राट्रीय जलवायु समृत्थान कृषि में नवप्रवर्तन

National Innovations in Climate Resilient Agriculture

Managing Weather Aberrations
through Real Time Contingency Planning

वार्षिक प्रतिवेदन

Annual Report
2019-20

AICRPDA-NICRA





अखिल भारतीय समन्वित बारानी कृषि अनुसंधान परियोजना

All India Coordinated Research Project for Dryland Agriculture

ICAR-Central Research Institute for Dryland Agriculture

Hyderabad

Seventh Annual Review Workshop of AICRPDA-NICRA

ICAR-CRIDA, Hyderabad, 26-28 May, 2019



Release of publications



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



Dr. Ch. Srinivasa Rao, Director, ICAR-NAARM addressing the participants



Dr. B. Venkateswarlu, Former Vice Chancellor, VNMKV, Parbhani addressing the participants



Dr. G. Ravindra Chary, Director, CRIDA & PC (AICRPDA) briefing the purpose of the workshop





Visit of participants to Climate Research Facilities at Hayatnagar Research Farm of the institute

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Front Cover: Cotton + cowpea (1:1) intercropping system, Warkhed village, Akola district; Sorghum + chickpea (2:4) intercropping system, kavalagi village, Vijayapura district

Back Cover: Performance of fingermillet variety GPU 28 in Chikkamaranahalli, bengaluru Rural district; Performance of pigeonpea var. Asha in Raura and Patauna villages, Rewa district; Performance of short duration rice variety Dishang in Chamua village, Lakhimpur district; Performance of groundnut variety GJG-9, Patameghpar, Jamnagar district.

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Preface



In the rainfed agroecosystem, the inter-seasonal and in-season weather aberrations like delayed onset of south-west monsoon and early/midseason/terminal drought impact the production and productivity of rainfed crops. To address this, Real-Time Contingency Plan (RTCP) implementation was conceptualized in All India Coordinated Research Project for Dryland Agriculture (AICRPDA) conceptualized under National Innovations in Climate Resilient Agriculture (NICRA) with two pronged approach i.e. preparedness and real-time contingency measures, with established village level institutional mechanisms. RTCP was implemented, both on-station and on-farm trials/demonstrations by 23 network centres of AICRPDA.

During the Seventh Annual Review Workshop of AICRPDA-NICRA at ICAR-CRIDA during 26-28 May, 2019, the trials/demonstrations at both on-station and in 55 AICRPDDA-NICRA villages in 24 districts across 15 states, were critically reviewed and the technical programme 2019-20 for 23 centres was finalized by considering all the above recommendations i.e. i) continuation of on-station research with two common experiments ii) farming situation-wise (soil type/physiography) on-farm demonstrations in cluster approach, and iii) convergence with AICRPAM-NICRA centres and NICRA-TDC-KVKs for technical inputs on real time contingency planning and doable technologies.

During 2019-20, the interventions to cope with delayed onset of monsoon and seasonal drought (early, midseason and terminal) were demonstrated in about 2000 farmers' fields in 55 villages in 23 village clusters enhanced the crop yields.. The Village climate risk management committees (VCRMCs) and other village institutions such as custom hiring centres played a greater role in the implementation of RTCPs.

The salient achievements during 2019-20 are reported in this document. I compliment the team of scientists from PC Unit, AICRPDA and 23 AICRPDA centres for implementing the technical program and for generating data on impact of NICRA programme. We hope that the information in this document may be useful for all the stakeholders involved in climate resilient agriculture in rainfed areas.

We are grateful to Dr. T. Mohapatra, Secretary (DARE) & DG, ICAR, New Delhi for his valuable guidance to the project. We profusely thank Dr. S.K. Chaudhari, DDG (NRM), Dr. K. Alagusundaram, former DDG(NRM)I/C and Dr. S. Bhaskar, ADG (A, AF & CC) for all the guidance and support to AICRPDA from time to time. We acknowledge the support of Dr. P. Vijaya Kumar, PC, AICRPAM, Dr M. Prabhakar, PI, NICRA and scientists of AICRPAM centres and NICRA-KVKs. We are highly thankful to all the participating farmers from 55 NICRA villages across the country for their participation, contribution and support.

(G. Ravindra Chary)
Director (Acting), ICAR-CRIDA &
Project Coordinator, AICRPDA

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Executive Summary

The 23 Centers of All India Coordinated Research Project for Dryland Agriculture (AICRPDA) are conducting on-station and on-farm demonstrations/trials under National Innovations in Climate Resilient Agriculture (NICRA) with the focus on real time contingency plan (RTCP) implementation and preparedness to cope with weather aberrations. The RTCPs implementation has been in a two-pronged approach i.e. i) Real-time contingency measures and ii) Preparedness. During 2019-20, the interventions to cope with delayed onset of monsoon and seasonal drought (early, mid season and terminal) were demonstrated in more than 2879 farmers' fields in 23 village clusters (55 villages) in 24 districts across 15 states. The onset of monsoon during 2019 was delayed by 9 (Chamua), 11 (Khaner), 12 (Patuana, Raura & Tahkapal), 13 (Hardoiya), 14 (Babhulgaon), 16 (Balawas & Budhshelly), 20 (Kumbhi), 21 (Tedha) and 29 (Narotewadi) days. Further, there were 1-3 dry spells at different stages of crops in NICRA villages in Akola, Anantapuramu, Bhilwara, Bengaluru rural, Vijayapura, Bhiwani, Bastar, Lalitpur, Parbhani, Jamnagar, Rewa, Banaskanta, Solapur and Mirzapur districts. The salient achievements are summarized below.

A. On-station

Delayed onset of monsoon

At Jagdalpur, the onset of monsoon was delayed by 12 days (17 June). Improved variety of rice cv. Dagat deshi produced significantly higher grain yield (4342 kg/ha) with higher net returns (Rs.39519/ha), B:C ratio (2.60) and RWUE (4.41 kg/ha-mm) followed by DXD (124)-66 (4271 kg/ha) and DXD (124)-102 (4107 kg/ha) as compared to other varieties.

At Rajkot, the onset of monsoon was delayed by 8 days (23rd June). Semi-spreading variety of groundnut, GJG-22 recorded higher pod yield (2221 kg/ha), net returns (Rs.86150), B:C ratio (2.62) and RWUE (1.63 kg/ha-mm) compared to GG-20 (2013 kg/ha). Among semi-bunch groundnut varieties, GJG-9 recorded higher pod yield (2341 kg/ha), net returns (Rs.87985), B:C ratio (2.66) and RWUE (1.72 kg/ha-mm) compared to other varieties. Similarly, among blackgram varieties, GU-1 recorded higher seed yield (823 kg/ha) compared to T-9 (800 kg/ha) with higher net returns (Rs.20658), B:C ratio (2.12) and RWUE (1.34 kg/ha-mm).

Mid season drought

At Akola, in semiarid vertisols during dry spell of 14 days, foliar spray of 2% water soluble complex fertilizer (19:19:19) at flowering and pod development stage in soybean recorded higher seed yield (1818 kg/ha), net returns (Rs.39386/ha), B:C ratio (2.10) and RWUE (2.45 kg/ha-mm) followed by foliar spray of 2% urea 35-40 DAS + 2% soluble NPK (19:19:19) at pod development stage (1807 kg/ha).

At Anantapuramu, during dry spell of 28 days coinciding with pod development stage of groundnut, the pod yield (1133 kg/ha) of groundnut was improved significantly through foliar spray after relieving of stress/dry spell over foliar spray during dry spell (979 kg/ha). Among the treatments, foliar spray of water soluble complex fertilizer (19:19:19) @ 0.5% + recommended dose of micronutrient ($ZnSO_4$ @ 0.2%) after relieving of stress/dryspell recorded higher groundnut pod yield (1267 kg/ha), net returns (Rs.42630/ha), B:C ratio (2.71) and RWUE (2.26 kg/ha-mm) compared to other treatments.

At Kovilpatti, during *rabi*, foliar spray during dry spell in sorghum (var.K12) recorded higher grain yield (1795 kg/ha), net returns (Rs. 7610/ha), B:C ratio (1.27) and RWUE (4.21 kg/ha-mm) as compared to foliar spray after relieving of stress/dry spell (1745 kg/ha). Further, foliar spray of 0.5% water soluble complex fertilizer (19:19:19) during dry spell recorded higher sorghum grain yield

(1875 kg/ha), net returns (Rs.9300/ha), B:C ratio (1.33) and RWUE (4.40 kg/ha-mm) compared to rest of the treatments.

B. On-farm

I. Real-time contingency measures

Delayed onset of monsoon

At Chamua village (Lakhimpur district, Assam), under delayed onset of monsoon by 10 days (14 June), high yielding rice varieties, Dishang (short duration) in upland and TTB-404 (medium duration) in medium land situation gave 63.5 and 66.2% higher grain yield (4940 and 5020 kg/ha), respectively over local var. Mahsuri (3020 kg/ha), with higher net returns (Rs.35340 and 36220/ha) and B:C ratio (1.82 and 1.90).

At Raura & Patauna village (Rewa district, Madhya Pradesh), under delayed onset of monsoon by 12 days (7 July), pigeonpea var. TJT-501 recorded higher seed yield (855 kg/ha), net returns (Rs.36590/ha), B:C ratio (2.81) and RWUE (0.93 kg/ha-mm) compared to local variety (687 kg/ha). Similarly, Rice var. DRT-42 recorded higher grain yield (2280 kg/ha), net returns (Rs.25382/ha), B:C ratio (2.59) and RWUE (2.58 kg/ha-mm) followed by varieties Danteshwari (2120 kg/ha) and Sahbhagi (2050 kg/ha) compared to var. IR-64 (1550 kg/ha) (Table).

Early season drought

At Vannedoddi village (Anantapuramu district, Andhra Pradesh), opening of conservation furrows in every row of groundnut and pigeonpea with country plough for *in-situ* moisture during dry spell (12 days) gave 17.7 and 13.5% higher yields (1550 and 1012 kg/ha), net returns (Rs.48750 and 39946/ha), B:C ratio (2.69 and 3.13) and RWUE (2.33 and 1.52 kg/ha-mm) compared to without conservation furrow (1317 and 891 kg/ha),.

At Chamua village (Lakhimpur district, Assam), one supplemental irrigation of 5 cm depth with the water lifting pump from farm pond during dry spell of 17 days gave 19.8% higher rice grain yield (4240 kg/ha), net returns (Rs.35340/ha) and WUE (2.71 kg/ha-mm) as compared to no irrigation (3540 kg/ha).

At Honnutagi village (Vijayapura district, Karnataka), during a dry spell of 20 days at vegetative stage, weeding and intercultivation with bullock drawn hoe increased the yield of pigeonpea by 17.3% (1254 kg/ha), net returns (Rs.51979/ha), B:C ratio (4.06) and RWUE (3.44 kg/ha-mm) as compared to farmers' practice (1070 kg/ha).

Mid season drought

At Tahkapal village (Bastar district, Jagdalpur), supplemental irrigation of 2 cm in rice from harvested rainwater to cope with a dry spell 10 days gave 12.2% higher grain yield (1609 kg/ha), net returns (Rs.9118/ha), B:C ratio (2.30) and WUE (2.48 kg/ha-mm) compared to no supplemental irrigation (1413 kg/ha).

At Honnutagi and Kavalagi villages (Vijayapura district, Karnataka), during a dry spell of 64 days, two supplemental irrigations of 40 mm each with sprinklers from harvested rainwater gave higher yields in pigeonpea (1677 kg/ha) and greengram (1250 kg/ha) respectively, over farmers' practice of no supplemental irrigation (1045 and 775 kg/ha), with higher net returns (Rs.73739 and 65500/ha), B:C ratio (4.98 and 7.89) and WUE (4.61 and 11.46 kg/ha-mm).

At Babhulgaon village (Parbhani district, Maharashtra), to cope with a dry spell of 18 days coinciding with flowering and boll formation stage of cotton, foliar spray of KNO_3 @ 1% recorded 20.5% higher seed cotton yield (1350 kg/ha), net returns (Rs.44925/ha), B:C ratio (2.49) and RWUE (2.36 kg/ha-mm) as compared to without foliar spray (1120 kg/ha).

Terminal drought

At Kalimati/Dholiya village (Banaskantha district, Gujarat), to cope with a dry spell of 15 days, supplemental irrigation from harvested rainwater in farm pond, through drip in castor gave 44.4% higher seed yield (1434 kg/ha) with higher net returns (Rs.52282/ha), B:C ratio (3.03) and WUE (1.62 kg/ ha-mm) compared to no supplemental irrigation (1434 kg/ha).

At Chamua village (Lakhimpur district, Assam), one supplemental irrigation (2 cm) from harvested water in farm pond during the dry spell of 18 days gave 14.8% higher rice grain yield (5540 kg/ha), net returns (Rs.35400/ha) and B:C ratio (1.77) compared to farmers' practice of no supplemental irrigation (4826 kg/ha).

Preparedness

Rainwater management

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

At Warkhed village (Akola district, Maharashtra), *in-situ* moisture conservation with broadbed and furrow (BBF) method of soybean sowing gave 10% higher seed yield (2021 kg/ha) with higher net returns (Rs.60558/ha), B:C ratio (3.46) and RWUE (2.28 kg/ha-mm) compared to farmers' practice of flatbed method (1844 kg/ha).

At Nagla Dulhe Khan village (Agra district, Uttar Pradesh), sowing of pearlmillet with ridger seeder gave 12.1% higher grain yield (2465 kg/ha), net returns (Rs.41096/ha), B:C ratio (3.37) and RWUE (5.34 kg/ha-mm) as compared to broadcasting (2198 kg/ha).

At Patameghpar village (Jamnagar district, Gujarat), ridge and furrow system and earthing for *in-situ* moisture conservation in groundnut recorded higher seed yield (2310 kg/ha) compared to farmers practice (2132 kg/ha) with higher net returns (Rs.78821/ha), B:C ratio (2.48) and RWUE (1.63 kg/ha-mm).

At Kalimati/Dholiya villages (Banaskantha district, Gujarat), *in-situ* moisture conservation in castor with ridge and furrow system recorded higher seed yield (1161 kg/ha) compared to flat bed method (967 kg/ha) with higher net returns (Rs.40571/ha), B:C ratio (2.55) and RWUE (1.31 kg/ha-mm). Similarly, *in-situ* moisture conservation in pearlmillet with compartmental bunding recorded higher grain and fodder yield (1157 and 3084 kg/ha) compared to no compartmental bunding (959 kg/ha), with higher net returns (Rs.22678/ha), B:C ratio (2.00) and RWUE (1.31kg/ha-mm)

Cropping systems

At Warkhed village (Akola district, Maharashtra), soybean + pigeonpea (4:2) intercropping system recorded 6.4% higher soybean equivalent yield (2637 kg/ha) as compared to farmers' practice of soybean + pigeonpea (6:1) system (2480 kg/ha), with higher net returns (Rs. 49231/ha), B:C ratio (2.64) and RWUE (2.43 kg/ha-mm). Similarly, cotton + greengram (1:1) intercropping system gave 32.5% higher cotton equivalent yield (2354 kg/ha), with higher net returns (Rs. 50594/ha), B:C ratio (1.99) and RWUE (2.02 kg/ha-mm) compared to sole cotton (1780 kg/ha).

At Nagla Dulhe Khan village (Agra district, Uttar Pradesh), strip cropping of pearlmillet + clusterbean (4:4) gave 16.3% higher pearlmillet equivalent yield (2575 kg/ha) with higher net returns (Rs.43704/ha) and B:C ratio (3.57) compared to farmers' practice of sole pearlmillet (2215 kg/ha). Similarly, strip cropping of pearlmillet + sesame (4:4) gave 40.7% higher pearlmillet equivalent yield (3025 kg/ha) with higher net returns (Rs.55309/ha) and B:C ratio (4.46) compared to sole pearlmillet (2150 kg/ha).

At Chikkamaranahalli village (Bengaluru rural district, Karnataka), fingermillet (MR-1) + pigeonpea (BRG-5) (8:2) intercropping system recorded 20.2% higher fingermillet equivalent yield (2833 kg/ha), net returns (Rs.50335/ha), B:C ratio (2.30) and RWUE (5.95 kg/ha-mm) as compared to farmers' practice of fingermillet + *akkadi* (multiple crops) (2356 kg/ha).

At Muttukrishnapuram village (Thoothukudi district, Tamil Nadu), cotton + onion (2:1) intercropping system recorded higher cotton equivalent yield (2170 kg/ha), net returns (Rs.57840/ha), B:C ratio (2.05) and RWUE (4.97 kg/ha-mm) as compared to sole cotton (920 kg/ha).

Nutrient management

At Vannedoddi and Bachupalli villages (Anantapuramu district, Andhra Pradesh), soil test based fertilizer application + P biofertilizer consortium recorded higher groundnut pod yield (1668 kg/ha and 1718 kg/ha), net returns (Rs.39608 and 43789/ha), B:C ratio (1.78 and 1.90) and RWUE (2.92 and 3.14 kg/ha-mm) compared to farmers' practice of blanket fertilizer application (1420 and 1449 kg/ha).

At Mudalapalaya village (Bengaluru rural district, Karnataka), in finger millet (MR-1) + pigeonpea (BRG-5) (8:2) intercropping system, 100% RDF (50:40:37.5 kg NPK/ha) + 12.5 kg/ha $ZnSO_4$ recorded maximum grain equivalent yield (3199 kg/ha), net returns (Rs.65504/ha) and B:C ratio (2.67) compared to application 100% RDF alone (2318 kg/ha).

Energy management

At Vannedoddi village (Anantapuramu district, Andhra Pradesh), the actual field capacity, seed rate and energy requirement of the tractor drawn Ananta planter was recorded as 7 ha/day, 120-130 kg/ha and 435.82 MJ/ha, respectively. The saving in cost of operation and labour was 35% and 75-80%, respectively. Sowing of groundnut with tractor drawn Ananta planter recorded higher pod and haulm yield (1496 and 3100 kg/ha) and net returns (Rs.64245/ha), over farmers' practice (1375 and 2988 kg/ha).

At Babhulgaon village (Parbhani district, Maharashtra), soybean sowing using BBF planter recorded higher seed yield (1185 kg/ha), net returns (Rs.24463/ha), B:C ratio (2.25) and RWUE (2.07 kg/ha-mm) with field efficiency of 4.5 hr/ha and energy use efficiency of 2.28 compared to farmers' practice of flat bed sowing with seed drill (930 kg/ha).

Alternate land use system

At Budhadani village (Kandhamal district, Odisha), mango + turmeric system gave higher mango equivalent yield (11000/ha), net returns (Rs.160000/ha), B:C ratio (3.67) and RWUE (7.33 kg/ha-mm) compared to farmers' practice of sole mango (2000 kg/ha).

At Kadesara Kalan village, during the 8^{th} year in a agri-pasture system, plant height (6.2 m), collar diameter (23.5 cm), DBH (14.9 cm), fruit yield of Aonla (11400 kg/ha) and fodder yield (5.1 t/ha) were maximum in contour staggered trenches. The yield of Aonla was also higher in continuous trenches (10330 kg/ha) compared to other treatments.

NICRA-Strategic research

Evaluation of the performance of different crops under organic, inorganic and integrated production systems showed that the seed yield of sunflower was similar under organic and inorganic management (971-995 kg/ha) but less than integrated management (1031 kg/ha). However, different production systems had no significant effect on seed yields of greengram (663-712 kg/ha) and pigeonpea (510-553 kg/ha). Different production systems had no significant effect on soil pH and available Mn. However, plots under organic management recorded significantly higher soil organic C (0.63%), compared to inorganic and integrated production systems. The plots under organic

management recorded higher steady infiltration rate (126.3 mm/hr), cumulative infiltration (55.9 cm), mean weight diameter (0.78 mm) and stable aggregates (22.5%) compared to other production systems. Similarly, the plots under organic management recorded higher microbial biomass carbon (324 µg/g soil) compared to integrated (318 µg/g soil) and inorganic (281 µg/g soil) production systems.

Village Climate Risk Management Committee (VCRMC)

VCRMCs established in each NICRA village proved to be an effective village level institution in identification of beneficiaries and implementation of various climate risk resilient interventions such as contingency crop planning, soil and crop based interventions and efficient functioning of custom hiring centers.

Custom Hiring Centre (CHC)

CHCs helped in hiring the need based implements/machinery by resource poor farmers at affordable cost and carrying out land preparation, timely and precision sowing covering large area in short time and other agricultural operations with high energy efficiency. During 2019-20, more than 950 ha area was covered for various agricultural operations in 55 villages through CHCs and significantly contributed to alleviate labour shortage during peak demand period.

Village seed bank

Participatory village level seed production of short duration, drought and flood tolerant varieties of different field crops was taken up in NICRA villages. Efforts were made to provide the seed of alternative crops and varieties of the rainfed crops to address the problem of seed unavailability. During the year, about 47.0 tons seed of different rainfed crops was produced/maintained in different NICRA villages.

Fodder bank

At Naiwan and Achalpur, Hoshiarpur district seed of improved variety of pearlmillet (FBC 16) was provided and hybrid Napier cuttings were planted on the field bunds of the farmers. At Chikkamaranahalli village, Bengaluru Rural district, farmers were supplied with seeds of *Stylosanthes hamata* for sowing on the bunds to establish perennial fodder source and to stabilize bunds. The fodder was used for feeding small ruminants. Sub sequently, fodder maize (South African Tall) was grown in an area of 4 ha (38708 kg/ha) in 20 farmers' fields produced for realizing better fodder supply to milch animals in the cluster, 47064 kg/ha of fodder bajra and 2717 kg/ha of dry fodder of finger millet was produced during the year. At Tahakpal village, Bastar district farmers produced seed of *Stylosanthes* (64 kg), hybrid Napier bajra (10 kg), berseem (44 kg), perennial sorghum (17 kg) and fodder sorghum (52 kg). At Babhulgaon village Parbhani district, about 1200 kg of *kharif* sorghum and 4200 kg of *rabi* sorghum was produced. At Chamua village Lakhimpur district, in collaboration with AICRP on Forage Crops, Jorhat Centre, AAU, three species of perennial fodder varieties viz. Hydrid Napier (Variety: CO-2 and CO-4), Congo signal and Setaria are being grown in the fodder bank. Cultivation of mixed fodder (sorghum + pearlmillet + cowpea) was demonstrated in 5 ha in Khaner and Madana villages, Samba district. In Kadesara kala village, Lalitpur district, about 10 tons of hybrid napier slips were sold to farmers of different villages. Further about 150 tons of BN hybrid green fodder, 1.0 ton of silage and 8.0 q urea treated straw was produced during the year.

