NICRA ICAR-ATARI Jodhpur	January 31, 2022	Virtual
M. Prabhakar	Institute Management Committee (IMC) meeting, ICAR, NIASM, Baramati	February 9, 2022	Virtual
M. Prabhakar	QUAD working group meeting	February 10, 2022	MoEF&CC, Virtual
Pushpanjali	1st International Electronic Conference on Agriculture: Advances in Agricultural Science and Technology" by *agriculture* journal (MDPI)	February 10–25, 2022.	Virtual
Pushpanjali	National Seminar on Agrophysics for Smart Agriculture	February 22-23, 2022.	NASC Complex, New Delhi Hyderabad
DBV Ramana	SAC meeting	February 25, 2022	DDS KVK, Sanga Reddy
C A Rama Rao	Launch Workshop of New KVKs in NICRA-TDC programme of ICAR-ATARI, Kolkata	February 28, 2022	Virtual
C A Rama Rao	Launch, Action Plan and Review Workshop of KVKs implementing TDC-NICRA	March 2, 2022	Virtual

Scientist	Programme Name	Duration	Venue
T.V. Prasad	Launch Workshop for New KVKs and Review for the existing KVKs of ATARI Guwahati (Zone VI) and ATARI Barapani (Zone VII)	March 4-5, 2022	Guwahati, Assam
Anshida Beevi CN	National Webinar on "Cyber Security for Women" organized by ISAE Project Phase-II	March 8, 2022	Virtual
M. Prabhakar	Scaling up climate actions in Asia – For resilient and low emission landscapes organized by FAO	March 15-16, 2022	Virtual
M. Prabhakar	56th Session of the IPCC and 14th Session of Working Group III organized by IPCC	March 21 – April 1, 2022	Virtual
C A Rama Rao	State Level Workshop on Land and Water Management for Building Drought Resilience, Watershed Organization Trust (WOTR)	March 22-23, 2022	WoTR, Pune
Pushpanjali	National Seminar on "Managing Soils in a Changing Climate"	March 24-26, 2022	ICAR-NBSS&LUP Campus, Nagpur
B M K Raju	Workshop on 'Mandal level Risk and Vulnerability Assessment and District level Climate Adaptation plans for Telangana State'	March 25, 2022	EPTRI, Hyderabad
K.Nagasree, Jagriti Rohit	International Webinar Series on Technology Backstopping for Agri-Extension: Indian Experiences- ICAR-CRIDA-MANAGE	March 29, 2022	Virtual
K Ravishankar	Success Saga of Sahyadri FPO: Challenges faced and Strategies Adopted for Sustenance	March 29, 2022	SEP, EEI Campus, Hyderabad.
C A Rama Rao, B M K Raju, T.V. Prasad	4th Virtual meeting to discuss details of PMFBY in respect of the 'study on operational issues in the implementation of PMFBY to recommend effective implementation strategies for the most vulnerable districts'	April 4, 2022	NRAA, DA&FW Virtual
C A Rama Rao	Sectoral Working Group Meeting for preparation of India's Adaptation Communication	April 5, 2022	MoEFCC, Virtual
Salini K	National Seminar on ""Breeding Approaches for Improvement of Under-utilized Legumes"	April 9-11, 2022.	Virtual
M. Prabhakar	Sectorial working group meeting – Disaster management infrastructure resilience	April 11, 2022	NDMA, Virtual
M. Prabhakar	Steering committee meeting – National Adaptation Communications	April 11, 2022	MoEF&CC, Virtual
M. Prabhakar	QUAD climate ambition pillar meeting	April 14, 2022	MoEF&CC, Virtual
C A Rama Rao	Second Sectoral Working Group Meeting for preparation of India's Adaptation Communication	21 April 2022	MoEF&CC, Virtual
C A Rama Rao	XXX Meeting of RAC of ICAR-CRIDA	April 25-27, 2022	ICAR-CRIDA

Scientist	Programme Name	Duration	Venue
HB Santosh, Savitha Santosh	International Symposium on Advances in Plant Biotechnology and Nutritional Security	April 28-30, 2022.	NASC Complex, New Delhi Virtual
C A Rama Rao	Second Meeting of Adaptation Resourcing Working Group	April 29 2022	MoEF&CC, Virtual
C A Rama Rao	Meeting of the Working Group on Disaster Management Resilient Agriculture for preparing Adaptation Communication,	April 29 2022	MoEF&CC, Virtual
M. Prabhakar	17th NICRA Expert Committee meeting	May 2, 2022	CRIDA, Hyderabad
C A Rama Rao	Foundation Day of ICAR-NIAP, New Delhi	May 4, 2022	ICAR-NIAP, New Delhi
Suvana S	12th Indian Fisheries and Aquaculture forum	May 5-7, 2022	TNJFU, Chennai
M. Prabhakar	National symposium on self-reliant coastal agriculture	May 11-12, 2022	CCARI, Goa
M. Prabhakar	Workshop for establishing a Danish – India partnership on smart plant protection	May 16, 2022	ICRISAT, Hyderabad
Anshida Beevi CN	National Seminar cum Webinar on "Climate Change Concerns: Challenges for Agriculture Sector and Food and Nutrition Security" jointly organized by ICAR-IIMR, Hyderabad and Karnataka Agri-Professionals Association (KAPA)	May 14-15, 2022	ICAR-IIMR, Hyderabad (Virtual)
C A Rama Rao	Third meeting of the Steering Committee to prepare India's Adaptation Communication,	May 25, 2022	MoEFCC, Virtual
K.A. Gopinath, C A Rama Rao, Nagarjuna Kumar, V. Girija Veni, K.Nagasree	27th Biennial Workshop of AICRPDA and 9th Annual Review Workshop of NICRA-AICRPDA	June 2-4, 2022	ICAR-CRIDA, Hyderabad
C A Rama Rao, B M K Raju, Salini K, Nagarjuna Kumar, Dhimate Ashish Satish, V. Girija Veni, DBV Ramana, Anshida Beevi CN, AGK Reddy, M. Manjunath V. Visha Kumari, K.Nagasree TV Prasad, K Ravishankar, P.K.Pankaj	Brainstorming Session on "Water Policy for Rainfed Agriculture" jointly organized by Indian Society of Dryland Agriculture (ISDA) and ICAR-CRIDA, Hyderabad	June 4, 2022	ICAR-CRIDA, Hyderabad
M. Prabhakar	UNFCCC Climate Change Conference, 50th Session of the Subsidiary bodies (SB)	June 6-16, 2022	Bonn, Germany