Agro-advisories/Agromet advisories

Real time contingency measures were advised for implementation in all the villages through display of weather information and agro-advisories on black boards, SMS service through mobiles and All India Radio. During 2019-20, timely agromet advisories were given in collaboration with AICRPAM centres in adopted villages of Akola, Anantapuramu, Bengaluru Rural, Kovilpatti, Parbhani, Solapur and Vijayapura districts.

Soil health cards

During the year, 1135 soil health cards were provided in the adopted villages of Ananthapuramu, Ballowal Saunkhri, Bengaluru, Chianki, Jhansi, Rajkot, Rakh Dhiansar, Rewa, SK Nagar and Solapur.

Trainings/Field visits/Field days

During the year, 67 trainings and 11 field days/exposure visits were organized by the centres which benefitted 4000 stakeholders including farmers.

Collaboration with AICRPAM and KVKs

Agromet advisories from common centres of AICRPDA-AICRPAM were issued by AICRPAM centres in AICRPDA NICRA villages. Similarly, NICRA-KVKs in the domain districts of AICRPDA centres (Akola, Anantapuramu, Bengaluru, Biswanath Chariali, Chianki, Hisar, Indore, Jagdalpur, Jhansi, Kovilpatti, Parbhani, Rajkot, Rakh Dhiansar, SK Nagar, Solapur, Varanasi and Vijayapura) were given technical inputs on real time contingency planning and doable technologies.

Linkages for operationalizing district agriculture contingency plans

During 2019-20, the scientists of the centres were actively involved in updating the district level crop contingency plans, involving scientists and officials from KVKs and line departments in respective states. Further, the scientists from centres also participated in state level meetings organized in 5 states (Maharashtra, Odisha, Karnataka, Gujarat and Andhra Pradesh) for operationalization of district agriculture contingency plans and contributed in developing action plans.

Climate change/variability impacts are evident in Indian agriculture. The projected impacts are likely to further aggravate yield fluctuations of many crops with impact on food security and prices. Climate variability impacts are more pronounced in rainfed agriculture due to delayed onset of monsoon, deficit rainfall and long dry spells. In the XI Five Year Plan, ICAR launched the National Initiative on Climate Resilient Agriculture (NICRA). Under Technology Demonstration component of NICRA, the climate risk resilient technologies are being demonstrated in farmers' fields in a participatory mode in vulnerable districts in the country.

AICRPDA-NICRA Programme

The All India Coordinated Research Project for Dryland Agriculture (AICPRDA), a natural resource management project, has the network of 19 main, 3 sub and 9 voluntary centres (Table 1; Fig.1). The AICRPDA network centres have generated agroecology-specific doable rainfed technologies/practices which basically address rainwater harvesting and reuse for higher resource use efficiency and water productivity, efficient crops/varieties sand cropping systems for higher yield and income, contingency crop planning, integrated nutrient management, farm mechanization with cost effectiveness and timeliness, and alternate land use systems for diversification, higher income and resource use efficiency.

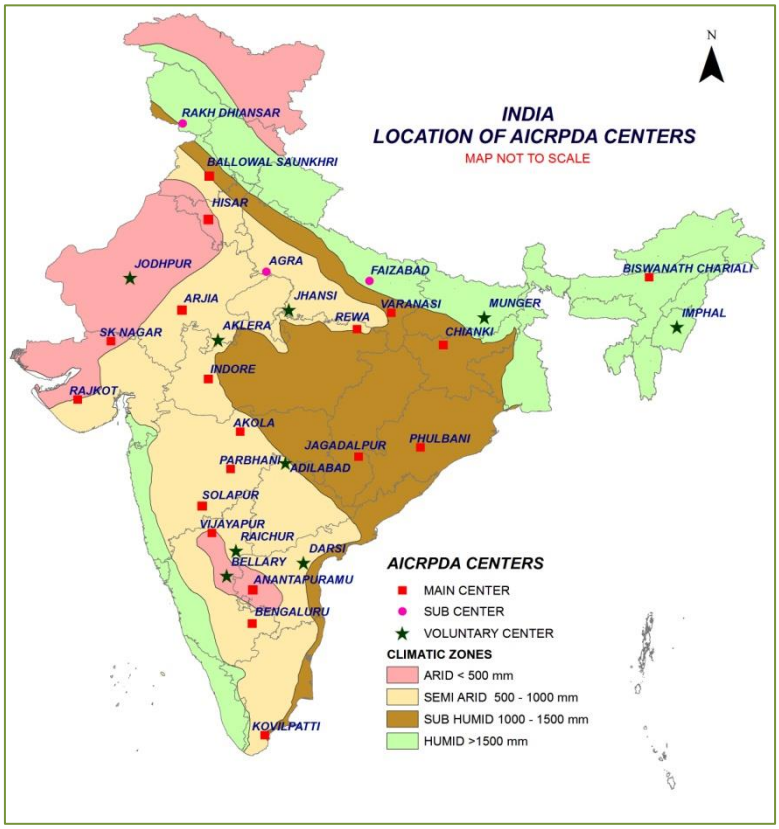


Fig.1: Location map of AICRPDA Network Centres

Table 1: AICRPDA Network Centres - Agro-ecological setting

Name of the Centre	SAU / ICAR Inst/other (Hqrs)	Agro-Climatic Zone (NARP)/ Agro–eco Sub Region(AESR)	Climate**	MARF (mm)	Dominant Soil Type	Predominant Rained Production Systems
Main Centre						
Akola	Dr. PDKV Akola	Western Vidarbha Zone in Maharashtra (6.3)	Semiarid (Hot moist)	824	Vertisols	Cotton
Anantapuramu	ANGRAU, Guntur	Scarce rainfall zone (Rayalaseema) in Andhra Pradesh (3.0)	Arid (Hot)	544	Alfisols	Groundnut
Arjia	MPUAT, Udaipur	Southern zone in Rajasthan (4.2)	Semiarid (Hot dry)	656	Vertisols	Maize
Ballowal Saunkhri	PAU, Ludhiana	Kandi region in Punjab (9.1)	Sub-humid (Hot dry)	1011	Inceptisols	Maize
Bengaluru	UAS_B, Bengaluru	Central, eastern and southern dry zone in Karnataka (8.2)	Semiarid (Hot moist)	926	Alfisols	Fingermillet
Biswanath Chariali	AAU, Jorhat	North Bank plain zone in Assam (15.2)	Humid (Hot)	1990	Alfisols	Rice
Chianki	BAU, Ranchi	Western plateau zone of Jharkhand(11.0)	Subhumid (Hot moist)	1179	Inceptisols	Rice
Hisar	CCSHAU, Hisar	South-western dry zone in Haryana (2.3)	Arid (Hyper)	412	Inceptisols	Pearlmillet
Indore	RVSKVV, Gwalior	Malwa plateau in Madhya Pradesh (5.2)	Semiarid (Hot moist)	958	Vertisols	Soybean
Jagdalpur	IGAU, Raipur	Bastar Plateau zone in Chhattisgarh (12.1)	Subhumid (Hot moist)	1297	Inceptisols	Rice
Kovilpatti	TNAU, Coimbatore	Southern zone of Tamil Nadu (8.1)	Semiarid (Hot dry)	723	Vertisols	Cotton
Parbhani	VNMKV, Parbhani	Central Maharashtra Plateau Zone in Maharashtra (6.2)	Semiarid (Hot moist)	901	Vertisols	Cotton
Phulbani	OUAT, Bhubaneswar	Eastern Ghat Zone in Orissa (12.1)	Subhumid Hot moist)	1580	Oxisols/ Aliosls	Rice
Rajkot	JAU, Junagarh	North Saurashtra zones in Gujarat (5.1)	Semiarid (Hot dry)	590	Vertisols	Groundnut
Rewa	JNKVV, Jabalpur	Keymore plateau and Satpura Hill zone in Madhya Pradesh (10.3)	Subhumid (Hot dry)	1088	Vertisols	Soybean
S.K. Nagar	SDAU, Dantewada	Northern Gujarat in Gujarat (2.3)	Semiarid/ Arid (Hot dry)	670	Entisols	Pearlmillet
Solapur	MPKV, Rahuri	Scarcity zone in Maharashtra (6.1)	Semiarid (Hot dry)	732	Vertisols	*Rabi* Sorghum
Varanasi	BHU, Varanasi	Eastern Plain and Vindhyan Zone in Uttar Pradesh (9.2)	Subhumid (Hot dry)	1049	Inceptisols	Rice
Vijayapura	UAS_D, Dharwad	Northern dry zone in Karnataka (6.1)	Semiarid (Hot dry)	595	Vertisols	*Rabi* Sorghum
Sub Centres						
Agra	RBS Collge, Agra	South–western semiarid zone in Uttar Pradesh (4.1)	Semiarid (Hot dry)	665	Inceptisols	Pearlmillet
Faizabad	NDUAT, Faizabad	Eastern plain zone in Uttar Pradesh (9.2)	Subhumid (Hot dry)	1051	Inceptisols	Rice
Rakh	SKUAS_T,	Low altitude	Semiarid	860	Inceptisols	Maize

Dhiansar	Jammu	subtropical zone in Jammu and Kashmir (14.2)	(Moist dry)			
Voluntary Centres						
Adilabad	PJTSAU, Hyderabad	Godavari zone of Telangana (7.3)	Semiarid	1150	Alfisols/ Vertisols	Cotton
Aklera	Agriculture University, Kota	South eastern plain zone of Rajasthan (5.2)	Semiarid	844	Vertic Inceptisols	Soybean
Ballari	IISWC, Dehradun	Northern dry zone in Karnataka (3.0)	Arid (Hot)	502	Vertisols	*Rabi* Sorghum
Darsi	ANGRAU, Guntur	Krishna-Godavari zone of Andhra Pradesh (7.3)	Semiarid	871	Alfisols/ Vertisols	Pigeonpea
Imphal	CAU, Imphal	Sub-tropical zone of Manipur (17.2)	Perhumid	1372	Inceptisols	Rice
Jhansi	IGFRI, Jhansi	Bundelkhand zone in Uttar Pradesh (4.4)	Semiarid (Hot moist)	870	Inceptisols	*Kharif* Sorghum
Jodhpur	CAZRI, Jodhpur	Arid Western zone of Rajasthan (2.1)	Arid (Hyper)	331	Aridisols	Pearlmillet
Munger	BAU, Sabour	South Bihar Alluvial plain zone of Bihar (13.1)	Subhumid	1143	Inceptisols	Maize
Raichur	UAS, Raichur	North-eastern dry zone of Karnataka (6.2)	Semiarid	621	Vertisols/ Alfisols	*Rabi* sorghum

**Climate details as per AESR details given by NBSSLUP (ICAR); MARF- Mean Annual Rainfall; MRPS- Major Rained Production System

During the first phase (2011-17) of the Technology Demonstration component of NICRA, the AICRPDA-NICRA programme was undertaken at 23 centres. The focus of the programme during the period was not only to demonstrate the climate resilient agriculture technologies but also to institutional mechanisms at the village level for implementation of successful adaptation strategies on a sustainable basis. Since 2011, the AICRPDA network centres initiated both on-station and on-farm research/demonstrations on real-time contingency measures. In the second phase (2017-20), since 2017-18, the on-farm programme as cluster approach was extended to 55 villages in 24 districts across 15 states (Fig.2; Table 2).



Fig.2: Location map of AICRPDA-NICRA villages

Table 2: Details of AICRPDA-NICRA villages

AICRPDA Centre	AICRPDA-NICRA cluster of villages	District	State
Agra	Nagla Duleh khan, Faziyatpura	Agra	Uttar Pradesh
Akola	Warkhed and Kajleshwar	Akola	Maharashtra
Anantapuramu	Vannedoddipally, Bachepalli	Anantapur	Andhra Pradesh
Arjia	Kochariya, Tara ka Kheda and Dhagoliya ka Kheda	Bhilwara, Rajasamand	Rajasthan
Ballowal Saunkhri	Naiwan, Achalpur and Bhawanipur	Hoshiarpur	Punjab

Bengaluru	Chikkamaranahalli, Chikkahosapalya	Bengaluru Rural	Karnataka
Biswanath Chariali	Chamua, Borkhet, Kachikata, Borbali and Nagaya	Lakhimpur	Assam
Chianki	Kumbhi, Chiraunjiya and Bankheta	Garhwa	Jharkhand
Faizabad	Hardoiya and Pero Saraiya	Faizabad	Uttar Pradesh
Hisar	Balawas and Nalwa	Bhiwani	Haryana
Indore	Ningnoti and Bishakhedi	Indore	Madhya Pradesh
Jagdalpur	Gumiyapal and Tandapal	Bastar	Chhattishgarh
Jhansi	Kadesara Kala, Hanauta	Lalitpur	Uttar Pradesh
Kovilpatti	Toppureddiapatti, Muthukrishnapuram, Dharmathanpatti	Thoothukkudi	Tamil Nadu
Parbhani	Babhulgaon, Ujalamba	Parbhani	Maharashtra
Phulbani	Budhadani and Gunjidraga	Kandhamal	Odisha
Rajkot	Pata meghapar and Dangarvala	Jamnagar	Gujarat
Rakh Dhiansar	Khaner and Madana	Samba	Jammu & Kashmir
Rewa	Patauna, Raura and Khira	Rewa	Madhya Pradesh
SK Nagar	Kalimati, Dholia and Ghagu	Banaskantha	Gujarat
Solapur	Narotewadi and Banegoan	Solapur	Maharashtra
Varanasi	Tedha, Patharaha (Hinauti), Gurkhuli and Danti	Mizapur	Uttar Pradesh
Vijayapura	Kavalagi and Honnutagi	Bijapur	Karnataka

For on-farm research/demonstration, the first step was to select a representative village in a most vulnerable district to weather aberrations such as drought, extreme events such as floods etc. In the selected villages, the bottom-up process included baseline survey and PRA to document the initial details about the impacts of weather aberrations on agriculture etc and to understand the farmers' awareness about climate change/variability. To implement RTCPs, innovative Village Level Institutions (VLIs) were constituted in a participatory mode such as Village Climate Risk Management Committee (VCRMC) for deciding on interventions effective implementation and overall smooth functioning, Custom Hiring Centre (CHC) for maintaining and hiring need based arm implements/machinery for timely agricultural operations with precision, cost effectiveness and energy efficiency and Custom Hiring Centre Management Committee to maintain and hire farm implements. The other specific VLIs include fodder banks for fodder production and supply, seed banks for maintaining and supply of quality seed, nutrient banks (vermicomposting units etc) for production and supply of organic fertilizers etc. The approach was to saturate whole village with the climate resilient technologies. The interventions which require high investment like farm pond were planned for few suitable locations in the village. The *in situ* moisture conservation and improved agronomic practices, intercropping and new varieties were demonstrated in a contiguous area in the village. In selection of beneficiaries, the farmers' most vulnerable to climatic variability and small holders were given priority. It was also ensured that the village has control farm/plot/animals for all the implemented interventions in order to assess the impact of interventions in a short period. The action plans were prepared for each village with details of activities along with roles and responsibilities of stakeholders, period and budget for each intervention.

Real Time Contingency Plan Implementation (RTCP) - Concept

In view of frequent weather aberrations around the year in one or other part of the year impacting agricultural production, to minimize the losses in agriculture and allied sectors and to improve the efficiency of the production systems to enhance the production and income, the need was felt to implement contingency measures on real-time basis. Thus, Real Time Contingency Planning is

considered as "Any contingency measure, either technology related (land, soil, water, crop) or institutional and policy based, which is implemented based on real time weather pattern (including extreme events) in any crop growing season".

The RTCP at AICRPDA centres was implemented with two pronged approach i.e. preparedness and real-time contingency measures, with major emphasis i) to establish a crop with optimum plant population during delayed onset of monsoon; ii) to ensure better performance of crops during seasonal drought (early/mid and terminal drought) and extreme events; and iii) enhance performance, improve productivity and income.

RTCP Measures in Rainfed Agriculture

Some of the methods/measures to be adopted as real-time contingency plan implementation during various weather aberrations are presented below:

a. Delayed onset of monsoon

In rainfed areas, as a general rule early sowing of crops with the onset of monsoon is the best-bet practice that gives higher realizable yield. Major crops affected due to monsoon delays are those crops that have a narrow sowing window and therefore cannot be taken up if the delay is beyond this cut-off date. Crops with wider sowing windows can still be taken up till the cut-off date without major yield loss and only the change warranted could be the choice of short duration cultivars. Beyond the sowing window, choice of alternate crops or cultivars depends on the farming situation, soil, rainfall and cropping pattern in the location and extent of delay in the onset of monsoon.

b. Early season drought

Early season drought may at times result in seedling mortality needing re-sowing or may result in poor crop stand and seedling growth. Further, the duration of water availability for crop growth gets reduced due to the delayed start, and the crops suffer from an acute shortage of water during reproductive stage due to early withdrawal of monsoon. The effect of early season drought is less on the crop, because during this period sowing is carried out. Various operations carried out are primary tillage, sowing, fertilizer application and intercultural operations.

Other agronomic measures include resowing within a week to 10 days with subsequent rains for better plant stand when germination is less than 30%, thinning in small-seeded crops, interculture to break soil crust and remove weeds and create soil mulch for conserving soil moisture, avoiding top dressing of fertilizers till favourable soil moisture, opening conservation furrows at 10 to 15 m intervals, ridge and furrow across the slope for effective moisture conservation as well in as rainwater in wide spaced crops (>30 cm), pot watering may be taken up along with gap filling when the crop stand is less than 75% in crops like cotton, foliar spray of 2% urea during prolonged dry spells and providing supplemental irrigation wherever ground / surface water is available.

c. Mid-season drought

Stunted growth takes place if mid-season drought occurs at vegetative phase. If it occurs at flowering or early reproductive stage, it will have an adverse effect on the ultimate crop yield. *In-situ* soil-moisture conservation is a vital component of dryland crop management practices. During mid season drought plant protection, top-dressing of fertilizer, intercultural and supplemental irrigation are the usual practices.

In case of long dry spells, crop based production system (location) related specific contingency plans are needed. Other agronomic measures include repeated interculture to remove

weeds and create soil mulch to conserve soil moisture, thinning, avoiding top-dressing of fertilizers until receipt of rains, opening conservation furrows for moisture conservation, foliar spray of 2% KNO_3 or 2% urea solution or 1% water soluble fertilizers like 19-19-19, 20-20-20, 21-21-21 to supplement nutrition during dry spells, open alternate furrows, surface mulching with crop residues, and providing supplemental irrigation (10 cm depth), if available.

d. Terminal drought

If there is a terminal drought, crop-management strategies like plant protection, soil and water conservation, interculture, supplemental irrigation and harvesting are to be adopted. Terminal droughts are more critical as the grain yield is strongly related to water availability during the reproductive stage. Further, these conditions are often associated with an increase in ambient temperatures leading to forced maturity. The agronomic measure include providing life- saving or supplemental irrigation, if available, from harvested pond water or other sources, harvesting crop at physiological maturity with some realizable yield or harvest for fodder and prepare for winter (*rabi*) sowing in double- cropped areas. Ratoon maize or pearl millet or adopt relay crops as chickpea, safflower, *rabi* sorghum and sunflower with minimum tillage after soybean in medium to deep black soils in Maharashtra or take up contingency crops (horsegram/cowpea) or dual-purpose forage crops on receipt of showers under receding soil moisture conditions.

e. Unseasonal heavy rainfall events

Suggested contingency measures include re-sowing, providing surface drainage, application of hormones/nutrient sprays to prevent flower drop or promote quick flowering/fruiting and plant-protection measures against pest/disease outbreaks with need based prophylactic/curative interventions. At crop maturity stage suggested measures include prevention of seed germination and harvesting of produce.

If untimely rains occur at vegetative stage, the contingency measures include: draining out the excess water as early as possible, application of 20 kg N + 10 kg K/acre (0.4 ha) after draining excess water, application of 50 kg urea + 50 kg muriate of potash (MOP)/acre (0.4 ha) after draining excess water, gap filling either with available nursery or by splitting the tillers from the surviving hills in rice, weed control, suitable plant protection measures in anticipation of pest and disease out breaks, foliar spray with 1% KNO_3 or water-soluble fertilizers like 19-19-19, 20-20-20, 21-21-21 at 1% to support nutrition, need-based fungicidal spray with Copper oxychloride 0.3% or Carbendazim 0.1% or Mancozeb 0.25% 2 to 3 times by rotating the chemicals, interculture at optimum soil-moisture condition to loosen and aerate the soil and to control weeds, earthing up the crop for anchorage etc.

AICRPDA-NICRA Technical Programme 2019-20

The Annual NICRA Review Workshop of All India Coordinated Research Project for Dryland Agriculture (AICRPDA) and All India Coordinated Research Project on Agrometeorology (AICRPAM) was organized at ICAR-CRIDA, Hyderabad during 26-28 May, 2019 with the main objective to critically review the progress at centres and finalize technical programme for 2019-20. Dr. S. Bhaskar, ADG (Agronomy, Agroforestry & Climate Change), NRM Division, ICAR, Dr. Ch. Srinivasa Rao, Director, NAARM, Dr. B. Venkateswarlu, Former Vice Chancellor, VNMKV, Dr. K.P.R. Vittal, Former Director, ICAR-NIAM, Dr. Y.S. Ramakrishna, Former Director, ICAR-CRIDA, Dr. G. Ravindra Chary, Director (Acting), ICAR-CRIDA & Project Coordinator (AICRPDA), Dr. B.V. Ramana Rao, Former PC, AICRPAM, Dr. G.G.S.N. Rao, Former PC, AICRPAM, Dr. V.U.M. Rao, Former PC, AICRPAM, Dr. G. Subba Reddy, Former PC, AICRPDA, scientists from PC Units, AICRPDA & AICRPAM, ICAR-CRIDA, 23 AICRPDA centres and 25

AICRPAM centres participated in the workshop. The AICRPDA-NICRA Technical Porgramme 2019-20 was finalized with the following recommendations.

a. On-station

- Two common experiments would be continued across 23 AICRPDA centres: a) Studies on foliar sprays to cope with midseason drought, and b) Evaluation of crops/varieties including bio-fortified varieties under delayed onset of monsoon.

Table 3: The number of on-station experiments at AICRPDA centres

Climate zone/Centre	No. of experiments	Climate zone/Centre	No. of experiments
Dry Semi Arid Zone (500-750 mm)		**Dry Sub-humid Zone (1000-1250 mm)**	
Arjia	2	Ballowal Saunkhri	3
Ananthapuramu	2	Chianki	2
Agra	2	Faizabad	2
Hisar	2	Varanasi	2
Kovilpatti	2	Rewa	2
Rajkot	2	**Total**	**11**
SK Nagar	3	**Moist Sub-humid zone (1250-1500 mm)**	
Solapur	2	Jagdalpur	2
Vijayapura	3	Phulbani	2
Total	**20**	**Total**	**4**
Moist Semi Arid Zone (750-1000 mm)		**Per- humid Zone (>1500 mm)**	
Akola	4	Biswanath Chariali	2
Bangalore	2	**Total**	**2**
Indore	3	**Grand Total**	**51**
Parbhani	2		
Jhansi	1		
Rakh Dhiansar	2		
Total	**14**		

b. On-farm

- Take up demonstration of bio-fortified varieties of different crops in the adopted villages
- Data on impact of on-farm interventions to be statistically analysed by all the centres for drawing valid conclusions, publication of the data in journals and policy briefs
- Document the details on number of farmers who prefer fodder cultivation, if the onset of monsoon is delayed beyond certain threshold
- ICAR-IGFRI centre to provide suitable planting material of both annual and perennial crops to other centres for strengthening the fodder banks in the adopted villages
- All the centres to bring out a note on what were the RTCPs which worked and which didn't work in farmers' fields, based on the experiences during 2011-19
- Document the seed replacement ratio and extent of adoption of improved varieties in different field crops in the adopted villages
- Location- and situation-specific climate resilient practices to cope with weather aberrations to be documented by all the centres.
- Convergence with NICRA-TDC-KVKs: Details of technologies (both RTCP and preparedness) given to KVKs and their performance/impact TDC villages to be documented
- All the centres to bring out a document on village level institutions (VLIs viz. VCRMC, CHC, seed bank, fodder bank etc): How each of these VLIs was established in the village, mechanisms

for their functioning, year-wise number of farmers benefitted, how VLIs performed during drought and normal years, advantages and limitations.

- Organize *kisan melas* and exposure visit of students in the adopted villages
- Convergence with ongoing central/state programmes/schemes for scaling up of resilient technologies/practices particularly, *in-situ* moisture conservation, farm ponds, implements etc.

Experienced weather at AICRPDA- NICRA villages during 2019-20

During 2019-20, in NICRA villages the onset of monsoon was delayed by 9 (Chamua), 11 (Khaner), 12 (Patuana, Raura & Tahkapal), 13 (Hardoiya), 14 (Babhulgaon), 16 (Balawas & Budhshelly), 20 (Kumbhi), 21 (Tedha) and 29 (Narotewadi) days (Table). Further, there were 1-3 dry spells at different stages of crops in NICRA villages in Akola, Anantapuramu, Bhilwara, Bengaluru rural, Vijayapura, Bhiwani, Bastar, Lalitpur, Parbhani, Jamnagar, Rewa, Banaskanta, Solapur and Mirzapur districts during *kharif* and 1-4 dry spells in Bengaluru rural, Vijayapura, Lakhimpur, Bastar, Thoothukkudi, Parbhani, Kandhamal, Banaskanta, Solapur and Mirzapur districts during *rabi* season.

Table 4: Details of onset of monsoon in AICRPDA-NICRA villages (2019)

Villages & district	Agro-climatic Zone	Onset of monsoon		Delay in onset (days)
		Normal	Actual	
Nagla Dulhe Khan (Agra)	South–western semiarid zone in U.P	2-July	3-July	-
Warkhed (Akola)	Western Vidarbha Zone in Maharashtra	10-June	10-June	-
Vannedoddipally (Ananthapuramu)	Scarce rainfall zone (Rayalaseema) in Andhra Pradesh	7-June	3-June	-
Kochariya (Bhilwara)	Southern zone in Rajasthan	1-July	3-July	-
Lapsiya (Rajsamand)	Southern zone in Rajasthan	2-July	5-July	-
Achalpur & Nainwan (Hoshiarpur)	Kandi region in Punjab	1-July	8-July	7
Chikkamaranahalli (Bengaluru Rural)	Central, eastern and southern dry zone in Karnataka	2-June	3-June	-
Kavalagi (Vijayapura)	Northern dry zone in Karnataka	7-June	2-June	-
Chamua (Lakhimpur)	North Bank plain zone in Assam	5-June	14-June	9
Kumbhi (Garhwa)	Western plateau zone of Jharkhand	10-June	30-June	20
Hardoiya (Faizabad)	Eastern plain zone in Uttar Pradesh	24-June	6- July	13
Balawas & Budhshelly (Bhiwani)	South-western dry zone in Haryana	1-July	17-July	16
Nignoti (Indore)	Malwa plateau in Madhya Pradesh	12-June	14-June	-
Tahkapal (Bastar)	Basthar Plateau zone in Chattisgarh	5-June	17-June	12
Kadesara Kala (Lalitpur)	Bundhelkhand zone in Uttar Pradesh	25-June	16-June	-
Muthukrishnapuram (Thoothukkudi)	Southern zone of Tamil Nadu	19-Oct	16-Oct	-
Babhulgaon (Parbhani)	Central Maharashtra Plateau Zone in Maharashtra	10-June	24-June	14
Budhadani (Kandhamal)	Eastern Ghat Zone in Orissa	10-June	13-June	-
Patameghpar (Jamnagar)	North Saurashtra zones in Gujarat	16-June	18-June	-
Khaner (Samba)	Low altitude subtropical zone in J &K	27-June	9-July	11
Patuana & Raura (Rewa)	Keymore plateau and Satpura Hill zone in Madhya Pradesh	23-June	7-July	12
Kalimati (Banaskantha)	Northern Gujarat in Gujarat	25-June	13-June	-
Narotewadi (Solapur)	Scarcity zone in Maharashtra	7-June	6-July	29
Tedha (Mirzapur)	Eastern Plain and Vindhyan Zone in U.P.	12-June	2-July	21

In general, the total rainfall during *kharif* season (June-September), 2019 was below normal in NICRA villages viz., Achalpur & Nainwan (Hoshiarpur), Kavalagi (Vijayapura), Balawas (Bhiwani), Nignoti (Indore) Kadesara Kala (Lalitpur), Kahner (Samba), Kalimati (Banaskantha) and Narotewadi (Solapur) and remaining 12 villages of NICRA showed above the normal rainfall (Fig. 3). Similarly, during *rabi* season (October -December) 2019, the rainfall was below normal seasonal rainfall in NICRA villages viz., Nagala Dulhe Khan (Agra), Vannedoddi (Anantapuramu), Kochariya (Bhilwara), Chikkamaranahalli (Bengaluru rural), Hardoya (Faizabad), Nignoti (Indore), Kadesara Kala (Lalitpur), Babhulgaon (Parbhani) and Patameghpar (Jamnagar) and remaining 13 villages of NICRA showed above the normal rainfall (Fig. 4).

During 2019, in June, the rainfall was deficit by more than 80% in Hardoya, Kahner and Narotewadi, and more than 60% in Warkhed, Vannedoddi, Kochariya, Achalpur & Nainwan, Patameghpar and Tedha villages. In July, the deficit in rainfall was more than 60% in villages of Chikkmaranahalli and Kalimati. Similarly, in August, villages in Vijayapur, Lakhimpur, Faizabad, Bhiwani and Samba districts recorded more than 50% deficit rainfall. In September, NICRA villages in Hoshiarpur, Bhiwani, Parbhani districts received more than 50% deficit rainfall. Similarly, in October, 7 villages in Agra, Bhilwara, Hoshiarpur, Faizabad, Indore, Lalitpur and Parbhani districts received 80-100% deficit rainfall (Table 5).

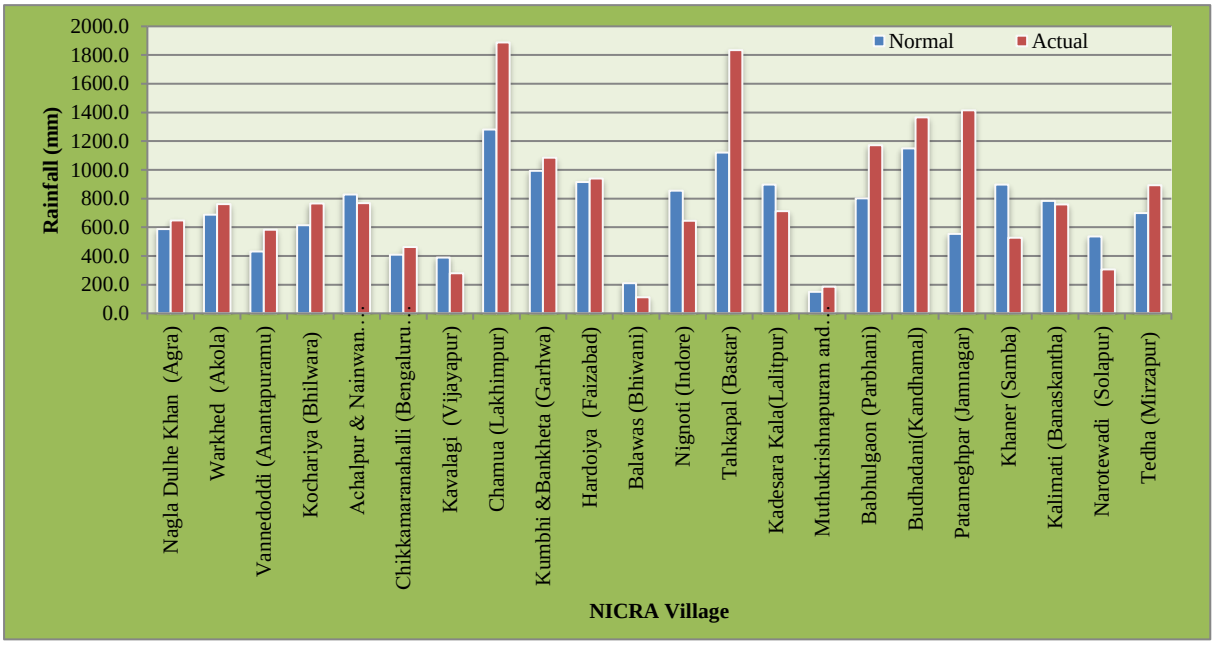


Fig.3: Normal and actual (2019) rainfall in AICRPDA-NICRA villages (June - September)

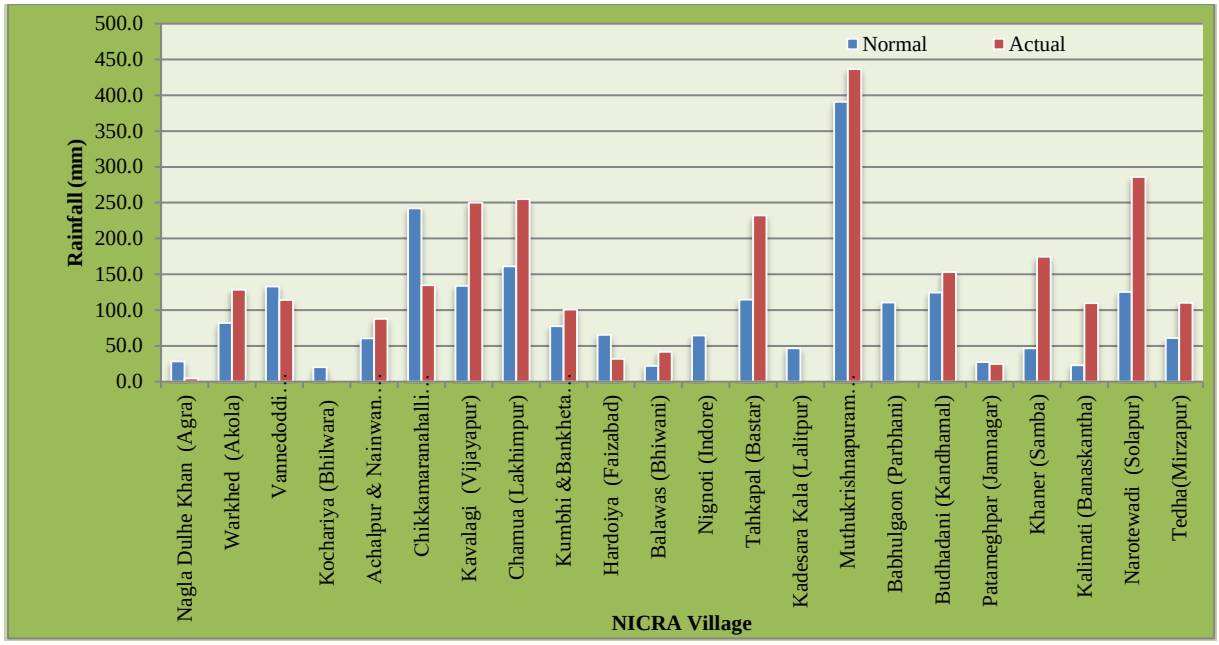


Fig.4: Normal and actual (2019) rainfall in AICRPDA-NICRA villages (October - December)

During 2019-20, the emphasis was on on-farm real-time contingency crop plan implementation and preparedness to cope with weather aberrations with interventions such as rainwater harvesting (*in-situ* and *ex-situ*) and efficient use, drought tolerant crops/varieties, resilient crop management practices, and efficient energy management. The agroclimatic zone wise and centre–wise salient achievements and other activities are presented in the following chapters.

Table 5: Month-wise rainfall in AICRPDA-NICRA villages during June-December, 2019

NICRA Villages & District	June			July			August			September			October			November			December		
	N	A	% Dev	N	A	% Dev	N	A	% Dev	N	A	% Dev	N	A	% Dev	N	A	% Dev	N	A	% Dev
Nagla Dulhe Khan (Agra)	51.5	28.6	-44.5	238.6	237.7	-0.4	207.2	192.3	-7.2	89.8	187.8	109.1	24.6	4.7	-80.9	2.0	0.0	-100.0	1.9	0.0	-100.0
Warkhed (Akola)	151.7	39.0	-74.3	209.2	242.0	15.7	216.0	217.0	0.5	111.1	263.0	136.7	52.3	100.0	91.2	20.5	24.0	17.1	9.2	4.4	-52.2
Vannedoddi (Anantapuramu)	94.0	23.4	-75.1	97.0	75.4	-22.3	97.0	154.2	59.0	142.0	329.8	132.3	21.0	80.0	281.0	107.0	23.8	-77.8	5.0	10.4	108.0
Kochariya (Bhilwara)	73.5	0.8	-99.0	195.6	217.7	11.3	248.8	389.4	56.5	96.6	157.2	62.7	9.6	0.0	-100.0	6.8	0.0	-100.0	3.8	0.0	-100.0
Achalpur & Nainwan (Hoshiarpur)	106.7	38.0	-64.4	274.7	237.4	-13.6	296.2	430.2	45.2	151.1	61.9	-59.0	26.8	0.0	-100.0	6.9	16.1	133.3	26.8	71.7	167.5
Chikkamaranahalli (Bengaluru Rural)	58.9	82.0	39.2	80.4	31.0	-61.4	131.4	161.0	22.5	139.0	189.0	36.0	154.1	132.0	-14.3	61.3	3.0	-95.1	26.8	0.0	-100.0
Kavalagi (Vijayapur)	85.4	97.2	13.8	72.5	82.0	13.1	78.0	7.1	-90.9	151.6	93.0	-38.7	97.3	218.2	124.3	29.5	32.0	8.5	7.2	0.0	-100.0
Chamua (Lakhimpur)	359.6	366.6	1.9	363.9	986.0	171.0	315.5	45.0	-85.7	241.1	490.3	103.4	130.1	127.0	-2.4	20.2	6.0	-70.3	10.8	122.0	1029.6
Kumbhi &Bankheta (Garhwa)	162.1	107.5	-33.7	319.5	291.0	-8.9	358.8	461.7	28.7	152.1	225.0	47.9	62.1	59.0	-5.0	9.6	0.0	-100.0	5.9	42.0	611.9
Hardoiya (Faizabad)	137.4	24.0	-82.5	292.5	396.5	35.6	294.1	123.2	-58.1	191.1	396.0	107.2	50.5	10.0	-80.2	4.0	0.0	-100.0	11.1	22.0	98.2
Balawas (Bhiwani)	20.2	18.5	-8.4	80.2	66.6	-17.0	60.0	17.5	-70.8	50.3	10.2	-79.7	8.6	14.9	73.3	10.0	20.2	102.0	3.4	6.9	102.9
Nignoti (Indore)	120.8	153.5	27.1	260.8	196.6	-24.6	225.4	148.2	-34.3	247.5	147.6	-40.4	39.7	0.0	-100.0	18.3	0.0	-100.0	6.5	0.0	-100.0
Tahkapal (Bastar)	235.5	210.5	-10.6	342.6	592.9	73.1	350.5	554.6	58.2	192.9	475.3	146.4	88.2	226.5	156.8	20.2	0.4	-98.1	6.4	5.5	-13.6
Kadesara Kala (Lalitpur)	95.2	58.5	-38.6	323.1	235.8	-27.0	336.7	185.6	-44.9	141.9	231.9	63.4	18.7	0.0	-100.0	5.7	0.0	-100.0	22.2	0.0	-100.0
Muthukrishnapuram (Thoothukkudi)	11.1	12.7	14.4	19.8	22.0	11.1	35.1	57.4	63.5	84.2	93.1	10.6	198.6	209.9	5.7	138.5	147.2	6.3	53.8	79.7	48.1
Babhulgaon (Parbhani)	172.4	186.9	8.4	225.0	542.5	141.1	235.8	359.1	52.3	167.3	82.3	-50.8	80.4	0.0	-100.0	20.9	0.0	-100.0	9.2	0.0	-100.0
Budhadani (Kandhamal)	188.7	156.2	-17.2	350.4	281.2	-19.7	383.2	503.0	31.3	228.2	425.2	86.3	95.7	137.6	43.8	24.0	0.0	-100.0	5.0	15.6	210.1
Patameghpar (Jamnagar)	102.7	166.0	61.6	252.0	265.0	5.2	103.3	405.0	292.1	96.5	578.0	499.0	21.6	25.0	15.7	5.4	0.0	-100.0	0.3	0.0	-100.0
Khaner (Samba)	95.2	4.5	-95.3	323.1	182.2	-43.6	336.7	170.8	-49.3	141.9	169.2	19.2	18.7	8.3	-55.6	5.7	86.1	1410.5	22.2	80.4	262.2
Kalimati (Banaskantha)	87.3	83.0	-4.9	278.1	100.0	-64.0	275.4	286.3	4.0	142.0	288.8	103.4	19.7	87.0	341.6	2.8	17.6	528.6	0.6	5.0	681.3
Narotewadi (Solapur)	107.1	0.0	-100.0	115.8	92.0	-20.6	139.6	78.5	-43.8	172.7	135.5	-21.5	97.9	286.0	192.1	21.6	0.0	-100.0	6.0	0.0	-100.0
Tedha (Mirzapur)	86.8	18.5	-78.7	283.3	256.1	-9.6	326.9	227.3	-30.5	2.5	391.4	15556.0	49.1	74.1	50.9	7.2	0.0	-100.0	4.6	36.0	682.6

N: Normal A: Actual during 2019 % Dev: % Deviation

1.1 Dry Semi-Arid Zone (500-750 mm)

1.1.1 ARJIA

a. Agro-ecological setting

Arjia is located in north Gujarat plain (inclusion of Aravalli range and east Rajasthan uplands) hot dry semiarid eco-sub region (AESR 4.2) and Southern zone in Rajasthan. Normal annual rainfall is 658 mm. Annual potential evapo-transpiration is 1681 mm. Length of growing period is 90-120 days.

b. On-station experiments

Experienced weather conditions during 2019-20

During the year 2019, the onset of monsoon was early by 5 days (28th June). A rainfall of 1085.5 mm was received which was excess by 427.8 mm compared to normal rainfall of 657.7 mm. During south-west monsoon (June to September), 1029.0 mm rainfall was received which was excess by 414.5 mm (67.5%). During October-December, there was 10.5 mm of rainfall against normal rainfall of 20.2 mm (Fig.5).

Normal onset of monsoon	2 July
Onset of monsoon during 2019	28 June
Annual mean rainfall (mm)	657.7 mm
Actual annual rainfall (mm) during 2019-20	1085.5mm
Mean crop seasonal rainfall during *kharif* and *rabi*	614.5 mm and 20.0 mm
Crop seasonal rainfall during 2019-20 (*kharif* and *rabi*)	1029.0 mm and 10.5 mm

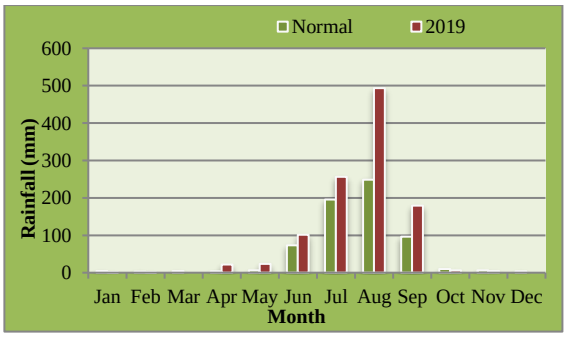


Fig.5: Normal and actual (2019) monthly rainfall at Arjia

Dry spells during crop growing season (2019-20)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
9	8 July - 17 July	Maize, sorghum, greengram and blackgram	Vegetation
26	4 October - 30 October	Maize	Maturity
52	9 November - 31 December	Maize	Maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Terminal drought	Maize	Grain filling	Foliar spray

c. On-farm demonstrations

Village profile

The program is being implemented in Kochariya village, Suwana block, Bhilwara Tehsil & district and in Lapsiya village, Railmagra block, Rajsamand district, Rajasthan. The total cultivated area is 287 and 253 ha at Kochariya and Lapsiya villages, respectively. The mean annual rainfall is 657.7 mm and 512.9 mm with seasonal rainfall of 603 mm and 474 mm during *kharif* (June-September) at Kochariya and Lapsiya villages, respectively. The major soil types are sandy loam and sandy clay loam in Kochariya and sandy loam in Lapsiya village. The major rainfed crops during *kharif* are maize, blackgram, groundnut in Kochariya while sorghum, maize, blackgram in Lapsiya and during *rabi* are wheat, barley and mustard in both the villages. The ground water table is 210 and 250 m at Kochariya and Lapsiya, respectively. The source of irrigation is dug well and tube well covering 23.9 and 22.1% of cultivated area in village Kochariya and Lapsiya.