Scientist	Programme Name	Duration	Venue
K.A. Gopinath	Final International Conference of AdaptNET project	June 14-15, 2022	Goa
N. Jyothi Lakshmi	National Webinar on '*Phenomics in Plant Physiology: The Key to Close the Genotype-Phenotype Knowledge Gap*'	June 11, 2022	Virtual
K.A. Gopinath	Technical Workshop on Regional Adaptation Fund Proposal 'Strengthening Resilience of Vulnerable Communities in Sri Lanka and India to Increased Impacts of Climate Change'	June 21-22, 2022	New Delhi
M. Prabhakar	Stakeholder meeting workshop on Climate Resilient Agriculture for problematic soils by NAAS Chapter of Lucknow	June 23, 2022	ICAR-CSSRI RS, Karnal
K.V Rao	Sensitization workshop on Disaster Management	June 27-28, 2022	NIDM, New Delhi
M. Prabhakar	Parliamentary Standing Committee meeting on agriculture and climate change	June 27-29, 2022	IARI, New Delhi
C A Rama Rao, B M K Raju	Virtual meeting on 'Operational issues in the implementation of PMFBY to recommend effective implementation strategies for the most vulnerable districts'	June 29, 2022	Virtual meeting from DA&FW
K.V Rao	ICAR-IWMi Workplan Meeting	July 8, 2022	IWMI Office, New Delhi
DBV Ramana	Annual Zonal Workshop of KVKs of Zone X	July 12-14, 2022	Kanha Shanti Vanam, Near Chegur Village, Hyderabad
K.V Rao	Interface meeting for enhancing the preparedness for Agricultural Contingencies- Rajasthan	July 18, 2022	Virtual
DBV Ramana	State Level virtual Interface Meeting on Enhancing the Preparedness for Agriculture Contingencies during kharif 2022 for Rajasthan	July 18, 2022	Virtual
V. Maruthi	Participated in the a-Idea meeting on BIRAC-BIG as a nodal officer- a-Idea, ICAR-CRIDA	July 21, 2022	Virtual
M. Prabhakar, K.A. Gopinath	Thematic Review meeting of NRM & AE institutes under NICRA	July 21-22, 2022	NASC, New Delhi
K.V Rao, DBV Ramana	Interface meeting for enhancing the preparedness for Agricultural Contingencies- Maharashtra	July 22, 2022	Virtual
K.V Rao	Review meeting of External Aided projects	July 22-23, 2022	IIWM, Bhubaneshwar
C A Rama Rao, V. Girija Veni, T. V Prasad	Capacity building programme on 'Technology demonstrations for enhancing resilience'	July 24-25 2022	ICAR-CRIDA, Hyderabad
DBV Ramana	State Level Interface Meeting on Agricultural Contingency Preparedness for Jharkhand	July 25, 2022	Virtual

Scientist	Programme Name	Duration	Venue
K.A. Gopinath	Thematic Review meeting of Crop Improvement, Crop Protection & Social Sciences	July 26-28, 2022	NASC, New Delhi
V. Girija Veni	Global symposium on soils for plant nutrition	July 26-29, 2022	FAO, United states Virtual
C A Rama Rao	NICRA Expert Committee Review of research activities and strengthening future research programme (Social Sciences	July 28, 2022	NASC, New Delhi
DBV Ramana	State Level Interface Meeting on Enhancing the Preparedness for Agriculture Contingencies during kharif 2022 for Gujarat	July 26, 2022	Virtual
DBV Ramana	State Level Interface Meeting on Agricultural Contingency Preparedness for Telangana	July 28, 2022	Virtual
M. Prabhakar	EFC finalization meeting of NRM Division, ICAR	August 9-11, 2022	Krishi bhavan, New Delhi
T.V. Prasad	National Workshop on "*Pathways for Effective Implementation of SC Sub Plan Scheme in ICAR*"	August 18-19, 2022	ICAR-NAARM, Hyderabad
Anshida Beevi CN	International Conference on "Advances in Agriculture and Food System towards Sustainable Development Goals"	August 22-24, 2022	UAS, Bangalore (Virtual)
DBV Ramana, K.A. Gopinath	Review of Research Activities and Strengthening Further Research Program of NICRA Strategic Research Partner Institutes under Animal Sciences Theme	August 26, 2022	NASC, New Delhi
K.V Rao	Regional Workshop on Assessing Drought Risks using Earth Observation Data & Launch of South Asia Drought Management System (SADMS)	August 31 – September 2, 2022	SDMC (IU), Gandhi Nagar
M. Prabhakar	National Conference on Agriculture for Rabi Campaign	September 6-7, 2022	NASC, New Delhi
AGK Reddy	Improving farm productivity and farm economic in changing climate: Challenges and prospects	September 11, 2022	Lucknow, Uttar Pradesh
M. Prabhakar, K.A. Gopinath	Technical Review Workshop of Horticulture & Modeling	September 14-15, 2022	CSSRI, Karnal
Dhimate Ashish Satish	Brainstorming session on dryland mechanization at ICRISAT	September 19, 2022	ICRISAT, Hyderabad
DBV Ramana	On-campus Farmers Training-cum-Demonstration on "Rainwater Management Practices"	September 20, 2022	KVK-Ranga Reddy, ICAR-CRIDA, Hyderabad
B M K Raju	Participatory prioritization workshop on Agronomy R&D for Climate Change Adaptation	September 24, 2022	Jaypee Siddharth hotel, New Delhi