Climate vulner*abi*lity in general

The climate in this agro-climatic zone is semiarid. Out of the total annual average rainfall of 657.7 mm, the south-west monsoon contributes 93.1%, north-east monsoon contributes 3.7% and summer contributes 3.2%. The historical rainfall data (of 30 years) indicated that the variability in rainfall during south-west monsoon was 17.8% deficit of the average rainfall. The onset (south-west) of monsoon was during 26 SMW. The dry spells during crop season were experienced for the past 15 years. They occurred in September and at reproductive stages of the major rainfed crops. The soil moisture status was deficit during reproductive stages of major rainfed crops. During *rabi*, there was a decrease of 0.96ºC in maximum temperature as compared to normal for the past 20 years. The extreme events like unusual and high intensity rainfall in short span were increasing during August. The area has been experiencing drought during *kharif* and frost during *rabi*. There has been considerable shift in rainfall pattern which resulted to change in climate from dry sub-humid to semi-arid and sowing window has been shifted by almost one week to 25 SMW for the dominant rainfed crops.

Experienced weather conditions during 2019-20

During 2019, in Lapsiya village, onset of monsoon was delayed by 2 days (5 July). A rainfall of 758.6 mm was received which was excess by 100.9 mm compared to normal (657.7 mm). During south-west monsoon (June to September), 727.6 mm rainfall was received which was excess by 113.1 mm (18.4%) than normal rainfall of 614.5 mm. During *rabi*, 14.2 mm of rainfall was received against normal of 20.2. During summer 14.5 mm of rainfall was received against the normal of 15.1 mm (Fig.6).

Normal onset of monsoon	2 July (Bhilwara and Rajasmand)
Onset of monsoon during 2019	3 July (Bhilwara and Rajasmand)
Annual mean rainfall (mm)	512.9 mm (Rajasmand, Lapsya)
Actual annual rainfall (mm) during 2019-20	758.6 mm (Rajasmand, Lapsya)
Mean crop seasonal rainfall during *kharif* and *rabi*	714.8 mm and 20.0 mm
Crop seasonal rainfall during 2019-20	762.98 mm (Kocharia and Lapsya)

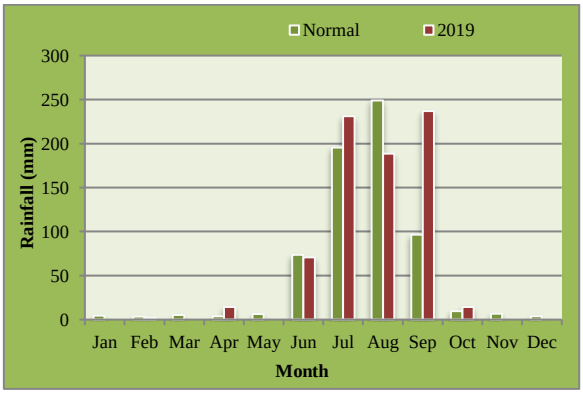


Fig.6: Normal and actual (2019) monthly rainfall at Lapsiya

Dry spells during crop growing season (2019-20)

Dry spell		Crop	Stage of the crop
Duration (days)	**Dates & months**		
10	8 -17 July	Maize , sorghum, greengram and blackgram	Vegetative
26	4-30 October	Maize	Maturity
52	9 November - 31 December	Maize	Maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Terminal drought	Maize	Grain filling	Foliar spray

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Terminal drought

At village Tara ka Kheda (Lapsiya), supplemental irrigation (5mm) from harvested water in farm pond, during dry spell at 45 DAS gave 21.6% higher MGEY of maize + blackgram (2:2) intercropping system (3074 kg/ha) over farmers' practice of no supplemental irrigation (2528 kg/ ha). Similarly, at village Kochariya, supplemental irrigation gave 30.5% higher MGEY of maize + blackgram (2:2) intercropping system (3432 kg/ha) over farmers' practice (2631 kg/ha). At new village Dagoliya ka kheda, supplemental irrigation during dry spell at 42 DAS gave 26.2% higher MGEY of maize + blackgram (2:2) intercropping system (3147 kg/ha) with higher net returns, B:C ratio and RWUE when compared to farmers practice without any supplemental irrigation (2494 kg/ha) (Table 6).

Table 6: Yield and economics of maize + blackgram (2:2) intercropping system with supplemental irrigation

Treatment	MGEY (kg/ha)		RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Grain	Straw				
Tara ka Kheda (Lapsiya) village						
With supplemental irrigation	3074	4535	6.22	18910	38539	3.04
Without supplemental irrigation	2528	3835	5.11	18160	29343	2.62
Kocharia village						
With supplemental irrigation	3432	4883	6.04	19650	44034	3.24
Without supplemental irrigation	2631	4168	4.63	17430	32453	2.86
Dagoliya ka Kheda village						
With supplemental irrigation	3147	4627	6.36	19120	39651	3.07
Without supplemental irrigation	2494	3869	5.04	17980	29096	2.62

MGEY: Maize grain equivalent yield



Maize + blackgram (2:2) under supplemental irrigation

At Lapsiya village, supplemental irrigation (5 mm) from harvested rain water in farm pond, during dry spell at 45 DAS gave 23.2% higher GPEY of groundnut + sesame (6:2) intercropping system (1603 kg/ha) over farmers' practice of no supplemental irrigation (1302 kg/ha). Similarly, at village Kochariya (Bhilwara), supplemental irrigation in groundnut + sesame (6:2) intercropping system gave 21.7% higher GPEY (1707kg/ha) over farmers' practice (1403 kg/ha). At new village Dagoliya ka kheda, supplemental irrigation during dry spell at 35 DAS gave 20.15% higher GPEY in groundnut + sesame (6:2) intercropping system (1479 kg/ha) over farmers' practice (1231 kg/ha) with higher net returns, B:C ratio and RWUE (Table 7).

Table 7: Yield and economics of groundnut + sesame (6:2) intercropping system as influenced by supplemental irrigation

Treatment	GPEY (kg/ha)		RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Pod	Stover				
Tara ka Kheda (Lapsiya) village						
With supplemental irrigation	1603	1840	2.19	21340	39182	2.95
Without supplemental irrigation	1302	1707	1.62	20670	25694	2.37
Kocharia village						
With supplemental irrigation	1707	1929	2.62	23500	57738	3.71
Without supplemental irrigation	1403	1724	1.96	20350	40065	2.97
Dagoliya ka Kheda village						
With supplemental irrigation	1479	2027	2.99	20130	58946	3.93
Without supplemental irrigation	1231	1572	2.49	18760	46604	3.48

GPEY: Groundnut pod equivalent yield



Groundnut+sesame under supplemental irrigation

Preparedness

Rainwater management

In village Tara ka Kheda (Lapsiya), *in- situ* moisture conservation practices (chiselling, peripheral bunding and ridging 30 DAS) in maize gave 23.7% higher grain yield (2770 kg/ha) over farmers practice of cultivator twice (2240 kg/ha), with higher net returns (Rs.34185/ha), B:C ratio (2,89) and RWUE (7.32 kg/ha-mm). Similarly, at village Kochriya (Bhilwara), *in- situ* moisture conservation practices gave 27.2% higher maize grain yield (2963 kg/ha) over farmers' practice (2330 kg/ha), with higher net returns (Rs.39345/ha), B:C ratio (3.17) and RWUE (5.21 kg/ha-mm). Further, at new village Dagoliya ka kheda, improved practices in maize gave 24.3% higher grain yield (2218 kg/ha) over farmers' practice (1784 kg/ha) with higher net returns, B:C ratio and RWUE (Table 8).

Table 8: Yield and economics of maize as influenced by *in-situ* moisture conservation

Treatment	Yield (kg /ha)			RUWE (kg/ha/ mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ ha)	B: C ratio
	Grain	Straw	Mean (9 years)				
Tara ka Kheda (Lapsiya)							
With in-situ practices	2770	4290	1900	7.32	18090	34185	2.89
Without in-situ practices	2240	3770	1542	5.92	17630	25395	2.44
Kochriya							
With in-situ practices	2963	5215	3685	5.21	18130	39345	3.17
Without in-situ practices	2330	4353	3032	4.10	17260	28571	2.66
Dagoliya ka kheda							
With in-situ practices	2218	4045	2315 (3)*	4.48	15620	27755	2.78
Without in-situ practices	1784	3340	1864 (3)	3.61	14100	21006	2.49

***Mean of 3 years**



In-situ moister conservation in maize

In village Tara ka Kheda (Lapsiya), *in- situ* moisture conservation practices viz., chiselling, peripheral bunding and ridging 30 DAS in maize gave 26.6% higher grain yield (2670 kg/ha) over farmers' practice of cultivator twice (2110 kg/ha), with higher net returns (Rs.28250/ha), B:C ratio (2.67) and RWUE (5.40 kg/ha-mm). Similarly, at village Kochriya (Bhilwara), *in- situ* moisture conservation practices gave 32.3% higher maize grain yield (2963 kg/ha) over farmers' practice (2240 kg/ha), with higher net returns (Rs.27153/ha), B:C ratio (2.44) and RWUE (4.74 kg/ha-mm). Further, at new village Dagoliya ka kheda, improved practices in maize gave 25.3% higher grain yield (2730 kg/ha) over farmers' practice (2180 kg/ha) with higher net returns (Rs.28300/ha), B:C ratio (2.62) and RWUE (5.52 kg/ha-mm) (Table 9).

Table 9: Yield and economics of sorghum as influenced by *in-situ* moisture conservation

Treatment	Yield (kg /ha)			RUWE (kg/ha/mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ ha)	B: C ratio
	Grain	Straw	Mean (9 years)				
Tara ka Kheda (Lapsiya)							
With *in-situ* practices	2670	5240	2300	5.40	16890	28250	2.67
Without in-situ practices	2110	4220	1834	4.27	15640	20230	2.29
Kochriya							
With *in-situ* practices	2693	5493	2605**	4.74	18900	27153	2.44
Without *in-situ* practices	2240	4450	2170**	3.94	17450	20555	2.18
Dagoliya ka kheda							
With *in-situ* practices	2730	5200	2591*	5.52	17460	28300	2.62
Without *in-situ* practices	2180	4070	2067*	4.41	16540	19795	2.20

*Mean of 3 years; ** Mean of 2 years



In-situ moisture conservation in sorghum

Cropping systems

At village Tara ka Kheda (Lapsiya), among improved varieties of maize, PM-3 gave 27.3% higher grain yield (2450 kg/ha) followed by DHM-121 which gave 24.8% higher yield (2403 kg/ha) over local cultivar (1925 kg/ha). Similarly, at village Kochriya (Bhilwara), improved variety of maize, DHM-121 followed by PM-3 gave 22.4 and 16.3% higher grain yield (2525 and 2398 kg/ha) over local variety (2063 kg/ha). At new village Dagoliya ka kheda, improved variety of maize, PM-3 followed by DHM-121 gave 39.6 and 24.3% higher grain yield (2490 and 2218 kg/ha) over local cultivar (1784 kg/ ha), with higher net returns (Rs.240099 and 33520/ha) and B:C ratio (3.81 and 3.15) (Table 10).

Table 10: Yield and economics of maize varieties

Variety	Yield (kg /ha)		RUWE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ ha)	B: C ratio
	Grain	Straw				
Tara ka Kheda (Lapsiya)						
DHM-121	2403	4162	4.86	14620	38070	3.60
PM-3	2450	4163	4.95	13560	39966	3.95
Local	1925	3382	3.89	13240	29096	3.20
Kochriya						
DHM-121	2525	4135	4.44	15460	39317.5	3.54
PM-3	2398	3988	4.22	16270	35896	3.21

Local	2063	3900	3.63	14230	31820	3.24
Dagoliya ka kheda						
DHM-121	2218	4045	4.48	15620	33520	3.15
PM-3	2490	4210	5.03	14250	40099	3.81
Local	1784	3340	3.61	14100	25644	2.82



Maize at Tara ka kheda

At village Tara ka Kheda (Lapsiya), among improved varieties of sorghum, CSV-17 gave 25.4% higher grain yield (2345 kg/ha) compared to local cultivar (1870 kg/ha) with higher net returns (Rs.28030/ha), B:C ratio (2.98) and RWUE (4.74 kg/ ha-mm). Similarly, at village Kochariya (Bhilwara), CSV-15 gave 46.18% higher grain yield (2412 kg/ha) over local variety (1650 kg/ha). At new NICRA village Dagoliya ka kheda, CSV-15 gave 23.12% higher grain yield (2194 kg/ha) over local cultivar (1782 kg/ha) with higher net returns (Rs.26510/ ha), B:C ratio (3.03) and RWUE (4.44 kg/ha-mm) (Table 11).

Table 11: Yield and economics of sorghum varieties

Variety	Yield (kg /ha)		RUWE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B: C ratio
	Grain	Straw				
Tara ka Kheda (Lapsiya)						
CSV-15	2167	3868	4.38	14320	25695	2.79
CSV-17	2345	3740	4.74	14150	28030	2.98
Local	1870	3294	3.78	12780	21635	2.69
Kochriya						
CSV-15	2412	4395	4.25	12980	31783	3.45
Local	1650	3815	2.90	11760	20878	2.78
Dagoliya ka kheda						
CSV-15	2194	3535	4.44	13040	26510	3.03
CSV-17	2191	3740	4.43	13150	26874	3.04
Local	1782	3181	3.60	10970	21938	3.00



Sorghum at Tara ka kheda

At village Tara ka Kheda (Lapsiya), improved variety of groundnut, TG-37A gave 42.5% higher pod yield (1193 kg/ha) over local cultivar (837 kg/ ha) with higher net returns (Rs.58323/ha) and B:C ratio (4.32). Similarly, at village Kochriya, TG- 37A gave 30.8% higher pod yield (1207 kg/ha) over local cultivar (923 kg/ha) with higher net returns (Rs.70147/ha) and B:C ratio (2.12). Similar results were recorded at new NICRA village Dagoliya ka kheda (Table 12).

Table 12: Yield and economics of groundnut varieties

Variety	Yield (kg /ha)		RUWE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ ha)	B: C ratio
	Grain	Straw				
Tara ka Kheda (Lapsiya)						
TG-37A	1193	1713	3.15	18760	58323	4.32
PM-2	1130	1633	2.28	17800	54403	4.11
Local	837	1303	2.21	17620	37008	3.25
Kochriya						
TG-37A	1207	1480	2.12	18760	70147	4.74
PM-1	1167	1510	2.05	17800	68397	4.84
Local	923	1137	1.63	17620	50423	3.86
Dagoliya ka kheda						
TG-37A	1323	2060	2.68	17860	66690	4.73
PM-2	1097	1633	2.22	17640	52243	3.96
Local	907	1543	1.83	16230	42028	3.59

At Tara ka Kheda (Lapsiya), blackgram variety, PU-01 gave 48.76% higher seed yield (540 kg/ha) as compared to local cultivar (363 kg/ha) with higher net returns (Rs.24700/ha) B:C ratio (2.88) and RWUE (1.09 kg/ha-mm). Similarly, at village Kochriya improved blackgram cultivar, PU-01 gave 35.6% higher seed yield (633 kg/ha) over local cultivar (467 kg/ha) with higher net returns (Rs.34667/ ha) and B:C ratio (4.60). Further, At new NICRA village Dagoliya ka kheda, improved variety of blackgram, PU-31 gave 43.96% higher seed yield (537 kg/ha) over the local cultivars (373 kg/ha) (Table 13).

Table 13: Yield and economics of blackgram varieties

Variety	Yield (kg /ha)		RUWE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ ha)	B: C ratio
	Grain	Straw				
Tara ka Kheda (Lapsiya)						
PU-01	540	907	1.09	13120	24700	2.88
Local	363	667	0.73	12230	13387	2.09
Kochriya						
PU-01	633	1043	1.11	9630	34667	4.60
Local	467	820	0.82	8410	24383	3.90

Dagoliya ka kheda						
PU-31	537	890	1.09	12890	24663	2.91
Local	373	633	0.75	12370	13797	2.12



Blackgram at Kochriya

At Tara ka Kheda (Lapsiya), sesame variety, RT-351 gave 15.0% higher seed yield (238 kg/ha) as compared to local cultivar (207 kg/ha) with higher net returns (Rs.35900/ha), B:C ratio (3.95) and RUWE (0.63 kg/ha-mm). Similarly at new NICRA village Dagoliya ka kheda, improved variety of sesame RT-351 gave 39.2% higher seed yield (213 kg/ha) over the local cultivars (153 kg/ha) (Table 14).

Table 14: Yield and economics of sesame varieties

Variety	Yield (kg /ha)		RUWE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ ha)	B: C ratio
	Grain	Straw				
Tara ka Kheda (Lapsiya)						
RT-351	238	403	0.63	12170	35900	3.95
Local	207	317	0.55	11540	30110	3.61
Dagoliya ka kheda						
RT-351	213	373	0.56	11750	31290	3.66
Local	153	267	0.41	10420	20513	2.97



Sesame at Kochriya

At Tara ka Kheda (Lapsiya**)** village, maize + blackgram (2:2) intercropping system gave 33.2% higher MGEY (2883 kg/ha) with higher net returns (Rs. 34790/ha) and B:C ratio (3.21) compared to farmers' practice of mixed cropping of maize and blackgram (2164 kg/ha). Similarly, at Kochriya village, maize + blackgram (2:2) intercropping system gave 32.3% higher MGEY (2953 kg/ha) over farmers' practice (2223 kg/ha). Further, at Dagoliya ka kheda village, intercropping system of maize + blackgram (2:2) gave 34.9% higher MGEY (2859 kg/ha), net returns (Rs.31822/ha) and B:C ratio (2.78) over farmers' practice of mixed cropping (2118 kg/ha) (Table 15).

Table 15: Yield and economics of maize + blackgram (2:2) intercropping system

Treatment	MGEY (kg/ha)		RWUE (kg/ha /mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Grain	Straw				
Tara ka kheda						
Maize + blackgram (2:2)	2883	4070	5.83	15740	34790	3.21
Farmers' Practice	2164	3680	4.37	14690	24803	2.69
Kochriya						
Maize + blackgram (2:2)	2953	4387	5.20	16280	36033	3.21
Farmers' Practice	2223	3667	3.91	15460	24833	2.61
Dagoliya ka kheda						
Maize + blackgram (2:2)	2859	3873	5.78	17890	31822	2.78
Farmers' Practice	2118	3197	4.28	17120	20523	2.20

MGEY: Maize grain equivalent yield; Farmers' practice: Mixed cropping of maize and blackgram



Maize + blackgram (2:2) intercropping system

At Tara ka Kheda (Lapsiya) village, improved practice of groundnut + sesame (6:2) intercropping system recorded 23.2% higher GPEY (1603 kg/ha) with net returns of Rs.39182/ha and B:C ratio (2.95) as compared to farmers' practice of mixed cropping (1302 kg/ha). Similarly, at Kochariya village, groundnut + sesame (6:2) intercropping system gave 23.6% higher GPEY (1802 kg/ha) over farmers' practice (1458kg/ha) with higher net returns (Rs.57758/ha) and B:C ratio (3.71). While at Dagoliya ka kheda village, improved practice of groundnut + sesame (6:2) intercropping system recorded 24.3% GPEY (998 kg/ha) with net returns of Rs.30062/ha and B:C ratio (2.70) as compared to farmers' practice (803 kg/ha) (Table 16).

Table 16: Yield and economic of groundnut + sesame (6:2) intercropping system

Treatment	GPEY (kg/ha)		RWUE (kg/ha /mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Grain	Straw				
Tara ka kheda						
Groundnut + sesame (6:2)	1603	1840	2.19	16400	39182	2.95
Farmers' Practice	1302	1507	1. 62	15750	25694	2.37
Kochriya						
Groundnut + sesame (6:2)	1802	1929	2.62	16400	57758	3.71
Farmers' Practice	1458	1724	1. 96	15750	40065	2.97
Dagoliya ka kheda						
Groundnut + sesame (6:2)	998	1149	2.64	17720	30062	2.70
Farmers' Practice	803	878	2.12	19560	18785	1.96

GPEY: Groundnut pod equivalent yield; Farmers' practice: Mixed cropping of groundnut and sesame

At Tara ka Kheda (Lapsiya) village, improved practice of blackgram + sesame (2:2) intercropping system recorded 48.2% higher blackgram seed equivalent yield (668 kg/ha) compared to farmers' practice of mixed cropping of blackgram and sesame (451 kg/ha) with higher net returns (Rs.23353/ha) and B:C ratio (3.01). Similarly, at Kochriya village, blackgram + sesame (2:2) intercropping system gave 30.1% higher blackgram seed equivalent yield (644 kg/ha) over farmers' practice (470 kg/ ha) with higher net returns (Rs.21504/ha) and B: C ratio (2.75). While at Dagoliya ka kheda village, blackgram + sesame (2:2) intercropping system recorded 41.7% higher blackgram seed equivalent yield (625 kg/ha) with higher net returns (Rs.20863/ ha) and B:C ratio (2.70) as compared to farmers' practice of mixed cropping of blackgram and sesame (441 kg/ha) (Table 17).