Scientist	Programme Name	Duration	Venue
CRIDA Scientists	National Seminar on 'Harnessing the potential of *panchabhutas (tatvas)* for sustainable climate resilient rainfed agriculture'	September 28-29, 2022	ICAR-CRIDA, Hyderabad
M. Prabhakar	Consultation meeting on Carbon Footprints	October 7, 2022	MSSRF, Chennai
K.V Rao	Review Meeting on PMFBY project	October 11, 2022	DA&FW, New Delhi
C A Rama Rao	Webinar on 'Farm ponds for securing agriculture in rainfed regions : A call for sustainable approaches', WCRes, Hyderabad,	October 13, 2022	Virtual
C A Rama Rao, K.A. Gopinath, R.Nagarjuna Kumar, V. Girija Veni, V. Maruthi V. Visha Kumari Savitha Santosh	Annual Co-operators' Conference	October 17-18, 2022	ICAR-CRIDA
M. Vanaja	International Conference on "Physiological and Molecular Mechanisms of Abiotic Stress Tolerance in Plants"	October 26-28, 2022	University of Calicut, Kerala
C A Rama Rao, B M K Raju, K.V Rao	National Meeting on Crop Diversification	October 31, 2022	ICAR-IIWM, Bhubaneswar
V. Girija Veni	Training Workshop on Analysis of Multi-Environment Trials (On-line Mode)	November 3-8, 2022	NAARM, Hyderabad
V. Visha Kumari	International workshop on farming on farming systems Design towards zero hunger and zero carbon	November 8-12, 2022	ICRISAT, Hyderabad
M. Prabhakar	National Symposium on achieving net zero emissions in Indian agriculture – Perspective of Soil Management organized by Indian Society of Soil Science (IISS)	November 15-17, 2022	MPKV, Rahuri
K.V Rao	Policy discussions on ORAM	November 18, 2022	Soil Conservation Directorate, Bhubaneswar
K Ravishankar	Promoting FPOs for resilient incomes and sustainable farming practices.	November 22, 2022.	Ecosystem Based Adaptation for Resilient Incomes (ECOBARI), WOTR, Pune.
Pushpanjali	One-day symposium (hybrid mode) on 'Soils: Where food begins Division of Soil Science and Agricultural Chemistry, ICAR-IARI, New Delhi and Indian Society of Soil Science (ISSS)-Delhi Chapter.	November 30, 2022.	Virtual
CRIDA Scientists	International Conference on "Reimagining Rainfed Agro-ecosystems: Challenges & Opportunities" jointly organized by Indian Society of Dryland Agriculture (ISDA) and ICAR-CRIDA, Hyderabad	December 22-24, 2022	ICAR-CRIDA, Hyderabad

Workshops/seminars/conference

14

14.1 Launch workshop of new KVKs and review of existing KVKs of Technology Demonstration Component of NICRA ICAR-ATARI Jodhpur

The launch workshop of new KVKs and review of existing KVKs of NICRA of ICAR-ATARI, Jodhpur was held on 31 January, 2022 through virtual mode. Dr VK Singh, Director-ICAR-CRIDA, Dr SK Singh, Director-ICAR-ATARI-Jodhpur, Director-CAZRI, Directors of Extension Education of SKRAU- Bikaner, AU - Jodhpur, SKNAU-Jobner, MPUAT-Udaipur, CCSHAU- Hisar, Heads of NICRA KVKs of the new districts and existing districts, PI of NICRA, and Co-PIs of TDC attended the launch workshop.

14.2 Garib Kalyan Sammelan- Nationwide farmer Interaction programme by Hon'ble Prime Minister in a virtual mode at Hayathnagar Research Farm.

"Garib Kalyan Sammelan" event and a nationwide farmer Interaction programme by the Hon'ble Prime Minister in a virtual mode was telecasted at Hayathnagar Research Farm, ICAR- CRIDA, Hyderabad, Telangana from 10.30 A.M. onwards on 31 May 2022.The event was presided over by Shri G. Kishan Reddy Garu, Union Minister of Tourism, Culture and Development of North Eastern Region of India, Shri M.P. Rethees Kumar, ED, LPG, HPCL, Shri. R. Sravan Kumar, ED, IOCL, Shri. Anita Mohan, ED, BPCL, and other political people. More than 4200 farmers and other GoI scheme beneficiaries participated in the programme.

14.3 ICAR-CRIDA organises 27th Biennial Workshop of AICRPDA, 9th Annual Review Workshop of NICRA-AICRPDA and 10th Annual Review Workshop of NICRA-AICRPAM

ICAR-Central Institute for Dryland Agriculture, Hyderabad organized the "27th Biennial Workshop of AICRPDA, 9th Annual Review Workshop of NICRA-AICRPDA and 10th Annual Review Workshop of NICRA- AICRPAM" from 2nd to 4th June, 2022.

14.4 Brainstorming session on Water Policy for Rainfed Agriculture, Brain storming session on Agroclimatic Atlas of India and Plenary session of AICRPDA and AICRPAM Workshops were organized during 3-4 June 2022.

A brainstorming session on Water Policy for Rainfed Agriculture was jointly organised in hybrid mode by ICAR-CRIDA and Indian Society of Dryland Agriculture (ISDA) on 4th June 2022. The session was chaired by Dr. S.K.Chaudhari, DDG(NRM), ICAR. Dr.B.Rath Technical Expert, NRAA (National Rainfed Area Authority) and Member for Water policy Development , Dr. V.K. Singh Director, ICAR-CRIDA, scientists from ICAR-CRIDA, AICRPDA, AICRPAM centres and other ICAR institutes, officials from NABARD, NGO's and other organisations participated. About 200 participants attended the brain storming session

14.5 State Level Interface Meeting on Agricultural Contingency Preparedness for Jharkhand organized

A State Level virtual Interface Meeting on Enhancing the Preparedness for Agriculture Contingencies during kharif 2022 for Jharkhand was jointly organized on 25th July by ICAR-Central Research Institute for Dryland Agriculture (CRIDA), Department of Agriculture, Govt of Jharkhand. The interface meeting was chaired by Mrs. Nisha Oraon Singhmarr, Director, Dept. of Agriculture, A.H. and Co-operative, Shri Pradeep Hazarika, Spl. Secretary, Jharkhand, Dr M Osman, Director (I/c), ICAR-CRIDA, Director, Seeds, BAU, Dr. G. Ravindra Chary, PC, AICRPDA, JDAs, DAOs and officials from ATAMA and other line department officials from Jharkhand, scientists from CRIDA, Dr D.N. Singh, Chief Scientist, AICRPDA also participated.

14.6 State Level Interface Meeting on Agricultural Contingency Preparedness for Gujarat - organized

A State Level Interface Meeting on Enhancing the Preparedness for Agriculture Contingencies during kharif 2022 for Gujarat was jointly organized on 26th July, 2022 by ICAR-Central Research Institute for Dryland Agriculture (CRIDA), Department of Agriculture, Govt of Gujarat. The interface meeting was chaired by Sri .S.J. Solanki, Director of Agriculture, Govt. of Gujarat. Mrs. Kamala Chhaiya, Additional Director, Dept. of Agriculture, Ms. Mittal Dudhat, Dy. Director, Agriculture, Dr G. Ravindra Chary, PC, AICRPDA, ICAR-CRIDA, Directors of Research, Dr. B.S Deora (SDAU), Dr. T.R. Ahlawat (NAU) and Dr.M.K. Jhala (AAU), Dr. D. S. Hirpara, Research Scientist, AICRPDA centre, Rajkot, senior scientists from CRIDA, JAU, NAU, AAU and SDAU, JDAs, officials from line departments, ATMA and KVKs participated.