Table 17: Yield and economics of blackgram+ sesame (2:2) intercropping system

Treatment	Blackgram equivalent yield (kg/ha)		RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Grain	Straw				
Tara ka kheda						
Balckgram + sesame (2:2)	668	903	1.76	11640	23353	3.01
Farmers' Practice	451	639	1.19	11120	12632	2.14
Kochriya						
Balckgram + sesame (2:2)	644	883	1.13	12300	21504	2.75
Farmers' Practice	470	689	0.83	11540	13317	2.15
Dagoliya ka kheda						
Balckgram + sesame (2:2)	625	946	1.65	12300	20863	2.70
Farmers' Practice	441	653	1.16	11240	12084	2.08

Improved practice: Farmers' practice: Mixed cropping of balckgram and sesame

Nutrient management

At village Tara ka Kheda (Lapsiya), application of $ZnSO_4$ @ 25 kg/ha in maize gave 15.5% higher grain yield (2535 kg/ha) with higher net returns (Rs.37994/ha) and B:C ratio (3.18) over farmers' practice of no Zn application (2195 kg/ ha). Similarly at village Dagoliya ka kheda application of $ZnSO_4$ @ 25 kg/ha gave 14.4% higher grain yield (2530 kg/ha) with higher net returns (Rs.38563/ha) and B:C ratio (3.28) over farmers' practice (2213kg/ha) (Table 18).

Table 18: Yield and economics of maize as influenced by application of zinc sulphate

Treatment	Yield (kg /ha)		RUWE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ ha)	B: C ratio
	Grain	Straw				
Tara ka kheda						
25 kg $ZnSO_4$ /ha	2535	4335	5.13	17460	37994	3.18
Control	2195	3768	4.44	16850	31201	2.85
Dagoliya ka kheda						
25 kg $ZnSO_4$ /ha	2530	4370	5.12	16890	38563	3.28
Control	2213	3830	4.47	15430	33100	3.15

1.1.2 ANANTAPURAMU

a. Agro-ecological setting

Anantapuramu is in Rayalaseema–Karnataka plateau (AESR 3). The climate is hot arid. Annual potential evapo-transpiration is 641 mm. Annual average rainfall is 615 mm. Length of growing period is 90-120 days. The predominant soils are shallow red soils.

b. On-station experiments

Experienced weather conditions during 2019-20

During 2019, the onset of monsoon was normal (3rd June). A total rainfall of 752 mm was received which was excess by 182.2 mm (31.9%) compared to normal (570 mm). Out of total rainfall, 396.9 mm was received in *kharif* season which was 44.8 mm excess (12.7%) than normal of 352 mm. In *rabi*, rainfall was 222.9 mm and was excess by 78.9 mm (54.8%) than normal of 144.0 mm and in summer season, 122.4 mm rainfall was received which was excess by 50.9 mm (71.2%) than normal of 71.5 mm (Fig. 7).

Normal onset of monsoon	1-5 June
Onset of monsoon during 2019:	3 June
Annual mean rainfall	570.0 mm
Annual rainfall during 2019-20	752 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	352.0 & 144.0 mm, respectively
Crop seasonal rainfall during 2019-20 (*kharif* and *rabi*)	396.9 & 222.9, respectively

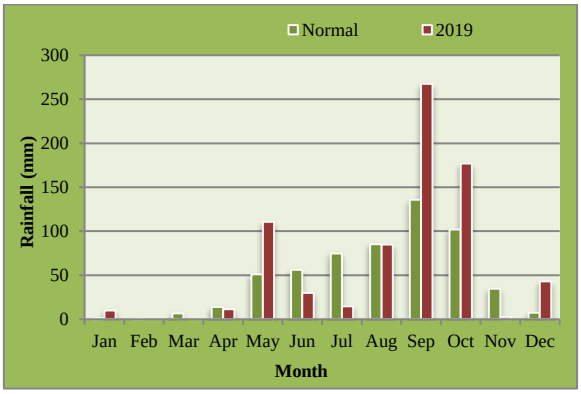


Fig. 7: Normal and actual (2019) monthly rainfall at Anantapuramu

Dry spells during crop growing season (2019-20)

Dry spell		Crop	Stage of the crop
Duration (days)	**Dates & months**		
24	23 August - 15 September	Groundnut	Seedling to vegetative stage
		Pigeonpea	Seedling to vegetative stage
		Castor	Seedling to vegetative stage
28	31 October – 27 November	Groundnut	Pod development to maturity stage
		Pigeonpea	Vegetative stage
		Castor	Primary spike development stage
29	3 December - 31 December	Pigeonpea	Pod initiation and pod development stages
		Castor	Secondary spike development

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented
Mid season drought	Groundnut	Foliar spray of KNO3 @ 0.5%
	Groundnut + pigeonpea (8:1)	Supplemental irrigation

Salient achievements of on-station experiments

Real time contingency planning

Situation: Mid season drought

During *kharif* 2019, there was a long dry spell of 28 days coinciding with pod development and maturity stage of groundnut. The pod yield (1133 kg/ha) of groundnut was improved significantly through foliar spray after relieving of stress/dry spell (with favorable soil moisture) over foliar spray during dry spell (979 kg/ha). Among the treatments, foliar spray of water soluble complex fertilizer (19:19:19) @ 0.5% + recommended dose of micronutrient (ZnSO4 @ 0.2%) after relieving of stress/dryspell recorded higher groundnut pod yield (1267 kg/ha), net returns (Rs.42630/ha), B:C ratio (2.71) and RWUE (2.26 kg/ha-mm) compared to other treatments (Table 19 & 20).

Table 19: Groundnut yield influenced by different chemical foliar sprays *s* during *kharif* 2019

Treatment	Urea @ 1%	Urea @ 2%	Water soluble complex fertilizer (19:19:19) @ 0.5%	Water soluble complex fertilizer (19:19:19) @ 0.5% + $ZnSO_4$ @ 0.2%	$ZnSO_4$ @ 0.2%	Water spray	Control (no spray)	Mean
Foliar spray during dry spell	985	994	995	1015	1008	942	918	979
Foliar spray after relieving of stress/dry spell	1090	1163	1178	1267	1173	1139	920	1133

Table 20: Yield and economics of groundnut crop as influenced by different chemical foliar sprays

Treatment	Yield (kg/ha)			Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Pod 2019	Mean pod (3 years)	Haulm			
Foliar spray during dry spell						
Urea @ 1%	986	1153	1684	27202	2.07	1.76
Urea @ 2%	994	1169	1961	27371	2.04	1.78
Water soluble complex fertilizer (19:19:19) @ 0.5%	995	1185	1959	28917	2.17	1.78
Water soluble complex fertilizer (19:19:19) @ 0.5% + $ZnSO_4$ @ 0.2%	1015	1196	2052	29938	2.20	1.81
$ZnSO_4$ @ 0.2%	1008	1182	2001	29556	2.19	1.80
Water spray	943	1153	1829	26127	2.06	1.69
Control (no spray of any material/water)	918	1130	1841	24901	2.01	1.64
Foliar spray after relieving of stress/dry spell						
Urea @ 1%	1090	1219	1783	32600	2.28	1.95
Urea @ 2%	1163	1264	1959	35817	2.36	2.08
Water soluble complex fertilizer (19:19:19) @ 0.5%	1178	1310	1914	37977	2.53	2.11
Water soluble complex fertilizer (19:19:19) @ 0.5% + $ZnSO_4$ @ 0.2%	1267	1333	2098	42630	2.71	2.26
$ZnSO_4$ @ 0.2%	1173	1256	2074	37952	2.53	2.10
Water spray	1139	1222	2032	36333	2.47	2.04
Control (no spray of any material/water)	921	1132	1888	25145	2.02	1.65

Recommended dose of fertilizer of 20-40-40 N-P_2O_5-K_2O kg/ha






c. On-farm demonstrations

Village profile

The program is being implemented in Vannedoddi village in Gooty Mandal, Ananthapuramu district, Andhra Pradesh. The total geographical area of the village is 810 ha. Predominant rainfed crops in this village are groundnut, pigeonpea, castor, setaria, cotton and sorghum. Groundnut crop covered 65- 70% of total rainfed area. The mean annual rainfall is 657.7 mm with seasonal rainfall of 190.4 mm during *kharif* (June- September).

Climate vulne*rabi*lity in general

The climate in this agro-climatic zone is arid. Out of the total annual average rainfall of 657.7 mm, the south-west monsoon contributes 55.5%, north-east monsoon contributes 26% and summer contributes 18.5%. For the past 15 years, the dry spells during crop season are experienced in August and October and at peg penetration, pod filling, pod development and harvesting stages of groundnut and flowering to reproductive stages in other crops. The onset of monsoon has been shifting (onset being in 25 SMW and withdrawal being 42-43 SMW). The soil moisture status was deficit during pod filling and pod development stages of groundnut.

Experienced weather conditions during 2019-20

During 2019, in Vannedoddi village, onset of monsoon was timely (3 June) and total rainfall received was 769.6 mm which was excess by 151.6 mm than normal rainfall of 618.0 mm. Out of the total annual rainfall, *kharif* season recorded 582.8 mm which was excess by 152.8 mm (35.5%) than normal of 430.0 mm and in *rabi* 114.2 mm rainfall was recorded against normal rainfall of 133.0 mm and during summer, 72.6 mm of rainfall was received against normal rainfall of 53.0 mm (Fig. 8).

Normal onset of monsoon	7-8 June
Onset of monsoon during 2019	3 June
Annual mean rainfall	618.0 mm
Annual rainfall during 2019-20	769.6 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	430.0 and 133.0 mm, respectively
Crop seasonal rainfall during 2019-20 (*kharif* and *rabi*)	582.8 and 114.2 mm, respectively

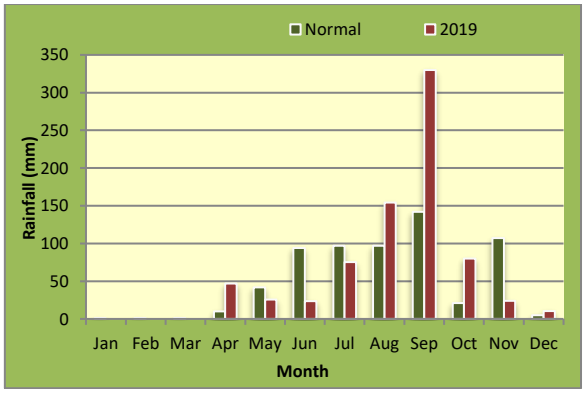


Fig 8: Normal and actual (2019) monthly rainfall at Vannedoddi village

Dry spells during crop growing season (2019-20)

Dry spell		Crop	Stage of the crop
Duration (days)	**Dates & months**		
12	4 August - 15 September	Groundnut	Seedling to vegetative stage
		Pigeonpea	Seedling to vegetative stage
		Castor	Seedling to vegetative stage
26	9 November – 4 December	Groundnut	Pod development to maturity stage
		Pigeonpea	Vegetative stage
		Castor	Primary Spike development stage

Real time contingency practices (RTCP) implemented

Weather aberration	Farming situation/ Soil type	Crop	RTCP implemented
Early season drought	Rainfed, *Alfisols*	Groundnut	Improved Groundnut variety: Harithandhra
	Rainfed, *Alfisols*	Castor	*In-Situ* moisture conservation by conservation furrows
	Rainfed, *Alfisols*	Pigeonpea	*In-Situ* moisture conservation by conservation furrows
Midseason drought	Rainfed, *Alfisols*	Castor	*In-Situ* moisture conservation by conservation furrows
	Rainfed, *Alfisols*	Pigeonpea	*In-Situ* moisture conservation by conservation furrows
	Rainfed, *Alfisols*	Groundnut	Supplementation irrigation through sprinklers from harvested rainwater
	Rainfed, *Alfisols*	Groundnut	Foliar spray in groundnut

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Early season drought

A dry spell of 12 days occurred coinciding with the seedling to vegetative stage of groundnut, castor and pigeonpea crops. Conservation furrows formed at vegetative stage adjacent to every row of groundnut, castor and pigeonpea crops with country plough for *in-situ* moisture conservation gave 17.7, 18.4 and 13.5% higher yields (1550, 437 and 1012 kg/ha) compared to without conservation furrow (1317, 369 and 891 kg/ha), with higher net returns, B:C ratio and RWUE (Table 21).

Table 21: Effect *in-situ* moisture conservation on yield and economics of groundnut, castor and pigeonpe

Crop	Farming situation/ soil type	Intervention	Seed yield (kg/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha - mm)
Groundnut	Rainfed *Alfisols*	With conservation furrows	1550	48750	2.69	2.33
		Without conservation furrows	1317	31100	2.29	1.98
Castor		With conservation furrows	437	- 892	0.94	0.65
		Without conservation furrows	369	- 3204	0.79	0.55
Pigeonpea		With conservation furrows	1012	39946	3.13	1.52
		Without conservation furrows	891	33678	2.75	1.34



Groundnut with conservation furrows



Farmers practice



Castor with conservation furrows



Farmers practice



Pigeonpea with conservation furrows

Situation: Mid season drought

A dry spell of 26 days occurred coinciding with the pod development to maturity stage of groundnut, supplemental irrigation (10 mm) at flowering stage were gave 21.33% higher yield (1500

kg/ha), net returns (Rs.65250/ha), B:C ratio (3.3) and RWUE (1.9 kg/ha-mm) compared to farmers practice of no supplemental irrigation (1180 kg/ha) (Table 22)

Table 22: Yield and economics of groundnut as influenced by supplemental irrigation

Farming situation/ Soil type	Intervention	Yield (kg/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Rainfed, *Alfisols*	Supplemental irrigation @ 10 mm at flowering stage	1500	65250	3.3	1.9
	Farmers' practice (no supplemental irrigation)	1180	49875	2.6	1.53



Supplemental irrigation through sprinklers



Supplemental irrigation through sprinklers

Groundnut crop (Kadiri 6) was subjected to severe moisture stress due to scanty rainfall during peg penetration to pod initiation. Foliar spray of KNO_3 @ 0.5% during peg penetration to pod initiation stage recorded higher groundnut pod yield (1527 and 1552 kg/ha, respectively at Vannedoddi and Bachupalli villages) with higher net returns (Rs.35597 & 37096/ha), B:C ratio (1.76 & 1.80) and RWUE (2.75 & 2.84 kg/ha-mm) when compared to farmers practice of no foliar spray (1345 & 1345 kg/ha) (Table 23).

Table 23: Yield and economics of groundnut (Kadiri 6) as influenced by foliar spray

Village	Farming situation/ soil type	Intervention	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
			Pod	Haulm			
Vannedoddi	Rainfed *Alfisols*	With foliar spray	1527	3071	2.75	35597	1.76
		Without foliar spray	1345	2490	2.42	28397	1.65
Bachupalli		With foliar spray	1552	2988	2.84	37096	1.80
		Without foliar spray	1345	2490	2.42	28397	1.65



Groundnut with foliar spray



Groundnut without foliar spray

Preparedness

Rainwater management

Deep ploughing using chisel plough after pre-monsoon showers in July, recorded higher gorundnut pod and haulm yield (1480 and 3667 kg/ha), net returns (Rs.62400/ha), B:C ratio (2.77) and RWUE (1.82 kg/ha-mm) compared to the farmers' practice of no deep ploughing (1250 and 2850 kg/ha) (Table 24).

Table 24: Effect of *in-situ* moisture conservation on yield and economics of groundnut

Farming situation/ soil type	Intervention	Yield (kg/ha)			Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Pod (2019)	Mean pod (2 yrs)	Haulm				
Rainfed *Alfisols*	Deep tillage with chisel plough	1480	985	3667	22535	62400	2.77	1.82
	Without deep tillage	1250	823	2850	21735	48765	2.24	1.62




***In-situ* moisture conservation by deep ploughing with chisel plough in groundnut**

Cropping systems

Pigeonpea + pearlmillet intercropping system gave higher main crop equivalent yield (546 kg/ha), net returns (Rs.15418/ha), B:C ratio (1.95) and RWUE (0.82 kg/ha-mm) compared to other intercropping systems and farmers practice of sole pigeonpea (Table 25).

Table 25: Evaluation of pigeonpea based intercropping systems in rainfed alfisols

Farming situation/ Soil type	Intervention	Yield (kg/ha)			Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Main crop	Inter crop	MCEY			
Rainfed Alfisols	Pigeonpea + pearlmillet (1:1)	212	775	546	15418	1.95	0.82
	Pigeonpea + foxtailmillet (1:11)	275	625	544	15302	1.94	0.82
	Pigeonpea + castor (1:2)	265	250	411	5088	1.27	0.62
	Farmers' practice (Sole pigeonpea)	467		467	10836	1.66	0.70


Pigeonpea + pearlmillet (1:1)


Pigeonpea + castor (1:2)


Pigeonpea + foxtailmillet (1:11)

Nutrient management

Soil test based fertilizer application + P bio fertilizer consortium recorded higher groundnut pod yield of 1668 kg/ha and 1718 kg/ha in Vannedoddi and Bachupalli villages, respectively. Similarly, soil test based fertilizer application + P bio fertilizer consortium recorded higher net returns, B:C ratio and RWUE compared to farmers practice (Table 26).

Table 26: Effect of P bio fertilizer consortium with soil test based fertilizer (STBF) application on yield and economics of groundnut (Kadri 6)

Village	Farming situation/ soil type	Intervention	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
			Pod	Haulm			
Vannedoddi	Rainfed *Alfisols*	STBF# + P bio fertilizer consortium	1668	3486	2.92	39608	1.78
		Farmers' practice	1420	2648	2.60	28986	1.61
Bachupalli		STBF# + P bio fertilizer consortium	1718	3237	3.14	43789	1.90
		Farmers' practice	1449	2739	2.73	30618	1.65

STBF: N –Low (20kg N/ha), P – Low (40 kg P_2O_5/ha), K – Medium 20kg K_2O/ha)
Bio fertilizer consortia: PSB @ 5kg/ha, PSF @ 5 kg/ha and VAM @ 12.5kg/ha



With STBF + P bio fertilizer consortium



Farmers' practice

Energy management

During 2019, the actual field capacity, seed rate and energy requirement of the tractor drawn Ananta planter was recorded as 7 ha/day, 120-130 kg/ha and 435.82 MJ/ha, respectively. The saving in cost of operation and labour was 35% and 75-80%, respectively. Sowing of groundnut with tractor drawn Ananta planter recorded higher pod and haulm yield (1496 and 3100 kg/ha), respectively over farmers' practice (1375 and 2988 kg/ha). Similarly, sowing of groundnut with tractor drawn Ananta planter recorded higher net returns (Rs.64245/ha), B:C ratio (3.46) and RWUE (1.94 kg/ha-mm) (Table 27).

Table 27: Effect of sowing with tractor drawn Ananta planter on groundnut yield and economics

Farming situation/ soil type	Intervention	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Pod	Haulm				
Rainfed *Alfisols*	Tractor drawn Ananta Planter	1496	3100	18575	64245	3.46	1.94
	Farmers' practice (bullock drawn jaddigam)	1375	2988	28375	48440	1.7	1.78




Sowing of groundnut using tractor drawn Ananta planter (left) and Bullock drawn jaddigam (right)

1.1.3 AGRA

a. Agro-ecological setting

Agra is located in Northern Plain (and Central Highlands) including, Ganga-Yamuna Doab and Rajasthan Upland (AESR 4.1) and South – Western semiarid agro-climatic zone in Uttar Pradesh. The climate is hot semi-arid. Annual rainfall is 669 mm. Length of growing period is 90-120 days.

b. On-station experiments

Experienced weather conditions during 2019-20

During 2019, the onset of monsoon was delayed by 2 days (4th July) in Agra. An annual rainfall of 746.8 mm was received which was excess by 84.3 mm (12.7%) than normal (662.5 mm). During *kharif*, there was a rainfall of 680.9 mm, excess by 93.8 mm (16%) than normal (587.1 mm) and in *rabi* season, 21.4 mm rainfall was recorded which was deficit by 7.1 mm (24.9%) against normal of 28.5 mm. (Fig. 9)

Normal onset of monsoon	2 July
Onset of monsoon during 2019	4 July
Annual mean rainfall (mm)	662.5 mm
Annual rainfall received during 2019-20	746.8 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	587.1 mm and 28.5 mm
Cop seasonal rainfall during 2019-20 (*kharif* & *rabi*)	680.9 mm and 21.4 mm, respectively

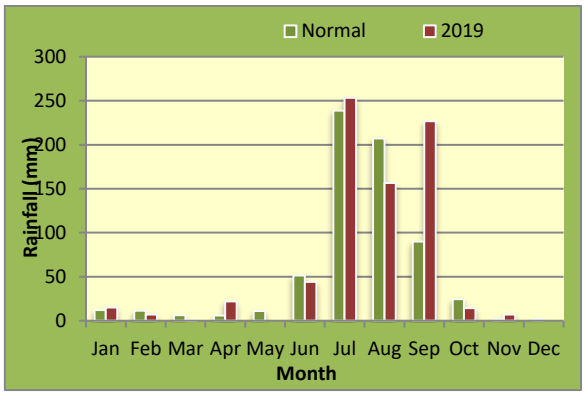


Fig 9: Normal and actual (2019) monthly rainfall at Agra

c. On-farm Demonstrations

Village profile

Nagla Dulhe Khan is situated in the South-western part of Agra district and lies between $26^0$55’ to 26^0 56’ North latitude and 77^0 40’30’ to 77^0 42’30’ East longitude. It is 60 km away from Agra city. The soil of the village varied from sandy loam to loamy sand in texture. The bulk density and particle density varies from 1.42 to1.50 gm/cm^3 and 2.40 to 2.71 g/cm^3 respectively. The field capacity and wilting point on volume basis are 15 to 21 and 4.0 to 8.0 per cent, respectively. The soils are low in availability of nitrogen, potash and medium in availability of phosphorus. Soil and ground water are saline and alkaline in nature.

Experienced weather conditions during 2019-20

During *kharif* 2019, the onset of monsoon was normal (3 July). An annual rainfall of 674.3 mm was received, which was excess by 11.8 mm (1.74%) as compared to normal annual rainfall (662.5 mm). During southwest monsoon (*kharif)*, a rainfall of 646.4 mm was received, which was excess by 59.3 mm (10.1%) than normal rainfall (587.1 mm). During *rabi*, the rainfall of 4.7 mm which was deficit by 23.8 mm than normal rainfall of 28.5 mm (Fig. 10)

Normal onset of monsoon	2 July
Onset of monsoon during 2019	3 July
Annual mean rainfall	662.5 mm
Annual rainfall during 2019-20	674.3 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	587.1 mm and 28.5 mm
Crop seasonal rainfall during 2019-20 (*kharif* and *rabi*)	674.3 mm and 4.7 mm

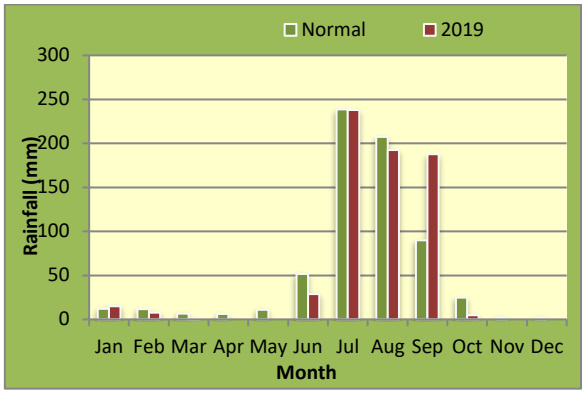


Fig 10: Normal and actual (2019) monthly rainfall at Nagla Dulhe Khan

Dry spells during crop growth season (2019-20) : Nil

Real time contingency plan (RTCP) implementation: Nil

Preparedness

Rain water management

Sowing of pearlmillet with ridge seeder gave higher yield (2465 kg/ha), net returns (Rs.41096), B:C ratio (3.37) and RWUE (5.34 kg/ha-mm) compared to broadcasting (2198 kg/ha) (Table 28).

Table 28: Effect of ridge and furrow method of sowing on yield and economics of pearlmillet.

Intervention	Variety	Yield (kg/ha)	Cost cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Ridger seeder	Pro agro-9450	2465	17320	41096	3.37	5.34
Without ridge seeder		2198	16911	34834	3.06	4.76
CD at 5%		3.88	-	-	-	-



Pearlmillet under ridge sowing



Pearlmillet under broadcasting

In-situ moisture conservation through compartmental bunding in pearlmillet gave higher yield (2433 kg/ha) compared to farmers' practice (2218 kg/ha) with higher net returns (Rs.40164), B:C ratio (3.32) and RWUE (5.27 kg/ha-mm) (Table 29).

Table 29: Effect of compartmental bunding on yield and economics of pearlmillet

Intervention	Variety	Yield (kg/ha)	Cost cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
INM + compartmental bunding	Pro agro-9450	2433	17320	40164	3.32	5.27
No compartmental bunding		2218	16911	35483	3.10	4.81




Pearlmillet under compartmental bunding




Pearlmillet without any compartmental bunding

Cropping systems

Pearlmillet variety Pro agro 9450 gave higher yield (2318 kg/ha) over 86 M 88 (2238 kg/ha) with higher net returns of Rs.37102/ha, B:C ratio of 3.14 and RWUE of 5.02 kg/ha-mm (Table). Sesame variety Shekar gave higher yield (397 kg/ha) over HT-01 (330 kg/ha) with higher net returns of Rs.23416/ha, B:C ratio of 2.60 and RWUE of 0.86 kg/ha-mm. Clusterbean variety RGC-1025 gave higher yield (653 kg/ha), net returns of Rs.13425/ha, B:C ratio of 1.81 and RWUE of 1.42 kg/ha-mm compared to RGC-1015 (Table 30).

Table 30: Performance of improved varieties of different crops

Crop	Variety	Yield (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Pearl millet	Proagro-9450	2318	17320	37102	3.14	5.02
	86 M 88	2238	17320	34898	3.01	4.85
Sesame	Shekhar	397	14664	23416	2.60	0.86
	HT-01	330	14664	17016	2.16	0.72
Clusterbean	RGC-1025	653	16628	13425	1.81	1.42
	RGC-1015	567	16628	9439	1.57	1.23



Proagro-9450



86 M 88


Shekhar


HT-01


RGC-1025


RGC-1015

Strip cropping of pearlmillet + clusterbean (4:4) gave higher pearlmillet equivalent yield (2575 kg/ha) than pearlmillet sole (2215 kg/ha), with higher net returns (Rs.43704) and B:C ratio (3.57) (Table 31).

Table 31: Performance of the pearlmillet + clusterbean (4:4) strip cropping

Intervention	Yield (kg/ha)	PMEY (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
Inter Cropping System					
Pro agro-9450 + RGC-1025	2138+205	2575	16974	43704	3.57
Farmers Practice					
Proagro-9450	2215	2215	16911	35319	3.09

PMEY: Pearlmillet equivalent yield


Pearlmillet + clusterbean (4:4) strip cropping


Pearlmillet sole

Strip cropping of pearlmillet + sesame (4:4) gave higher pearlmillet equivalent yield (3025 kg/ha) than pearlmillet sole (2150 kg/ha), with higher net returns (Rs.55309) and B:C ratio (4.46) (Table 32).

Table 32: Performance of the pearlmillet + sesame (4:4) strip cropping

Intervention	Yield (kg/ha)	PMEY (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
Strip cropping					
Pro agro-9450 + Shekhar	2125+188	3025	15992	55309	4.46
Farmers Practice					
Pro agro-9450	2150	2150	16911	33789	3.00



Pearlmillet + sesame (4:4) strip cropping



Pearlmillet sole

1.1.4 HISAR

a. Agro-ecological setting

Hisar is located in Western Plain, Kachchh and part of Kathiawar peninsula, Rajasthan Bagar, North Gujarat Plain and South-western Punjab plain (*AESR 2.3)* and South-western dry zone in Haryana. The climate is hot arid. Annual rainfall is 411mm. Annual potential evapotranspiration is 769 mm.

b. On-station experiments

Experienced weather conditions during 2019-20

During 2019, the onset of monsoon was delayed by 20 days (27th July) and an annual rainfall of 418.4 mm was received which was deficit by 6.4 mm (1.5%) compared to normal (412.0 mm) (Fig.11). During *kharif*, 305.9 mm rainfall was received which was deficit by 29.9 mm (9.8%) than normal (335.8 mm). In *rabi*, 29.0 mm rainfall was received which was 19.8 mm excess than normal (9.2 mm). In summer, 44.0 mm of rainfall was received against the normal of 38.0 mm.

Normal onset of monsoon	1 week of July
Onset of monsoon during 2019	27th July
Annual mean rainfall (mm)	412 mm
Actual annual rainfall (mm) during 2019-20	418.4 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	335.8 mm and 9.2 mm
Crop seasonal rainfall during 2019-20 (*kharif* and *rabi)*	305.9 mm and 29.0 mm

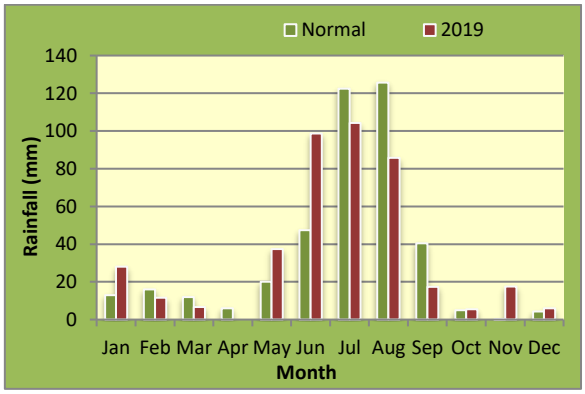


Fig 11: Normal and actual (2019) monthly rainfall at Hisar

Dry spells during crop growing season (2019-20)

Dry spell		Crop	Stage of the crop
Duration (days)	**Dates & months**		
10	7 -16 August	Pearl millet, mung bean, cluster bean	Tillering (pearl millet), Vegetative (mungbean and cluster bean)
16	18 August - 02 September	Pearl millet, mung bean, cluster bean	Flowering stage
26	04-19 September	Pearl millet, mung bean, cluster bean	Grain filling (pearl millet), Pod formation (mungbean and cluster bean)

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Mid season drought	Pearlmillet	Vegetative, flowering and grain filling	Foliar spray

Salient achievements of on-station experiments

Real time contingency planning

Situation: Mid season drought

During *kharif* 2019, three dry spells of 10, 16 and 26 days occurred coinciding with tillering, flowering and grain filling stage of pearlmillet. Foliar spray during the dry spell and after relieving the stress had no significant effect on both grain and stover yield of pearlmillet. However, foliar spray after relieving the stress gave marginally higher grain and stover yield (1024 and 1368 kg/ha), net returns (Rs.6121/ha), B:C ratio (1.34) and RWUE (7.69 kg/ha-mm) compared to foliar spray during the dry spell. Among various treatments, foliar spray of water soluble complex fertilizer (18:18:18) @ 0.5% + recommended dose of micronutrient foliar spray (0.5% ZnSO4) recorded significantly higher grain yield of pearlmillet (1132 kg/ha) with higher net returns (Rs 8345/ha), B:C ratio (1.45) and RWUE (8.51 kg/ha-mm) compared to control (884 kg/ha), 0.5% ZnSO4 spray (994 kg/ha) and water spray (910 kg/ha) (Table 33).

Table 33: Effect of foliar spray yield and economics of pearl millet

Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	BC ratio	RWUE (kg/ha-mm)
	Grain in 2019-20	Mean grain yield (3 years)	Stover				
Main plot							
Foliar spray during dry spell	992	1327	2082	18200	5387	1.29	7.45
Foliar spray after relieving the stress	1024	1368	2134	18200	6121	1.34	7.69
CD @ 5%	NS		NS				
Sub plot							
Urea @ 1%	1008	1362	2114	18230	5735	1.31	7.57
Urea @ 2%	1032	1383	2154	18260	6257	1.34	7.75
Water soluble complex fertilizer (18:18:18) @ 0.5%	1098	1423	2294	18400	7689	1.42	8.25

Water soluble complex fertilizer (18:18:18) @ 0.5% + 0.5% $ZnSO_4$	1132	1460	2364	18550	8345	1.45	8.51
0.5% $ZnSO_4$ spray	994	1333	2078	18350	5270	1.29	7.47
Water spray	910	1251	1904	18200	3427	1.20	6.84
Control (no spray of any material/water)	884	1223	1846	17400	3602	1.20	6.64
CD @ 5%	101		234				



Pearlmillet with foliar spray of water soluble complex fertilizer (18:18:18) @ 0.5% + 0.5% $ZnSO_4$



Pearlmillet without any foliar spray

c. On-farm demonstrations

Village profile

The program is being implemented in Balawas village, Hisar Tehsil, Hisar district, Haryana. The total cultivated area is 800 ha out of which 560 ha is rainfed. The mean annual rainfall is 350 mm with seasonal rainfall of 320 mm during *kharif* (June- September). The major soil types are loamy sand to sandy loam. The major rainfed crops in *kharif* are pearlmillet, clusterbean, greengram, mothbean, sesame and castor, and *rabi* crops are mustard, chickpea, barley and rapeseed. The number of small, marginal, medium and large farmers is 138, 22, 2 and 4, respectively. The ground water table is about 25 m. The source of irrigation is canal and tube well covering 30% of the cultivated area.

Climate vulner*abi*lity in general

In general, the climate in this agro-climatic zone is arid. The south-west monsoon contributes 85-90%. The historical (30 years) rainfall data indicated the variability in rainfall during southwest monsoon and every fourth year is a drought year. The onset (south-west) of monsoon is during 26 SMW. The dry spells during the crop season were experienced for the past 10 to 15 years during July, August and October and at seedling, vegetative and reproductive stages of major rainfed crops. The soil moisture status was deficit during vegetative and reproductive stages of major rainfed crops. The maximum/minimum temperature during crop season was almost static but frost occurred during *rabi* in December and January (-0.112/- 0.0710C) during past 10 years. The extreme events like unusual

and high intensity rainfall in short span had been increasing during *kharif*. The area had also been experiencing other extreme events like frost and cold wave. There had also been considerable shift in rainfall pattern with late onset (29/30 SMW) and early withdrawal (35/36 SMW) and sowing window to 31 or 32 SMW of the dominant rainfed crops *viz.*, pearlmillet, clusterbean, blackgram and castor.

Experienced weather conditions during 2019-20

The onset of monsoon was normal (17th July). An annual rainfall of 200.8 mm in Balawas and 217.9 mm in Nalwa was received which was deficit by 97.9 mm and 82.1 mm, respectively compared to normal (300 mm) (Fig.12). During *kharif*, 112.8 mm in Balawas and 126.9 mm in Nalwa respectively was received compared to normal (210.7 mm); *rabi* season recorded 42,0 mm in Balawas and 41.6 mm in Nalwa as against normal of 22 mm.

Normal onset of monsoon	1 week of July
Onset of monsoon during 2019	17th July
Annual mean rainfall (mm)	300.0 mm
Actual annual rainfall (mm) during 2019-20	200.8 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	210.7 mm and 22,0 mm
Crop seasonal rainfall during 2019-20	112.8 mm and 42.0 mm

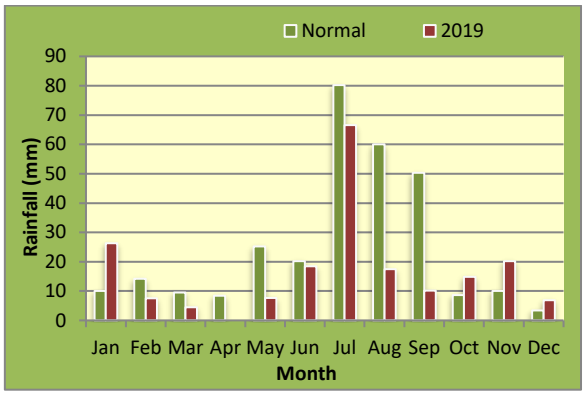


Fig 12: Normal and actual (2019) monthly rainfall at Balawas

Dry spells during crop growing season (2019-20)

Dry spell		Crop	Stage of the crop
Duration (days)	**Dates & months**		
17	06-22 August	Pearl millet, mung bean, cluster bean	Tillering (pearl millet), Vegetative (mungbean and cluster bean)
16	18 August - 02 September	Pearl millet, mung bean, cluster bean	Flowering stage
40	04 September – 13 October	Pearl millet, mung bean, cluster bean	Grain filling (pearl millet), Pod formation (mungbean and cluster bean)

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Mid Season Drought	Pearlmillet	Vegetative, flowering and grain filling	Foliar spray

1.1.5 KOVILPATTI

a. Agro ecological setting

Kovilpatti is in Tamil Nadu uplands and leeward flanks of South Sahayadris and Deccan (Karnataka) plateau (AESR 8.1). The climate is hot semi-arid. Potential evapo-transpiration is 812 mm. Rainfall is 728 mm. Length of growing period is 90-120 days. The frequency of drought is once in ten years. Water erosion is medium severe with slight loss of top soil, affecting 26-50% area. The soils are moderately deep to deep, loamy to clayey and mixed red and black. Available water capacity is medium. Soil reaction is neutral to slightly alkaline, medium in soil organic C and P, and high in K content. Deficient nutrients are sulphur, calcium and zinc.

b. On-station experiments

Experienced weather conditions during 2019-20

During 2019-20, onset of north-east monsoon was early by 4 days (16th October). A rainfall of 668.1 mm was received which was deficit by 54.5 mm compared to normal (722.6 mm). During *kharif* (June-September), 177.1 mm rainfall was received which was excess by 26.9 mm than normal of 150.2 mm; in *rabi* season (October-December), 426.4 mm rainfall was received which was excess by 35.5 mm than normal of 391 mm and during summer (March to May), 63.8 mm rainfall was received which was deficit by 77.1 mm than normal of 140.9 mm (Fig. 13)

Normal onset of monsoon	20 October
Onset of monsoon during 2019	16 October
Annual mean rainfall	722.6 mm
Annual rainfall during 2019-20	668.1 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	150.2 and 391.0 mm, respectively
Crop seasonal rainfall during 2019-20	177.1 and 426.4 mm,

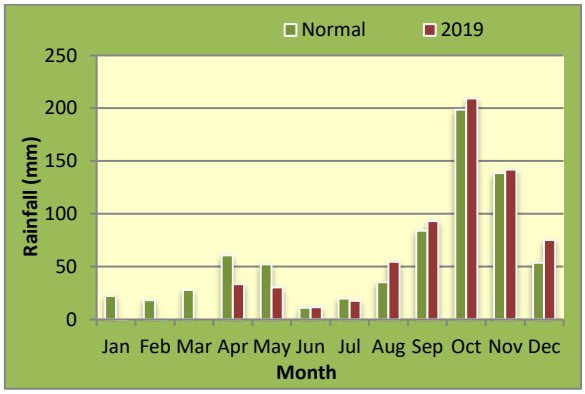


Fig. 13: Normal and actual (2019) monthly rainfall at Kovilpatti

Dry spells during crop growing season (2019)

Dry /wet spells		Crop	Stage of the crop
Duration (days)	Date & Month		
7	8-14 October	Pearlmillet, sorghum	Germination
7	19-25 November	Pearlmillet, sorghum	Grain filling stage
7	17-23 December	Pearlmillet, sorghum	Maturity stage

Real time contingency practices (RTCP) implemented

Weather	Crop	RTCP implemented
Mid season drought	Sorghum, pearlmillet	Foliar spray

Salient achievements of on-station experiments

Real time contingency planning

Situation: Mid season drought

During *rabi* 2019, a dry spell of 7 days occurred during 19-25 November coinciding with the grain filling stage of sorghum. Foliar spray during dry spell in sorghum (var. K12) recorded higher grain yield (1795 kg/ha), net returns (Rs.7610/ha), B:C ratio (1.27) and RWUE (4.21 kg/ha-mm) as compared to foliar spray after relieving of stress/dry spell (1745 kg/ha). Further, foliar spray of 0.5% water soluble complex fertilizer (19.19.19) during dry spell (M_1) recorded higher sorghum grain yield (1875 kg/ha), net returns (Rs.9300/ha), B:C ratio (1.33) and RWUE (4.40 kg/ha-mm) followed by foliar spray of water soluble complex fertilizer (19:19:19) @ 0.5% + recommended dose of micronutrient during dry spell compared to rest of the treatments. The lowest yield (1185 kg/ha) and net returns (Rs.1653/ha) was recorded in untreated control plot (Table 34).

Table 34: Effect of foliar spray on yield and economics sorghum (var.K12) in *Vertisols*

Treatments	Yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Main plot					
M_1: Foliar spray during dry spell	1795	51.5	4.21	7610	1.27
M_2: Foliar spray after relieving of stress/dry spell (with favorable soilmoisture)	1745	47.3	4.09	6660	1.23
Sub plot					
T_1: Urea @ 1%	1648	39.1	3.86	4704	1.17
T_2: Urea @ 2%	1675	41.4	3.93	5210	1.18
T_3: Water soluble complex fertilizer (19:19:19) @0.5%	1875	58.2	4.40	9300	1.33
T_4: Water soluble complex fertilizer (19:19:19) @ 0.5% + recommended dose of micronutrient for foliar spray (to be decided based on soil test: Zinc, Boron, Iron, Manganese, etc)	1750	47.7	4.10	6800	1.24
T_5: $ZnSO_4$ @0.5%	1704	43.8	4.00	6072	1.21
T_6: Water spray	1600	35. 2	3.75	3123	1.11
T_7: Control (no spray of any material/water)	1185	-	2.78	1653	1.07
CD at 5%	NS				



Aerial view of experimental field at vegetative stage



Field view of Sorghum K-12 variety



Sorghum crop at 50 % flowering stage



Sorghum crop at maturity stage

c. On-farm Demonstrations

Village profile

The program is being implemented in Muthukrishnapuram, Thoppurediapatti, Dharmathampatti and Vadakkupatti revenue villages, Kovilpatti Taluk, Thoothukudi district, Tamil Nadu. The total cultivated area is 578.83 ha out of which 342 ha is rainfed. The mean annual rainfall (normal) is 970.4 mm with seasonal rainfall of 150.2 mm during *kharif*, 390.9 mm during *rabi* (October-December) and 140.9 mm during summer (March-May). The major soil types are medium deep to deep black and red soils. The major rainfed crops during *rabi* are maize, greengram, blackgram, cotton and sunflower. The number of small, marginal and large farmers are 111, 368 and 69, respectively. The ground water table is 800 cm. The source of irrigation is open dug wells, covering 15% of cultivated area.

Climate vulner*abi*lity in general

The climate in this agro-climatic zone is semi-arid and north-east monsoon season is the main cropping season under rainfed conditions. Out of the total annual average rainfall of 970.4 mm, the south-west monsoon contributes 20.1%, north-east monsoon contributes 53.1% and summer contributes 20.6%. The historical rainfall data indicates that the variability in rainfall during south-west monsoon season (in the last 30 years from 1972 to 2011) is 17.6% surplus compared to the average rainfall from 1901 to 1971. While comparing the same periods, it was found that rainfall during north-east monsoon season was 5.9% surplus. The onset of south - west monsoon was during 22nd SMW (1st June) and north-east monsoon was during 42nd SMW (20th October) in the state. The length of growing period spans from 38th SMW to 47th SMW. The dry spells during cropping season are experienced in the months of December and January (from 49th SMW to 4th SMW) for the past 10 years which coincided with grain maturity stages of the major rainfed crops. The onset of the south-west monsoon (SWM) and north-east monsoon (NEM) in the last ten years is normal with a maximum deviation of ± 9 days. Maximum temperature during SWM and NEM season did not change in the last ten years (2002-2011) compared to the previous ten years (1992-2001); while comparing the same periods, it was found that minimum temperature increased by 2.4^{o}C in both the seasons. The extreme events like unusual and high intensity rainfall in short span did not show any change during *kharif* and *rabi* seasons. No other extreme event was experienced in this area. There has been no shift in the rainfall pattern and sowing window during NEM season; the sowing week is 37th SMW for the dominant rainfed crops.