14.7 State Level Interface Meeting on Agricultural Contingency Preparedness for Telangana - 2022 organized

A State Level Interface Meeting on Enhancing the Preparedness for Agriculture Contingencies during kharif 2022 for Telangana was organized on 28th July, 2022 jointly by ICAR-Central Research Institute for Dryland Agriculture (CRIDA) and Department of Agriculture, Govt of Telangana. Sri. Hanumanth Rao, Special Commissioner, Agriculture chaired the meeting. Dr. R. M. Sundaram, Director, ICAR-IIRR, Dr. C.V. Ratnavathi, Director, ICAR- IIMR, Dr. Dr. Jagadeeswar, Director of Research, PJTSAU, Director of Research, PVNRVU, Dr G. Ravindra Chary, PC, AICRPDA, scientists from CRIDA, IIOR, PJTSAU, District Agriculture Officers, officials of ATMA , line departments, and KVKs participated.

14.8 State Level Interface Meeting on Agricultural Contingency Preparedness for Rajasthan organized

A State Level virtual Interface Meeting on Enhancing the Preparedness for Agriculture Contingencies during *kharif* 2022 for Rajasthan was jointly organized on 18th July by ICAR-Central Research Institute for Dryland Agriculture (CRIDA), Department of Agriculture, Govt of Rajasthan. The interface meeting was chaired by Sri Dinesh Kumar, Pr. Secretary Agriculture & Horticulture, Govt of Rajasthan. Sri Kana Ram, Commissioner, Dept of Agriculture, Dr M Osman, Director (I/c), ICAR-CRIDA, Dr SK Sharma, Director (Research), MPUAT, Dr P Shekhawat, Director (Research), SKRAU, Bikaner, Dr T Satyavathi, Project Coordinator, AICRP on Pearl Millet, Jodhpur, Dr Rohilla , ATARI, Representatives from ICAR institutes, District and Divisional officials from Department of Agriculture etc.

14.9 State Level Interface Meeting on Agricultural Contingency Preparedness for Maharashtra organized

A State Level virtual Interface Meeting on Enhancing the Preparedness for Agriculture Contingencies during kharif 2022 for Maharashtra was jointly organized on 22th July by ICAR-Central Research Institute for Dryland Agriculture (CRIDA), Department of Agriculture, Govt of Maharashtra. The interface meeting was chaired by Sri Eknath Dawalle, Pr. Secretary Agriculture, Govt of Maharashtra. Sri Vikas Patil, Director (Extension & Training), Sri Raosaheb Bhagde, Commissioner, (Agriculture), Ms. Sarita Bandekar Deshmukh, Joint Secretary (Agriculture) Dr M Osman, Director (I/c), ICAR-CRIDA, Dr HS Pathak, Director, NIASM, Baramati, Dr VK Kharche,

Director (Research), PDKV, Akola, Dr S. R. Gadakh, Director (Research), MPKV, Rahuri Representatives from ICAR institutes locate din Maharashtra, Chief Scientists of AICRP on Dryland Agriculture, AICRP on Agro meteorology ,District and Divisional officials from Department of Agriculture, KVKs etc.

14.10 Launch and Review Workshop of ATARI Zone- I (Ludhiana) held at Kullu, Himachal Pradesh

The launch and review workshop of NICRA regarding ATARI Zone I Ludhiana was held at Kullu during July 18-19, 2022. About 17 KVK from 3 states and 2 Union territories participated in the workshop. The programme was chaired by Dr V K Singh, Director, ICAR CRIDA, Hyderabad and co-chaired by Dr Rajbir Singh, Director, ATARI Zone I. Dr Ashok Kumar, DEE PAU, Dr V K Sharma, DEE, CSK HPKV Palampur, Dr Divendra Gupta, DEE YPS UHF Solan, Dr Dileep Kachroo Former Registrar SKUAST Jammu and programme co-ordinators from KVKs participated in this workshop.

14.11 Review of Research Activities and Strengthening Future Research Program of NICRA Strategic Partner Institutes under NRM and Agril. Engineering during 21-22 July, 2022 at NASC, New Delhi

A meeting to review the research activities and strengthening further research program of NICRA strategic research partner institutes under NRM and Agril. Engineering was inaugurated on 21 July 2022 at NASC, New Delhi. Dr B Venkateswarlu, Former VC, VNMKV and Chairman, Expert Committee for NICRA Strategic Research, Dr. SK Chaudhari, DDG (NRM), Dr. NC Patel, Former VC, AAU and Member, Expert Committee, Dr. S. Bhaskar, ADG (AAF&CC) and member, Dr. VK Singh, Director, ICAR-CRIDA and Member Secretary participated in the meeting.

14.12 Review of Research Activities and Strengthening Further Research Program of NICRA Strategic Research Partner Institutes under Crop Improvement and Crop Protection Themes during 26-27 July 2022 at NASC, New Delhi.

A meeting to review the research activities and strengthening further research program of NICRA strategic research partner institutes under Crop Improvement and Crop Protection themes was inaugurated on 26 July 2022 at NASC, New Delhi. Dr B Venkateswarlu, Former VC, VNMKV and Chairman, Expert Committee, Dr. SK Chaudhari, DDG (NRM), Dr. Kuldeep Singh, Member, Expert Committee, Dr. U.S. Sharma, Member and Dr. VK Singh, Director, ICAR-CRIDA and Member Secretary and Dr. K.A. Gopinath, Co-PI, NICRA participated.

14.13 Review of Research Activities and Strengthening Further Research Program of NICRA Strategic Research Partner Institutes under Social Sciences Theme Inaugurated on 28 July 2022 at NASC, New Delhi.

A meeting to review the research activities and strengthening further research program of NICRA strategic research partner institutes under Social Sciences theme was inaugurated on 28 July 2022 at

NASC, New Delhi. Dr. SK Chaudhari, DDG (NRM) and Chairman, Dr. K.D. Kokate, Former DDG (Agri. Extension) & Member, Expert Committee, Dr. S. Bhaskar, ADG (A,AF & CC) and Member, Dr. VK Singh, Director, ICAR-CRIDA and Dr. K.A. Gopinath, Co-PI, NICRA participated.

14.14 Review of research activities and strengthening future research program of NICRA strategic partner institutes under Horticulture & Integrated Simulation Modelling themes

A two-day meeting to review research activities and strengthening future research program of NICRA strategic partner institutes under Horticulture & Integrated Simulation Modelling themes was inaugurated on 14 September 2022 at ICAR-Central

Soil Salinity Research Institute (CSSRI), Karnal. Dr. B. Venkateswarlu, Former VC, VNMKV and Chairman, Expert Committee, Dr. S.K. Chaudhari, DDG (NRM) and Co-Chairman, Dr. D. Nagesh Kumar, Professor, IISc, Bengaluru and Member, Dr. N. Kumar, Former Vice Chancellor, TNAU and Member, Dr. V.K. Singh, Director, ICAR-CRIDA and Dr. M. Prabhakar, PI, NICRA of ICAR-CRIDA participated.

14.15 Review of Research Activities and Strengthening Further Research Program of NICRA Strategic Research Partner Institutes under Animal Sciences Theme Inaugurated on 26 August 2022 at NASC, New Delhi

A meeting to review the research activities and strengthening further research program of NICRA strategic research partner institutes under Animal Sciences theme was inaugurated on 26 August 2022 at

NASC, New Delhi. Dr B Venkateswarlu, Former VC, VNMKV and Chairman, Expert Committee, Dr. SK Chaudhari, DDG (NRM) and Co-Chair, Dr. A.M. Paturkar, Vice Chancellor, MAFSU and Member, Dr S. Bhaskar, ADG (A,AF&CC) and Member, Dr. VK Singh, Director, ICAR-CRIDA and Member Secretary, and Dr. K.A. Gopinath, Co-PI, NICRA participated.

14.16 Capacity Building Program on "Technology demonstrations for enhancing resilience" 13-14 August, 2022, ICAR-CRIDA, Hyderabad-Inaugurated

Second phase of two days Capacity Building Program on "Technology demonstrations for enhancing resilience" held during 13-14, August 2022, organized by Technology Demonstration Component of NICRA at ICAR-CRIDA, Hyderabad. Dr. S.K. Chaudhari, DDG (NRM), ICAR. Dr. V.K. Singh Director, ICAR-CRIDA, Dr. JVNS Prasad, Project Leader, TDC-NICRA, scientists from ICAR-CRIDA and Dr.Lakhan

Singh Director ATARI, Pune, Dr.S.R.K.Singh, Director ATARI, Jabalpur, Dr.J.V.Prasad, Director ATARI, Hyderabad, Dr.D.V.Srinivas Reddy Nodal officer Bengaluru, Senior Scientists and Heads of 42 NICRA KVKs, NICRA Co-PIs and SRFs of respective KVKs participated in the programme.

14.17 3rd Phase of Capacity Building Programme on "Technology demonstrations for enhancing resilience" 22-23rd August, 2022, ICAR-CRIDA, Hyderabad.

The Third phase of 2 days capacity building program on "Technology demonstrations for enhancing resilience" was organized by the technology demonstration component of NICRA during 22-23rd August 2022 at ICAR-CRIDA, Hyderabad. Dr. S.B. Barbuddhe, Director, ICAR-NRC Meat, Hyderabad. Dr. V.K. Singh, Director, ICAR-CRIDA, Dr. Ashish S. Murari, Nodal officer, ATARI, Ludhiana, Dr. T. Amrutha, Nodal officer, ATARI Barapani, Dr. Bagish Kumar, Nodal officer, ATARI, Guwahati, Dr. J.V.N.S Prasad, Programme Leader, TDC-NICRA, Dr. T.V. Prasad, Co-PI, TDC-NICRA, scientists from ICAR-CRIDA, Senior Scientist and Head of 58 NICRA KVKs, NICRA Co-PIs and SRFs of respective KVKs participated.

14.18 National Seminar on Harnessing the Potential of Panchabhutas (tatvas) for Sustainable Climate Resilient Rainfed Agriculture

A National Seminar on "Harnessing the Potential of panchabhutas (tatvas) for Sustainable Climate Resilient Rainfed Agriculture" was organized on 28th September 2022 at ICAR-CRIDA in association with Bharatiya Agro Economic Research Centre, New Delhi, and Indian Society of Dryland Agriculture, Hyderabad in a Hybrid mode. About 300 stakeholders including scientists, research workers, farmers and students participated in the National Seminar.

14.19 Annual Co-operators' Conference

Annual Co-operators' Conference was inaugurated on 17 October 2022 which is being organized jointly by ICAR-Central Research Institute for Dryland Agriculture and Anglo-American's Crop Nutrients (AACN) from 17-18 October 2022 at ICAR-CRIDA campus, Hyderabad Telangana. About 200 members including scientists, research workers, and students participated.

14.20 International Conference on Reimagining rainfed agro-ecosystem: challenges and opportunities.

ICAR-Central Research Institute for Dryland Agriculture, Hyderabad in association with Indian Society of Dryland Agriculture organized International conference on Reimaging Rainfed Agro-ecosystem: Challenges and Opportunities at ICAR-CRIDA, Hyderabad on 22nd December 2022. About 500 delegates across different countries, farmers, NGO officials, officials of private sector dealing with various agricultural inputs participated.

14.21 Meeting of the National Committee on Crop Diversification

A meeting of the National Committee was organized jointly by ICAR-Central Research Institute for Dryland Agriculture (CRIDA), ICAR-Indian Institute of Water Management (IIWM) and Department of Agriculture and Farmers' Welfare (DA&FW) at ICAR-IIWM, Bhubaneswar on 31st October 2022.

14.22 Advocacy Programme on 'Competition Law & Public Procurement'

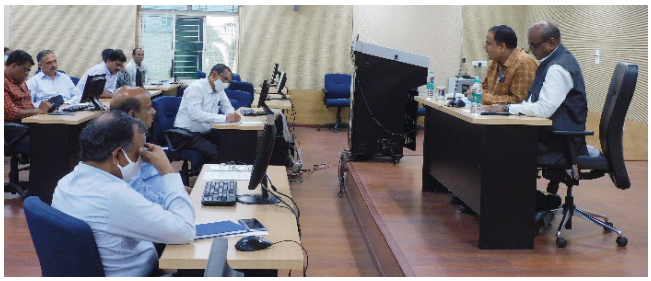
A 3-hr Advocacy Programme on 'Competition Law & Public Procurement' was conducted at the Institute on 14th November 2022. The event was attended by about 50 employees comprising Scientists, Senior Officers and Staff of Administration.