Experienced weather conditions during 2019-20

During 2018, in Muthukrishnapuram village, the onset of south-west monsoon was normal (1st June) and onset of north-east monsoon was early by 4 days (16 October). A rainfall of 686.6 mm

was received which was deficit by 36.5 mm compared to normal (722.6 mm). During *kharif* (June-September), 185.2 mm rainfall was received which was excess by 35 mm than normal of 150.2 mm; in *rabi* season (October-December), 436.8 mm rainfall was received which was excess by 45.9 mm than normal of 391.0 mm and during summer (March to May), 63.7 mm rainfall was received which was deficit by 77.2 mm than normal of 140.9 mm (Fig. 14)

Normal onset of monsoon	20 October
Onset of monsoon during 2019	16 October
Annual mean rainfall	722.6 mm
Annual rainfall during 2019-20	686.1 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	150.2 and 391.0 mm, respectively
Crop seasonal rainfall during 2019-20	185.2 and 436.8 mm,

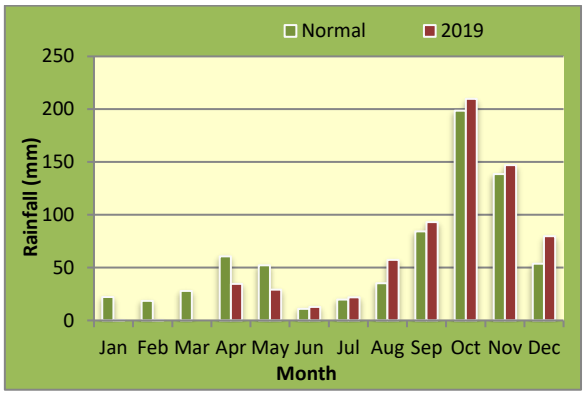


Fig. 14: Normal and actual (2019) monthly rainfall at Muthkrishnapuramu

Dry spells during crop growing season (2019)

Dry /wet spells		Crop	Stage of the crop
Duration (days)	**Date & Month**		
7	10-16 November	Maize	Vegetative
46	25 December – till harvest	Cotton	Flowering and grain filling stage

Real time contingency practices (RTCP) implemented

Weather aberration	Farming situation/ soil type	RTCP implemented	
		Crop	RTCP implemented
Early season drought	Deep black soil	Maize	Crops and varieties moisture conservation practices Contingency planning measures
Mid- season drought	Deep black soil	Cotton	Foliar spray in *rabi* crops
Terminal drought	Deep black soil	Maize	Foliar spray and supplemental irrigation

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Early season drought

During *rabi* 2019, a dryspell of 7 days occurred coinciding with the vegetative stage of maize crop. The maize hybrid, COH (M) 8 with improved practices recorded higher grain yield (6250 kg/ha), net returns (Rs.74625/ha), B:C ratio (3.62) and RWUE (14.3 kg/ha-mm) compared to farmers practice (5100 kg/ha). The moisture conservation practice of ridges and furrows method of sowing registered higher yield (6278 kg/ha), net returns (Rs.75087/ha), B:C ratio (3.63) and RWUE (14.4 kg/ha-mm) compared to farmers practice (5125 kg/ha). Further, it was noticed that both the maize

hybrids and moisture conservation practice improved the yield to the extent of 20.4 to 22.6% over farmers practice (Table 35).

Table 35: Effect of moisture conservation practice and varieties on yield and economics of maize

Farming situation	Treatment	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With improved practice	With farmers practice				
Deep black soils	COH(M)6	6124	5085	20.4	14.0	72546	3.55
	COH(M)8	6250	5100	22.6	14.3	74625	3.62
	Ridges and furrow	6278	5125	22.5	14.4	75087	3.63
	Check basin	6184	5099	21.3	14.2	73536	3.58



25 DAS



35 DAS



At maturity



Matured cobs

Situation: Midseason drought

During *rabi* 2019, a dry spell of 45 days occurred from 25 December to till harvest of cotton crop, foliar spray of TNAU cotton plus @ 2.5 kg/acre recorded higher seed cotton yield (985 kg/ha), net returns (Rs.10870/ha), B:C ratio (1.36) and RWUE (2.26 kg/ha-mm) compared to Pink pigmented facultative methylotrops (PPFM) spray @500 ml/ha (940 kg/ha) and farmer's practice (765 kg/ha). Further, it was noticed that the increase in yield due to foliar spray of TNAU cotton plus and PPFM was to the extent of 28.8 and 22.9% over farmer's practice of no foliar spray/control (Table 36).

Table 36: Effect of foliar spray on cotton yield and economics

Normal variety Variety	Seed cotton yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With improved practice	With farmers practice)				
TNAU cotton plus (2.5 kg/acre)	985	-	28.76	2.26	10870	1.36
PPFM spray (500 ml/ha)	940	-	22.88	2.15	8980	1.29
Control	-	765	-			



Field view of the experimental field



Cotton crop at boll bursting stage

Preparedness

Rainwater management

The improved pearlmillet cultivar CO 10 with land configuration method of ridges and furrows recorded 16.07 % higher yield (1680 kg/ha) over the farmers practice of seed drilling (1410 kg/ha). The improved cultivar recorded RWUE of 3.94 kg/ha mm with a net returns of 7740 Rs/ha whereas the farmers practice variety recorded a net return of Rs.2880/ha (Table 37).

Table 37: Effect of land configuration method and improved cultivars on yield and economics of pearlmillet

Farming situation	Treatment	Variety	Yield (kg/ha)	% increase in yield	Cost of cultivation (Rs./ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Deep black soils	Ridges and furrows	CO 10	1680	19.1	22500	7740	3.94	1.34
	Farmers practice	Private hybrid	1410	-	22500	2880	3.31	1.13



Field view of the pearl millet at tillering stage



Pearl millet at maturity stage

Among the crops maize recorded highest grain yield (6180 kg/ha), net returns (Rs.73470/ha), B:C ratio (3.58) and RWUE (14.15 kg/ha-mm) compared to sorghum (1315 kg/ha) and greengram (612 kg/ha) (Table 38).

Table 38: Effect of improved practices on crops yield and economics

Farming situation/ Soil type	Intervention	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Grain/seed yield	Stover/ stalk				
Deep black soil	Maize	6180	9270	28500	73470	3.58	14.15
	Green gram	612	1410	20500	8004	1.39	1.40
	Sorghum	1315	4580	20500	8170	1.40	3.01



Maize crop at 25 DAS



Field view of the experimental trial (Maize)



Greengram crop at 25 DAS



Field view of the experimental trial (Green gram)



Sorghum crop at 25 DAS



Sorghum crop at maturity stage

There was an excess rainfall of 11.85% when compared to normal rain fall. The supplemental irrigation was not given since no moisture stress was noticed in the crop growing period. The maize variety, COH (M)8) recorded higher grain and stover yield (6148 and 9545 kg/ha), net returns (Rs.72942 /ha), B:C ratio (3.56) and RWUE (14.08 kg/ha-mm) compared to cotton (957 and 2240 kg/ha) with (Table 39).

Table 39: Effect of Rainwater harvesting intervention on yield, RWUE and economics of maize and cotton

Farming situation/ Soil type	Intervention	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Grain/seed cotton	Stover/stalk				
Deep black soil	Maize - COH(M)8)	6148	9545	28500	72942	3.56	14.08
	Cotton- KC 3	957	2240	30500	13044	1.32	2.19



Maize crop at 25 DAS



Maize crop silking stage



Maize cob harvesting



Harvested cobs



Cotton at square formation stage



Cotton crop at boll bursting stage

Cropping systems

Among the cotton varieties, SVPR 2 recorded higher seed cotton yield (1125 kg/ha), net returns (Rs.16750/ha), B:C ratio (1.55) and RWUE (2.58 kg/ha-mm) compared to SVPR 4 (1085 kg/ha) and local hybrid. Both the cultivars, SVPR 2 and SVPR 4 recorded 23.6 and 19.2 % increased yield than local hybrid (910 kg/ha). The moisture conservation practice of ridges and furrows method

of sowing recorded 24.5% higher seed cotton yield (1210 kg/ha) over check basin method (972 kg /ha) (Table 40).

Table 40: Effect of moisture conservation practices on yield and economics of cotton cultivars

Intervention	Seed cotton yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Varieties					
SVPR 2	1125	23.6	2.58	16750	1.55
SVPR 4	1085	19.2	2.48	15070	1.49
Private hybrid	910				
Moisture conservation practice					
Ridges and furrow	1210	24.5	2.77	20320	1.67
Check basin	972				



Cotton (SVPR 2) crop at flowering stage



Cotton (SVPR 2) crop at boll bursting stage

During *rabi* 2019, though the crop experienced moisture stress at maturity stage, all the cotton based intercropping system recorded higher cotton equivalent yield, net return, LER and MAI over sole cotton. Among the cropping systems, cotton + onion (2:1) recorded significantly highest cotton equivalent yield (2170 kg/ha) with higher net returns (Rs.57840/ha), B:C ratio (2.05) and RWUE (4.97 kg/ha-mm) as compared to all other intercropping sytems and sole cotton. Cotton intercropped with onion ALSO recorded higher land equivalent ratio (LER) of 2.36 compared to rest of the treatments (Table 41).

Table 41: Performance of cotton based inter cropping systems

Farming situation/ soil type	Intervention	Yield (kg/ha)			LER	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Main crop	Inter crop	MCEY				
Deep black soils	KC3 cotton	920	-	920	1.00	19340	1.68	2.11
	Cotton + cluster bean (2:1)	810	1635	1137	1.24	22824	1.63	2.60
	Cotton + black gram(2:1)	790	285	1132	1.23	26364	1.81	2.59
	Cotton + green gram(2:1)	798	301	1219	1.33	30609	1.93	2.79
	Cotton + onion(2:1)	770	2000	2170	2.36	57840	2.05	4.97
CD at 5%				64	0.11			

LER: Land Equivalent Ratio; MCEY: Main Crop Equivalent Yield;



Sole cotton





Cotton + clusterbean





Cotton + greengram





Cotton + blackgram




Cotton + onion

1.1.6 RAJKOT

a. Agro-ecological setting

The centre is located 14 km North-East of Rajkot city (latitude of 20°17'N and longitude of 70°48'E and 137.7 meters above mean sea level). Annual rainfall is 648.8 mm. The climate is hot arid.

b. On-station experiments

Experienced weather conditions during 2019-20

During 2019, the onset of monsoon was delayed by 8 days (23rd June). A rainfall of 1360.4 mm was received which was excess by 770 mm compared to normal of 590.4 mm. During *kharif*, 1297.5 mm rainfall was recorded against normal rainfall of 557.9 mm (Fig. 15)

Normal onset of monsoon	15 June
Onset of monsoon during 2019	23 June
Annual mean rainfall	590.4 mm
Annual rainfall during 2019-20	1360.4 mm
Mean crop seasonal rainfall during *kharif*	557.9 mm
Crop seasonal rainfall during 2019-20 (*kharif*)	1297.5 mm

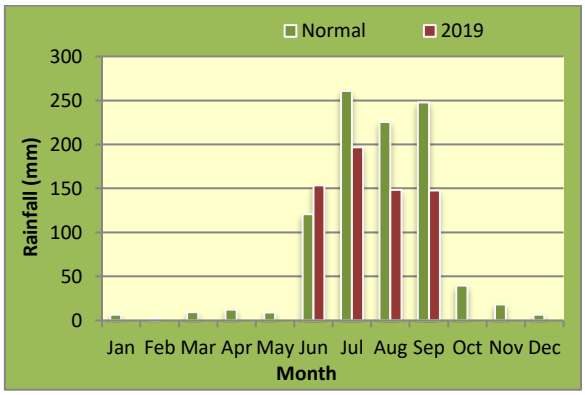


Fig. 15: Normal and actual (2019) monthly rainfall at Rajkot

Dry spells during crop growing season (2019-20)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates &months		
19	03- 21 July	Groundnut, Cotton, Sesame, Greengram/black gram	Vegetative

Real time contingency practices (RTCP) implemented

Weather aberration	Farming situation/ soil type	RTCP implemented	
		Crop	RTCP implemented
Early season drought	Medium black soil	Groundnut, blackgram	Improved varieties
Mid- season drought	Deep black soil	Groundnut	Foliar spray

Sailent achievements of on-station experiments

Real time contingency planning

Situation: Delayed onset of monsoon

The onset of monsoon was delayed by 8 days (23rd June). Among different semi-spreading varieties of groundnut, GJG-22 recorded higher pod yield (2221 kg/ha), net returns (Rs.86150), B:C ratio (2.62) and RWUE (1.63 kg/ha-mm) compared to GG-20. Among semi-bunch groundnut varieties GJG-9 recorded higher pod yield (2341 kg/ha), net returns (Rs.87985), B:C ratio (2.66) and RWUE (1.72 kg/ha-mm) compared to other varieties (Table 42).

Table 42: Performance of groundnut varieties under delayed onset of monsoon

Treatment	Yield (kg/ha)			Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Pod (2019)	Mean (3 years)	Haulm			
Semi-spreading						
GG-20	2013	1908	5234	73520	2.38	1.48
GJG-22	2221	1938	5680	86150	2.62	1.63
Bunch						
GG-7	2056	2040	4534	72570	2.37	1.51
GJG-9	2341	2377	4767	87985	2.66	1.72
JL-501	2289	2292	3987	81485	2.54	1.68



Groundnut var. GJG-9



Groundnut var. GG-20

Among blackgram varieties, GU-1 recorded higher seed yield (823 kg/ha) compared to T-9 with higher net returns (Rs.20658), B:C ratio (2.12) and RWUE (1.34 kg/ha-mm). Among cowpea varieties, GC-4 recorded higher seed yield (1112 kg/ha), net returns (Rs.33196), B:C ratio (2.64) and RWUE (1.81 kg/ha-mm) compared to other varieties. Similar results were observed in greengram (Table 43).

Table 43: Performance of improved varieties of blackgram, greengram and cowpea

Crop	Yield (kg/ha)			Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed (2019)	Mean seed (3 years)	Stover yield			
Black gram						
GU-1	823	933	1234	20658	2.12	1.34
T-9	800	947	1326	20198	2.10	1.30
Cow pea						
GC-5	1089	1384	1867	32681	2.62	1.77
GC-4	1112	1466	1786	33196	2.64	1.81
GC-3	1105	1303	1643	32201	2.59	1.80
Green gram						
GM-4	780	1026	1435	19441	2.03	1.27

Situation: Mid season drought

A dry spell of 19 days occurred during 3-21 July coinciding with vegetative stage of groundnut. The pod yield of groundnut was increased due to foliar spray during dry spell and foliar spray of water soluble complex fertilizer (19:19:19) @ 0.5% + $FeSO_4$ @ 1% recorded higher pod yield (3333 kg/ha), net returns (Rs.108483), B:C ratio (3.03) and RWUE (2.48 kg/ha-mm) compared to other treatments (Table). However, ferrous sulphate @ 1% after dry spell recorded higher pod yield (3299 kg/ha) and foliar spray of water soluble complex fertilizer (19:19:19) @ 0.5% + $FeSO_4$ @ 1% recorded higher net returns (Rs.102673), B:C ratio (2.92) and RWUE (2.37 kg/ha-mm) compared to other treatments (Table 44).

Table 44: Effect of different foliar sprays on yield and economics of groundnut

Treatment	Pod yield (kg/ha)			Haulm yield (kg/ha)		Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2019	Mean 3 yrs (2017-19)		2019	Mean 3 yrs (2017-19)			
Foliar spray during dry spell								
T_1: Urea @ 1%	1910	2061	4181	4599	72845	2.37	1.87	
T_2: Urea @ 2%	2382	2183	4903	4765	79675	2.49	1.98	
T_3: Water soluble complex fertilizer (19:19:19) @ 0.5%	3042	2434	4854	4829	92495	2.73	2.21	
T_4: Water soluble complex fertilizer (19:19:19) @ 0.5% + $FeSO_4$ @ 1%	**3333**	2728	4944	5107	108483	3.03	2.48	
T_5: Ferrous sulphate @ 1%	3160	2542	4292	4833	97985	2.84	2.31	
T_6: Zinc sulphate @ 1%	2882	2348	4458	4631	87205	2.63	2.13	
T_7: Water spray	1771	1880	4208	4306	62330	2.17	1.71	
T_8: Control	1632	1802	3993	3996	57080	2.08	1.64	
CD at 5 %	345.1	557.9	NS	430.5	-	-	-	
Foliar spray after relieving of dry spell								
T_1: Urea @ 1%	2910	2425	4000	4769	91895	2.73	2.20	
T_2: Urea @ 2%	3118	2463	4882	5075	95225	2.79	2.24	
T_3: Water soluble complex fertilizer (19:19:19) @ 0.5%	2535	2281	3389	4662	84010	2.57	2.07	
T_4: Water soluble complex fertilizer (19:19:19) @ 0.5% + $FeSO_4$ @ 1%	3125	2612	4465	5105	102673	2.92	2.37	
T_5: Ferrous sulphate @ 1%	**3299**	2565	4021	4862	99280	2.86	2.33	
T_6: Zinc sulphate @ 1%	3167	2401	4694	4890	91150	2.71	2.18	
T_7: Water spray	3090	2282	4604	4542	83610	2.57	2.07	
T_8: Control	2743	2122	4465	4196	74080	2.40	1.93	
CD at 5 %	NS	284.5	NS	NS	-	-	-	



Spraying of water soluble complex fertilizer (19:19:19) @ 0.5% + $FeSO_4$ @ 1%



Control



During dry spell



After dry spell

c. On-farm demonstrations

Village profile

The NICRA villages Patameghpar (22º14.33' N longitude 70º31.0' E and 95.7 m above MSL) and Dangar vada are in Taluka Kalavad of Jamnagar district (Gujarat). The total cultivated area is 2793 ha out of which 1675 ha is rainfed. The annual rainfall for last 20 years ranged from 128.5 mm to 1197 mm, with an average of 543.6 mm during *kharif* (June-September). The major soil type is medium black soil. The soils are generally high in available K and low to moderate in available N and P. It is neutral to alkaline in reaction and salinity is normal. The major crops are groundnut, cotton, sesame, castor, sesame and pulses in *kharif* and wheat, cumin, chickpea, fenugreek and coriander in *rabi*. The percentage of small, marginal, medium and large farmers is 28.7, 27.3, 27.8 and 16.1, respectively. The source of irrigation is open/bore wells covering 40.5% of cultivated area and quality of irrigation water is normal.

Climatic vulner*abi*lity in general

The climate of this agro-climatic zone is semi-arid. Out of the total annual average rainfall of 549.5 mm, the south-west monsoon contributes 70-80%. The historical rainfall data (30 years) indicates that the variability in rainfall during south-west monsoon was 62.5% of the average rainfall. The onset of south-west monsoon was during 24 SMW. Onset of monsoon during 2017-18 was 11th July 2017 (28th MSW). For the past 15 years, the dry spells during crop season were experienced during August and at flowering stages of the major rainfed crops. The onset of monsoon is normal.

Experienced weather conditions during 2019-20

During 2019, at Patameghpar village, the onset of monsoon was delayed by 3 days (18th June). A rainfall of 1439 mm was received which was excess by 837.6 mm compared to normal

(601.4 mm). During *kharif* season, 1414 mm of rainfall was recorded against normal rainfall of 554.5 mm (Fig. 16).

Normal onset of monsoon	15 June
Onset of monsoon during 2019	18 June
Annual mean rainfall	601.4 mm
Annual rainfall during 2019-20	1439 mm
Mean crop seasonal rainfall during *kharif*	554.5 mm
Crop seasonal rainfall during 2019 (*kharif)*	1414 mm

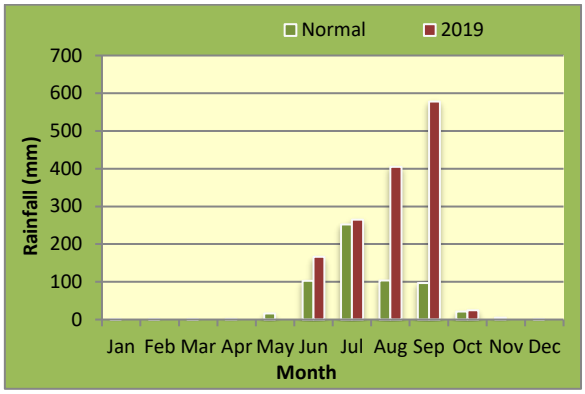


Fig. 16: Normal and actual (2019) monthly rainfall at Patameghpar village

Dry spells during crop growing season (2019-20)

Dry spell		Crop	Stage of the crop
Duration (days)	**Dates &months**		
24	28 June - 21 July	Groundnut, Cotton, Sesame	Vegetative

Real time contingency practices (RTCP) implemented

Weather aberration	Farming situation/ soil type	RTCP implemented	
		Crop	RTCP implemented
Early season drought	Medium black soil	Groundnut, cotton	In-situ moisture conservation, supplemental irrigation, weeding, inter culture

Situation: Early season drought

During 2019, at Patamegphar and Dargarvada, a dry spell of 24 days occurred during 31st June-21st July coinciding with vegetative stage of crops. Intercultivation and application of murram @ 8 t/ha before sowing in groundnut gave 8.1% and 4.95% higher pod yield (2256 and 2312 kg/ha) with net returns (Rs.85449 and 88968/ha), B:C ratio (3.77 and 3.85) and RWUE (1.60 and 1.69 kg/ha-mm) compared to normal practice of intercultivation (2087 and 2203 kg/ha). Similarly, broad bed furrow and mulching with agricultural waste increased the yield in cotton by 13 and 8.9% (1842 and 1658 kg/ha) with higher net returns (Rs.54226 and 46096/ha), B:C ratio (3.02 and 2.88) and RWUE (1.28 and 1.21 kg/ha-mm) compared to normal practice of intercultivation (1604 and 1523 kg/ha) (Table 45).