Distinguished Visitors

15

15.1 Visit of Dr S Bhaskar ADG (Agronomy, Agroforestry and Climate Change) to ICAR-CRIDA

Dr S Bhaskar, ADG (Agronomy, Agroforestry and Climate Change) visited ICAR-Central Research Institute for Dryland Agriculture, Hyderabad on August 19, 2022. During the interaction session, Dr V. K. Singh, Director-ICAR-CRIDA welcomed him and explained about the ongoing research activities and new initiatives being taken up in the institute. In his address, Dr Bhaskar explained about the impact of recent extreme events witnessed in the country particularly the heat wave which has caused considerable yield loss. He urged young scientists to focus their research efforts to minimise the impacts of climate change. He also focussed on the need for strengthening the village institutions in the NICRA villages and the need for strengthening NICRA villages. He also emphasised the need for developing technologies for various dryland ecosystems.



Dr S Bhaskar, ADG (Agronomy, Agroforestry and Climate Change) interacting with scientists

15.2 ICAR-IIRR Director Dr R M Sundaram visited ICAR-CRIDA

Dr R. M Sundaram, Director ICAR-IIRR along with senior colleagues visited ICAR-CRIDA on August 19, 2022. Dr V.K. Singh, Director, ICAR-CRIDA, welcomed Dr R.M. Sundaram and other senior colleagues of NRRI and highlighted the research activities being taken up by the institute. Both the Directors strongly urged to go for collaborations in areas especially on dryland/rainfed rice ecosystem and farm machineries. Later, scientists of AICRP on Agrometeorology (AICRPAM) unit of ICAR and the scientists of ICAR-IIRR discussed about the collaborative work on "Coupling biophysical modeling and machine learning for optimizing location-specific NRR adaptation strategies for rice under future climate in India".

Dr V K Singh, Director ICAR-CRIDA welcoming Dr R A Sundaram, Director ICAR-IIRR and the interaction meeting held on 19th August 2022.

15.3 Prof (Dr) Indra Mani, Hon Vice-Chancellor, Vasantrao Naik Marthwada Krishi Vidyapeeth, Parbhani visited ICAR-CRIDA

Prof (Dr) Indra Mani, Hon Vice-Chancellor, Vasantrao Naik Marthwada Krishi Vidyapeeth (VNMKV), Parbhani visited ICAR-CRIDA, Hyderabad on September 4, 2022. Dr V. K. Singh, Director ICAR-CRIDA welcomed Dr Indra Mani and apprised him about the history and accomplishments of ICAR-CRIDA. Dr G Ravindra Chary, I/c Project Coordinator, AICRPDA apprised about the Dryland centre accomplishments and the contributions made by the Parbhani centre to the AICRPDA network. Dr S K Bal, I/c Project Coordinator AICRPAM briefed about

the activities being carried out the AICRPAM network programme. Prof (Dr) Indra Mani, Vice-chancellor, VNMKV acknowledged the accomplishments made by ICAR-CRIDA in natural resource management in rainfed areas. He also stressed the need of CIC ie Collaboration, Innovation and Commercialization and sought active collaboration with ICAR-CRIDA in research, extension and training activities.

Dr V K Singh, Director ICAR-CRIDA welcoming Prof (Dr) Indra Mani, Vice-Chancellor, VNMKV, Parbhani.

15.4 Shri G. P. Sharma, Joint Secretary (Finance), ICAR visited ICAR-CRIDA

The Joint Secretary (Finance), ICAR, Shri G. P. Sharma, visited ICAR-CRIDA, Hyderabad after assuming charge on September 17, 2022. Shri N. V. R. N. Murthy, Chief Finance & Accounts Officer, ICAR-CRIDA briefed about Shri G. P. Sharma. Dr.V.K Singh, Director CRIDA welcomed Jt. Secretary(Finance),ICAR and briefed about CRIDA facilities and its infrastructure, its farms, laboratories, KVK, AICRP projects and NICRA project, apart from its research prowess that contributes inputs to seven different ministries. Later Shri G. P. Sharma interacted with Scientists, Technical and Administrative staff and appreciated ICAR-CRIDA for achieving 100% expenditure in the financial year 2021-22.

The Joint Secretary (Finance), ICAR, Shri G. P. Sharma Interacting with ICAR-CRIDA staff

Dr.V.K. Singh Director ICAR-CRIDA felicitated the Joint Secretary (Finance), ICAR, Shri G. P. Sharma

15.5 Sri. V. Srinivas, IAS, Secretary, DARPG and DPPW, Government of India reviewed the Swachhata Special Campaign 2.0 Activities

Sri V. Srinivas, IAS, Secretary, Department of Administrative Reforms and Public Grievances (DARPG) and DPPW, Govt of India reviewed the progress of Swachhata Special Campaign 2.0 activities at KVK, Ranga Reddy District which is under administrative control of ICAR-CRIDA, Hyderabad on October 8, 2022. Dr S. S. Balloli, Principal Scientist (Soil Science) and Nodal Officer of Swachh Bharat activities of ICAR-CRIDA presented the highlights of the Swachhta Pakhawada activities

Sri V. Srinivas, Secretary, Addressing on Swachhata Special Campaign 2.0.

Photo display on Swachhata activities

implemented at the Institute and in 12 adopted villages under Mera Goan Mera Gaurav, TSP, and SCSP programmes during 2014 to 2021 and the action plan of the activities planned during Special Swachhata Campaign 2.0.

15.6 International delegates from National Institute of Agricultural Extension Management (MANAGE) visited ICAR-CRIDA

About 20 International delegates from MANAGE visited ICAR-CRIDA on November 3, 2022. The visit was made as a part of International Training Program on "Climate Resilient Agriculture for Extension Professionals- India Experience" organized by MANAGE, Hyderabad. The training program is sponsored by Ministry of External Affairs, GOI under Indian Technical and Economic Cooperation (ITEC). During the visit, Dr.V.K.Singh, Director, ICAR-CRIDA explained about different climatic stresses in agriculture and the coping mechanisms. Dr.M. Prabhakar, Principal Scientist (Entomology) & PI, National Innovations in Climate Resilient Agriculture (NICRA) explained brief about NICRA project and highlighted strategic component of the project. Later, Dr.J.V.N.S. Prasad, Principal Scientist (Agronomy) & Co-PI, NICRA highlighted on Technology Demonstration Component of NICRA.

International delegates from MANAGE visited ICAR-CRIDA, Hyderabad

15.7 Visit of Shri Radha Krishna Mathur Hon'ble Lieutenant Governor Ladakh

Shri Radha Krishna Mathur Hon'ble Lieutenant Governor of Ladakh visited ICAR-CRIDA on December 14, 2022. Dr V. K. Singh, Director, ICAR-CRIDA welcomed Hon'ble Lieutenant Governor and apprised him about the mandate and achievements of the institute. Shri Radha Krishna Mathur, Hon'ble Lt Governor was shown/demonstrated the small equipment /machines developed by ICAR-CRIDA. He also visited different laboratories housed in the institute which are equipped with state-of-art facilities for carrying out research programmes. Dr V. K. Singh, Director ICAR-CRIDA also highlighted the various initiatives/activities taken by ICAR-CRIDA under Technology Demonstration Component of NICRA at Ladakh. Hon'ble Lieutenant Governor in his address to the scientists asked ICAR-CRIDA to help the Ladakh region in crop planning, identifying suitable areas for different crops-annual, horticultural, and floriculture. He also requested guidance in organic farming, medicinal and aromatic plants, and high value crops for enhancing the agriculture income so that the primary profession of agriculture will be more lucrative than tourism.

Dr. V.K Singh welcoming Shri Radha Krishna Mathur Hon'ble Lieutenant Governor of Ladakh

Dr. V. K Singh, Director ICAR-CRIDA explaining institute activities

Dr. I Srinivas Principal Scientist, FMP explaining about various agricultural implements developed by CRIDA.

Personnel 16

Institute staff as on 31st December 2022

Director Cell	
Dr. V.K. Singh	Director
Sri M.S.R. Anjaneyulu	Private Secretary
Smt M. Vanitha Raman	Private Secretary
All India Coordinated Research Project for Dryland Agriculture (AICRPDA)	
Dr. G. Ravindra Chary	Project Coordinator (I/c)
Dr. K.A. Gopinath	Principal Scientist (Agronomy)
Dr. B. Narsimlu	Senior Scientist (Soil & Water Conservation Engg.)
Dr. K.B Sridhar	Senior Scientist (Agroforestry)
Dr. H.B. Santosh	Senior Scientist (Genetics and Plant Breeding)
Dr. B. Bhargavi	Scientist(Agronomy)
Sri G. Prabhakar	Assistant Chief Technical Officer
Sri. S. Shankar Reddy	Skilled Support Staff
All India Coordinated Research Project on Agro meteorology (AICRPAM)	
Dr. Santanu Kumar Bal	Project Coordinator (I/c) Principal Scientist (Agri. Meteorology)
Dr. A.V.M. Subba Rao	Principal Scientist (Agri. Meteorology)
Dr. M.A. Sarath Chandran	Scientist (Agri. Meteorology)
Sri N. Manikandan	Scientist (Agricultural Meteorology)
Sri A. Mallesh Yadav	Skilled Support Staff
Division of Resource Management	
Dr. K. Sammi Reddy	Head (I/c.) & Principal Scientist (Soil Science) up to 8.12.22
Dr. G. Rajeshwar Rao	Head (I/c.) & Principal Scientist (Agroforestry) from 9.12.22
Dr. K. Srinivas Reddy	Principal Scientist (Soil & Water Conservation Engg.)
Dr. S.S. Balloli	Principal Scientist (Soil Science)
Dr. D.B.V. Ramana	Principal Scientist (Livestock Production & Management)
Dr. G. Pratibha	Principal Scientist (Agronomy)
Dr. K. Srinivas	Principal Scientist (Soil Science)
Dr. I. Srinivas	Principal Scientist (Farm Machinery Power)
Dr. J.V.N.S. Prasad	Principal Scientist (Agronomy)
Dr. K.V. Rao	Principal Scientist (Soil & Water Conservation Engg.)
Dr. B. Sanjeeva Reddy	Principal Scientist (Farm Machinery Power)
Dr. Ravikanth V. Adake	Principal Scientist (Farm Machinery Power)
Dr. Manoranjan Kumar	Principal Scientist (Soil & Water Conservation Engg.)
Dr. B. Krishna Rao	Principal Scientist (SWCE) (on deputation)
Dr. R. Rejani	Principal Scientist (Soil & Water Conservation Engg.)
Dr. G. Venkatesh	Principal Scientist (Forestry)
Sri. N.S. Raju	Scientist (Computer Applications in Agriculture)

Smt. Pushpanjali	Scientist (Soil Science- Pedology)
Dr. A. K. Indoria	Senior Scientist (Soil Physics)
Dr. V. Girija Veni	Senior Scientist (Soil Science and Agril. Chemistry)
Dr. Sumanta Kundu	Scientist (Agronomy)
Sri. Ashish S. Dhimate	Scientist (Farm Machinery Power)
Dr. Suvana Sukumaran	Scientist (Soil Science)
Smt. D.G.M. Saroja	Technical Officer
Sri. Hemanth Sahu	Senior Technical Assistant
Sri. K. Rajeshwar	Senior Technician
Sri. N.Raghunath	Principal Private Secretary
Division of Crop Sciences	
Dr. S. K Yadav	Head (I/c), Principal Scientist (Plant Biochemistry) up to 30.11.2022
Dr. M. Vanaja	Head (I/c), Principal Scientist (Plant Physiology) from 01.12.2022
Dr. V. Maruthi	Principal Scientist (Agronomy)
Dr. M. Srinivasa Rao	Principal Scientist (Entomology)
Dr. Arun Kumar Shanker	Principal Scientist (Plant Physiology)
Dr. M. Prabhakar	Principal Scientist (Entomology)
Dr. N. Jyothi Lakshmi	Principal Scientist (Plant Physiology)
Dr. Basudeb Sarkar	Principal Scientist (Plant Breeding)
Dr. N. Ravi Kumar	Principal Scientist (Computer Applications in Agriculture)
Dr. K. Sreedevi Shankar	Principal Scientist (Food & Nutrition)
Dr. T.V. Prasad	Principal Scientist (Entomology)
Dr. M. Manjunath	Senior Scientist (Agri. Microbiology)
Dr. A.Gopala Krishna Reddy	Senior Scientist (Horticulture)
Dr. K. Salini	Senior Scientist (Plant Breeding)
Dr. V. Visha Kumari	Senior Scientist (Agronomy)
Dr. Savitha Santosh	Scientist (Agri. microbiology)
Er. C.V.K. Nageswara Rao	Chief Technical Officer
Sri. S.S. Sishodia	Technical Officer
Sri. P. Sathish	Senior Technical Assistant
Smt. Lakshmi Aruna Gayathri	Technical Assistant
Smt. M.A. Rekha	Personal Assistant
Sri. Md. Asif Ahmed	Skilled Support Staff

Section of Transfer of Technology	
Dr. G. Nirmala	SIC & Principal Scientist (Agri. Extension)
Dr. K. Ravi Shankar	Principal Scientist (Agri. Extension)
Dr. K. Nagasree	Principal Scientist (Agri. Extension)
Dr. P. K. Pankaj	Principal Scientist (Livestock Production & Management)
Dr. Jagriti Rohit	Scientist (Agri. Extension)
Dr. C.N. Anshida Beevi	Scientist (Agri. Extension)
Sri. S. Yadagiri	Assistant Chief Technical Officer

Section of Design and Analysis	
Dr. C.A. Rama Rao	SIC & Principal Scientist (Agri. Economics)
Dr. A. Amarender Reddy	Principal Scientist (Agri. Economics)
Dr. B.M.K. Raju	Principal Scientist (Agri. Statistics)
Dr. R. Nagarjuna Kumar	Senior Scientist (Computer Applications in Agriculture)
Dr. Josily Samuel	Senior Scientist (Agri. Economics)
Smt. C. Kanaka Durga	Private Secretary
Prioritization, Monitoring and Evaluation Cell (PME Cell)	
Dr. Mohammed Osman	Incharge PME & principal Scientist (Agronomy) up to 31.7.22
Dr. S.S. Balloli	SIC & Principal Scientist (Soil Science) from 1.08.2022
Dr. Arun Kumar Shanker	Principal Scientist (Plant Physiology)
Dr. K.V. Rao	Principal Scientist (Soil & Water Conservation Engg.)
Dr. P. K. Pankaj	Principal Scientist (Livestock Production & Management)
Dr. M.A. Sarath Chandran	Scientist (Agri. Meteorology)
Sri. N.S. Raju	Scientist (Computer Applications in Agriculture)
Sri P. Ramakrishna	Senior Technical Assistant
Shri Amit Srivastava	Assistant Chief Technical Officer
Library	
Dr. K. Salini	SIC & Scientist (Plant Breeding)
Sri. P. Venkateshwarlu	Technical Assistant
Krishi Vigyan Kendra (KVK)	
Dr. D.B.V. Ramana	Head & Principal Scientist (Livestock Production & Management)
Dr. S.M. Vidyasekhar	Chief Technical Officer (Plant Protection)
Dr. D. Sudheer	Assistant Chief Technical Officer (Veterinary Sciences)
Er. S. Vijaya Kumar	Assistant Chief Technical Officer (Agri. Engineering)
Sri. G. Srikrishna	Assistant Chief Technical Officer (Horticulture)
Sri Ramakrishna	Assistant Chief Technical Officer (Soil Science)
Sri D. Sridhar	UDC
Hayathnagar Research Farm (HRF)	
Dr. I. Srinivas	OIC, Principal Scientist (Farm Machinery Power)
Sri. K. Shankaraiah	Technical Officer
Sri. B. Kurmaiah	Senior Technician
Sri. Mukund Chalkapur	Senior Technical Assistant
Sri. Golla Raju	Senior Technician
Sri. Govinda Lingaiah	Technician
Sri. Chalamcherla Singa Raju	Technician
Sri. Jakkidi Ramana Reddy	Technician
Smt. Avula Lalitha	Skilled Support Staff
Smt. N. Laxmamma	Skilled Support Staff
Gunegal Research Farm (GRF)	
Dr. G. Pratibha	SIC & Principal Scientist (Agronomy)
Sri. Y. Yellappa	Technical Officer (Retired on 31.12.2022)
Sri. Bandi Srikanth Goud	Technical Assistant
Sri. B. Krishna	Senior Technical Assistant
Sri. Chakali Buchaiah	Skilled Support Staff
Agriculture Knowledge Management Unit (AKMU)	
Dr. N. Ravi Kumar	OIC & Principal Scientist (Computer Applications in Agriculture)
Sri. P. Chandra Sekhar	Chief Technical Officer (Computer)

Institute Women's Complaints Committee	
Dr. M. Vanaja	Chairperson & Principal Scientist (Plant Physiology)
Dr. C.A. Rama Rao	Member & Principal Scientist (Agri. Economics)
Dr. K. Sreedevi Shankar	Member & Principal Scientist (Food & Nutrition)
Dr. K. Nagasree	Member & Principal Scientist (Agri. Extension)
Smt. D. Kalpana	Member & Assistant Administrative Officer
Vigilance Officer	
Dr. M. Srinivasa Rao	Principal Scientist (Entomology)
Works	
Dr. B. Sanjeeva Reddy	SIC & Principal Scientist (Farm Machinery Power)
Dr. B. Narsimlu	Member & Senior Scientist (Soil & Water Conservation Engg.)
Sri K. Narsimha	Member & Assistant Administrative Officer
Sri. G. Nagesh Kant Rao	Assistant Chief Technical Officer
Vehicle Section	
Dr. Ravikanth V. Adake	SIC & Principal Scientist (Farm Machinery Power)
Sri. K. Ganesh	Technical Officer
Sri. P. Raju	Technical Assistant
Sri. Ahmed Pasha	Senior Technical Assistant
Landscape	
Dr. A. Gopala Krishna Reddy	SIC & Scientist (Horticulture)
Sri. Avinash Brahamwanshi	Technician
Administrative Section	
Sri. Sushil Kumar Singh	Chief Administrative Officer
Sri. V. Sanu	Assistant Administrative Officer
Sri. K. Narsimha	Assistant Administrative Officer
Smt. D. Kalpana	Assistant Administrative Officer & DDO
Smt. G.M. Shashi Rekha	Personal Assistant
Sri. M. Yadaiah	Assistant
Sri. K. Gowtham Reddy	Assistant
Sri. M. Krishna Reddy	Assistant
Sri. Putta Santosh	Assistant
Sri. V. Venunath	U.D.C
Smt. S. Swathi Kiran	U.D.C.
Smt. J. Kavitha	U.D.C.
Sri. Bollampalli Prashanth	L.D.C.
Sri. B. Ramakrishna	Skilled Support Staff
Sri B. Kiran Kumar	Skilled Support Staff
Finance and Audit Section	
Sri. N.V.R.N Murthy	Chief Finance & Accounts Officer
Sri. R. Sudharshan	Assistant Finance & Accounts Officer
Ms. Sneha Verghese	Assistant
Sri. G. Udaya Bhaskar	U.D.C.
Sri. G. Anjaiah	Skilled Support Staff
Guest House	
Sri Amit Srivastava	In-charge & Assistant Chief Technical Officer
Sri. P. Venkateshwarlu	Technical Assistant

Contact address

Dr. V.K. Singh, Director, ICAR-CRIDA

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