Table 45: Effect of *in-situ* moisture conservation on crop yield and economics

Farming situation/ Soil type	Crop	Intervention	Yield (kg/ha)	Percent increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Patameghpar							
Rainfed /medium black	Groundnut	Intercultivation & application of murrum @ 8 t/ha before sowing	2256	8.10	1.60	85449	3.77
		Farmers practice (Intercultivation)	2087		1.48	74629	3.52
	Cotton	Broad bed and furrow & mulching with	1812	12.97	1.28	54226	3.02

		agricultural waste					
		Farmers practice (Intercultivation)	1604		1.13	42694	2.81
Dangarvada							
Rainfed /medium black	Groundnut	Intercultivation & application of murrum @ 8 t/ha before sowing	2312	4.95	1.69	88969	3.85
		Farmers practice (Intercultivation)	2203		1.61	81806	3.68
	Cotton	Broad bed and furrow & mulching with agricultural waste	1658	8.86	1.21	46096	2.88
		Farmers practice (Intercultivation)	1523		1.11	37492	2.71

Note: Mulching @ 6 t/ha of wheat straw and available biological material

Patameghpar



Application of murrum @ 8 t/ha before sowing



Interculturing frequently

Dangarvada



Application of murrum @ 8 t/ha before sowing



Interculturing frequently

At Patamegphar and Dargarvada, supplemental irrigation during dry spell from harvested rainwater in groundnut gave 1.14 and 2.71% higher pod yield (2304 and 2347 kg/ha) with higher net returns (Rs.82936 and 85473/ha), B:C ratio (2.56 and 2.61) and RWUE (1.63 and 1.14 kg/ha-mm) compared to farmers practice of no supplemental irrigation (2278 and 1543 kg/ha). Similarly, supplemental irrigation increased the yield in cotton by 4.1 and 87.4% (1606 and 1617 kg/ha) with higher net returns (Rs.38403 and 38995/ha), B:C ratio (1.97 and 1.99) and RWUE (1.14 and 1.18

kg/ha-mm) compared to farmers practice of no supplemental irrigation (1543 and 1506 kg/ha) (Table 46).

Table 46: Effect of supplemental irrigation on crop yield and economics

Farming situation/ Soil type	Crop	Intervention	Yield (kg/ha)	Percent increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Patameghpar							
Rainfed /medium black	Groundnut	Supplemental irrigation	2304	1.14	1.63	82936	2.56
		Farmers' practice (no supplemental irrigation)	2278	-	1.61	82402	2.58
	Cotton	Supplemental irrigation	1606	4.08	1.14	38403	1.97
		Farmers' practice (no supplemental irrigation)	1543	-	1.09	36013	1.76
Dangarvada							
Rainfed /medium black	Groundnut	Supplemental irrigation	2347	2.71	1.72	85473	2.61
		Farmers' practice (no supplemental irrigation)	2285		1.67	82815	2.59
	Cotton	Supplemental irrigation	1617	7.37	1.18	38995	1.99
		Farmers' practice (no supplemental irrigation)	1506		1.10	34023	1.72

Note: Patameghpar- 1 sprinkler irrigation 5.0 cm in groundnut; drip irrigation twice 4.0 cm in cotton
Dangarvada- 1 surface irrigation 6.0 cm in groundnut; drip irrigation twice 4.0 cm in cotton

Patameghpar



Sprinkler irrigation in groundnut



Control (No irrigation)

Dangarvada



Surface flood irrigation in cotton



Control (No irrigation)

At Patamegphar and Dargarvada, weeding/interculture in groundnut gave 4.64 and 2.92% higher pod yield (2209 and 2358 kg/ha) with higher net returns (Rs.82862 and 86122/ha), B:C ratio (3.72 and 2.62) and RWUE (1.56 and 1.72 kg/ha-mm) compared to normal practice of intercultivation (2111 and 2291 kg/ha). Similarly, weeding/interculture increased the yield in cotton by 9.7 and 11.4% (1720 and 1684 kg/ha) with higher net returns (Rs.49771 and 42599/ha), B:C ratio (2.95 and 2.07) and RWUE (1.22 and 1.23 kg/ha-mm) compared to normal practice of intercultivation (1543 and 1506 kg/ha) (Table 47).

Table 47: Effect of weeding/interculture on crop yield and economics

Farming situation/ Soil type	Crop	Intervention	Yield (kg/ha)	Percent increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Patameghpar							
Rainfed /medium black	Groundnut	Interculturing to fill soil cracks only twice	2209	4.64	1.56	82862	3.72
		Farmers practice (frequent intercultivation)	2111	-	1.49	76352	3.56
	Cotton	Interculturing to fill soil cracks once	1720	9.69	1.22	49771	2.95
		Farmers practice (frequent intercultivation)	1568	-	1.11	40160	2.76
Dangarvada							
Rainfed /medium black	Groundnut	Interculturing to fill soil cracks only twice	2358	2.92	1.72	86122	2.62
		Farmers practice (frequent intercultivation)	2291	-	1.67	83169	2.60
	Cotton	Interculturing to fill soil cracks once	1684	11.38	1.23	42599	2.07
		Farmers practice (frequent intercultivation)	1512	-	1.11	34346	1.72

Patameghpar



Intercultivation in groundnut



Control

Dangarvada



Intercultivation in groundnut



Control

Preparedness

Rainwater management

Ridge and furrow system and earthing for *in-situ* moisture conservation in groundnut recorded higher seed yield (2310 kg/ha) compared to farmers practice (2132 kg/ha) with higher net returns (Rs.78821/ha), B:C ratio (2.48) and RWUE (1.63 kg/ha-mm) (Table). Similarly, earthing up in cotton recorded higher seed cotton yield (1645 kg/ha) compared to farmers practice (1533 kg/ha) with higher net returns (Rs.44215/ha), B:C ratio (1.94) and RWUE (1.16 kg/ha-mm) (Table 48).

Table 48: Effect of *in-situ* rainwater management on yield and economics of groundnut and cotton

Farming situation/ soil type	Intervention	Yield (kg/ha)			Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Seed 2019-20	Mean seed (3 years)	Stalk				
Rainfed/medium black	**Groundnut**							
	Ridge and furrow	2310	2250	3324	53300	78821	2.48	1.63
	Farmers' practice*	2132	-	3068	52400	69540	2.33	1.51
	Cotton							
	Earthing up	1645	1791	3055	47200	44215	1.94	1.16
	Farmers' practice*	1533	-	2847	46240	38951	1.84	1.08

*Farmers' practice: Flat bed system

Supplemental irrigation (5 cm) from harvested rain water through sprinkler in groundnut recorded higher seed yield (2405 kg/ha) compared to farmers practice (2375 kg/ha) with higher net returns (Rs.84254/ha), B:C ratio (2.58) and RWUE (1.70 kg/ha-mm) (Table). Similarly, in cotton supplemental irrigation (6 cm) through alternate furrow method recorded higher seed cotton yield

(1782 kg/ha) compared to farmers practice of no supplemental irrigation (1644 kg/ha) with higher net returns (Rs.51428/ha), B:C ratio (2.08) and RWUE (1.26 kg/ha-mm) (Table 49).

Table 49: Effect of *ex-situ* rainwater management on yield and economics of groundnut and cotton

Farming situation/ soil type	Intervention	Yield (kg/ha)			Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Seed 2019-20	Mean seed (3 years)	Stalk				
Rainfed/ medium black	**Groundnut**							
	Supplemental irrigation	2405	2298	3461	53300	84254	2.58	1.70
	No supplemental irrigation	2357	-	3392	52500	82309	2.57	1.67
	Cotton							
	Supplemental irrigation	1782	1860	3309	47600	51428	2.08	1.26
	No supplemental irrigation	1644	-	2366	46800	42497	1.91	1.16

Cropping systems

Groundnut + castor (3:1) intercropping system gave higher groundnut equivalent yield (2863 kg/ha), LER (1.35), MAI (25273), net returns (Rs.98045/ha), B:C ratio (2.64) and RWUE (2.23 kg/ha-mm) compared to farmers practice of sole cotton (2125 kg/ha). Similarly, cotton + pulses (1:1) intercropping system gave higher cotton equivalent yield (2485 kg/ha), LER (1.43), MAI (21762), net returns (Rs.72245/ha), B:C ratio (2.27) and RWUE (1.83 kg/ha-mm) compared to farmers practice of sole cotton (2001 kg/ha) (Table 50).

Table 50: Performance of intercropping systems

Farming situation/ Soil type	Intervention	Yield (kg/ha)		MCEY		LER	MAI	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Main crop	Inter crop	2019-20	Mean (3 yrs)						
Rainfed/ medium black	Groundnut + castor (3:1)	2023	1200	2863	3157	1.35	25273	59780	98045	2.64	2.23
	Farmers' practice (Sole cotton)	2125	-	2125	2061	-	-	48600	54425	2.12	1.46
	Cotton + pulses (1:1)	1450	840	2458	2585	1.43	21762	56980	72245	2.27	1.83
	Farmers' practice (Sole cotton)	1806	-	1806	2001	-	-	47300	52725	2.11	1.41

Nutrient management

Application of 50 % RDF + 25 % through castor cake/ biofertilizer (Basal) in groundnut recorded higher yield (2215 kg/ha), net returns (Rs.77940/ha), B:C ratio (2.79) and RWUE (3.54 kg/ha-mm) compared to farmers practice (1985 kg/ha). Similarly, in cotton application of 50 % RDF + 25 % through castor cake/ biofertilizer (Basal) gave higher yield (1987 kg/ha), net returns (Rs.71220/ha), B:C ratio (2.82) and RWUE (3.31 kg/ha-mm) compared to farmers practice (1823 kg/ha) (Table 51).

Table 51: Effect of nutrient application on crop yield and economics

Farming situation/ Soil type	Crop	Intervention	Yield (kg/ha)	Mean seed (3 yrs)	Stalk/ stover	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Rainfed /medium black	Groundnut	50 % RDF + 25 % through castor cake/ biofertilizer (Basal)	2125	2184	3058	77940	2.79	3.54
		Farmers' practice	1985	-	2856	71232	2.68	3.31
	Cotton	50 % RDF + 25 % through castor cake/ biofertilizer (Basal)	1987	1937	3690	71220	2.82	3.31
		Farmers' practice	1823	-	3386	65067	2.80	3.04

FP: application of chemical fertilizers only

At Patamegphar and Dargarvada, foliar spray of 1% ferrous sulphate in groundnut gave 2.1 and 4.66% higher pod yield (2245 and 2314 kg/ha) with higher net returns (Rs.79955 and 84026/ha), B:C ratio (2.52 and 2.60) and RWUE (1.59 and 1.69 kg/ha-mm) compared to farmers practice of no foliar spray (2200 and 2211 kg/ha). Similarly, foliar spray of 1% potassium nitrate increased the yield in cotton by 4.15 and 2.61% (1606 and 1612 kg/ha) with higher net returns (Rs.38903 and 39226/ha), B:C ratio (1.99 and 2.00) and RWUE (1.14 and 1.18 kg/ha-mm) compared to farmers practice of no foliar spray (1542 and 1571 kg/ha) (Table 52).

Table 52: Effect of foliar spray on crop yield and economics

Farming situation/ Soil type	Crop	Intervention	Yield (kg/ha)	Percent increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Patameghpar							
Rainfed /medium black	Groundnut	Foliar spray of ferrous sulphate 1 %	2245	2.05	1.59	79955	2.52
		Farmers' practice (no foliar spray)	2200	-	1.56	77800	2.50
	Cotton	Foliar spray of potassium nitrate 1 %	1606	4.15	1.14	38903	1.99
		Farmers' practice (no foliar spray)	1542	-	1.09	35960	1.76
Dangarvada							
Rainfed /medium black	Groundnut	Foliar spray of ferrous sulphate 1 %	2314	4.66	1.69	84026	2.60
		Farmers' practice (no foliar spray)	2211	-	1.62	78449	2.51
	Cotton	Foliar spray of potassium nitrate 1 %	1612	2.61	1.18	39226	2.00
		Farmers' practice (no foliar spray)	1571	-	1.15	37520	1.79

*Note: Groundnut $FeSO_4$ 100g/ 10 litre, Total 400 lit/ha water used
Cotton:KNO_3 100g/ 10 litre, Total 400 lit/ha water used



Foliar spray $FeSO_4$ @ 100g/ 10 litre) Control (No foliar spray)

1.1.7 S.K. NAGAR

a. Agro-ecological setting

Saradar krishinagar is located in Western Plain, Kachchh and part of Kathiawar peninsula, Rajasthan Bagar, north Gujarat Plain and southwestern Punjab plain (AESR 2.3). Centre for Natural Resource Management, S.D. Agricultural University, Sardarkrushinagar, Taluka-Dantiwada, District-Banaskantha, geographically located in North Gujarat at 24°19' North latitude, 72°19' East longitude and 154.52 meter above mean sea level. The overall climate varies from arid to semi-arid. Summer is very hot and winter is cool and dry. The mean annual rainfall ranges from 328 mm (2018) to 2083 mm (2017) with an average annual rainfall is 692.8 mm. Rainfall is inadequate, uncertain and erratic as well as the soil is loamy sand in texture with low moisture retention capacity. The dry farming in such soils of North Gujarat is unassured and unpredicted.

b. On-station experiments

Experienced weather conditions during 2019-20

During 2019, the onset of monsoon was advanced by 12 days (13th June). A rainfall of 511.8 mm was received which was deficit by 126.2 mm (19.8%) compared to normal (638.0 mm). During south-west monsoon, a rainfall of 475.6 mm was received which was deficit by 122.5 mm (20.5) mm than normal crop seasonal rainfall. Terminal drought in different crops occurred due to early withdrawal of monsoon.

Normal onset of monsoon	25 June
Onset of monsoon during 2019	30 June
Annual mean rainfall	638.0 mm
Annual rainfall during 2019-20	511.8 mm
Mean crop seasonal rainfall	598.1 mm
Crop seasonal rainfall during 2019-20	475.6 mm

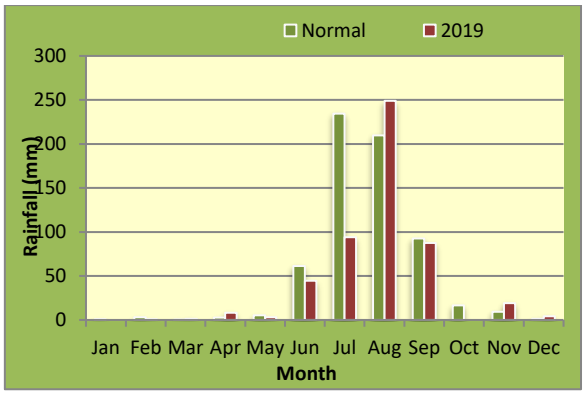


Fig. 17: Normal and actual (2019) monthly rainfall at SK Nagar

Dry spells during crop growing season (2019-20)

Dry spell		Crops	Stage of the crop
Duration (days)	Dates & months		
10	12-21 July	Pearlmillet, Pulses	Seedling
24	9 October - 2 November	Castor	Flowering and Capsule development
23	20 November -12 December		Maturity
-	20 December to onward		

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Terminal drought	Castor	Flowering till maturity	Life saving irrigation

Salient achievements of on-station experiments: Nil

Real time contingency planning: Nil

Situation: Terminal drought

During 2019, terminal drought occurred due to early withdrawal of monsoon affecting the seed filling and maturity of castor affecting the branching and flowering stages of castor. Application of two life saving irrigations (50 mm each) from harvested rainwater from farm pond to castor during flowering to capsule development recorded significantly higher seed yield (1304 kg/ha), with higher net returns (Rs.39393/ha), B:C ratio (2.80) and RWUE (1.52 kg/ha-mm) followed by two life saving irrigations (25 mm each) (1144 kg/ha) compared to control (808 kg/ha) (Table. 53).

Table 53: Effect of supplemental irrigation on yield and economics of castor (GCH 7)

Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed (2018-19)	Mean seed (2017-19)	Stalk				
Control (no life saving irrigation	808	818	1597	10150	22958	2.26	0.94
One life saving irrigation (25 mm)	999	991	1978	11650	29299	2.51	1.17
Two life saving irrigations (25 mm each)	1144	1133	2269	12950	33834	2.62	1.34
One life saving irrigation (50 mm)	1066	1047	2113	12150	31527	2.59	1.24
Two life saving irrigations (50 mm each)	1304	1274	2587	14050	39393	2.80	1.52
Alternate furrow irrigation (50 mm)	1011	1008	2000	11600	29850	2.57	1.18
CD at 5%	214.5	-	422.7	-			



Two lifesaving irrigation (25 mm each)



Two lifesaving irrigation (50 mm each)



Control

Performance of castor under different treatments

c. On farm demonstrations

Village profile

The program is being implemented in Kalimati/ Dholiya village, taluka Amirgadh, Banaskantha district, Gujarat located in North Gujarat at 24°36'7.40" North latitude, 72°59'33.65" East longitude and 216 meter above mean sea level. The overall climate varies from arid to semi-arid. The rainfall is inadequate, uncertain and erratic in nature. The average annual rainfall varies from 383 mm (2018) to 1393 mm (2017). The major soil types are sandy loam and clay. The major rainfed crops during *kharif* are pearlmillet, greengram, castor, cotton, blackgram, sorghum, clusterbean, and maize and cumin during *rabi*. The numbers of small, marginal, medium and large farmers are 83, 49, 75 and 39. The source of irrigation is well, tube well, canal, check dam and farm ponds covering 51.05% of cultivated area. The new village is Ghanghu, District Banaskanta, located in North Gujarat at 24°35'6.94" North latitude, 72°60'78.71" East longitude and 225 meter above mean sea level.

Climate vulner*abil*ity in general

In general, the climate is semi-arid. The south-west monsoon contributes 94% of the total annual average rainfall of 873 mm. The historical rainfall data (of 30 years) indicated that there was variability in rainfall during south-west monsoon. The onset (south-west) of monsoon was during 26 SMW. The dry spells during crop season were experienced, for the past 15 years, during August and September and at vegetative to reproductive stages of the major rainfed crops. The onset of monsoon has been shifting from 26 SMW (June) to 27 SMW (July). The soil moisture status was deficit during vegetative, reproductive and maturity stages of major rainfed crops. The extreme events like unusual and high intensity rainfall in short span were increasing in July and August during *kharif* season. The area was also experiencing other extreme events like floods, heat wave and cold wave. There had been considerable shift in rainfall pattern and uneven distribution with shift in sowing window (27 to 28 SMWs) of pearlmillet, greengram, sorghum, cluster bean, maize, castor, cotton etc.

Experienced weather conditions during 2019-20

During 2019, in Kalimati village, onset of monsoon was 12 days early (13th June). A total rainfall of 884 mm was received which was deficit by 10.8 mm (1.2%) compared to normal (873.2 mm). Out of total rainfall, crop seasonal rainfall was 758.1 mm which was deficit by 24.7 mm (3.2%) than normal of 782.8 mm.

Normal onset of monsoon	25 June
Onset of monsoon during 2019	13 June
Annual mean rainfall	873.2
Annual rainfall during 2019-20	884 mm
Mean crop seasonal rainfall	782.8 mm
Crop seasonal rainfall during 2019-20	758.1 mm

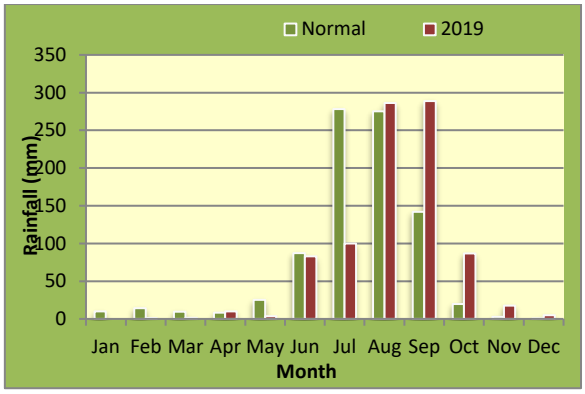


Fig 18: Normal and actual (2019) monthly rainfall at Kalamati

Dry spells during crop growing season (2019-20)

Dry spell		Crops	Stage of the crop
Duration (days)	**Dates & months**		
7	14 July - 20 July	Cereals, Pulses	Seedling
16	16 October - 31 October	Castor	Flowering and Capsule development
07	10 November - 16 November		Capsule development to Maturity onward
15	27 November - 11 December		Maturity
-	20 December – till harvest		

Real time contingency practices (RTCP) implemented

Weather aberration	Farming situation/ Soil type	RTCP implemented	
		Crop	RTCP implemented
Kalimati/Dholiya village &Ghanghu village			
Terminal drought	Sandy loam to clay	Castor	Supplemental irrigation

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Terminal drought

Terminal drought occurred at Kalimati/Dholiya village due to early withdrawal of monsoon affecting branching and flowering of castor. Supplemental irrigation (60 mm each) twice (on 23.10.2019 & 01.12.2019) through micro-irrigation (MIS) after flowering to capsule development in castor from harvested rainwater in farm pond gave 44.4% higher seed yield (1434 kg/ha) and stalk yield (2841 kg/ha) compared to farmers' practice of no supplemental irrigation (993 kg/ha), with higher net returns (Rs.52282/ha), B:C ratio (3.03) and WUE (1.62 kg/ha-mm) (Table 54).

Table 54: Effect of supplemental irrigation on yield and economics of castor

Intervention	Yield (kg/ha)		Net returns (Rs/ha)	B:C ratio	WUE (kg/ha-mm)
	Seed	Stalk			
Supplemental irrigation	1434	2841	52282	3.03	1.62
No supplemental irrigation	993	2268	33948	2.37	1.12

Terminal drought occurred at Ghanghu village due to early withdrawal of monsoon affecting branching and flowering of castor Supplemental irrigation (60 mm each) twice (on 23.10.2019 &

01.12.2019) through micro-irrigation (MIS) after flowering to capsule development in castor from harvested rainwater in farm pond recorded 37.65% higher seed and stalk yields (1404 & 2947 kg/ha, respectively) compared to farmers' practice of no supplemental irrigation (1020 kg/ha), with higher net returns (Rs.50910/ha), B:C ratio (2.95) and WUE (1.59 kg/ha-mm) (Table 55).

Table 55: Effect of supplemental irrigation on yield and economics of castor

Intervention	Yield (kg/ha)		Net returns (Rs/ha)	B:C ratio	WUE (kg/ha-mm)
	Seed	Stalk			
Supplemental irrigation	1404	2947	50910	2.95	1.59
No supplemental irrigation	1020	2304	35248	2.46	1.15



Castor with supplemental irrigation



Castor without supplemental irrigation

Preparedness

Rainwater management

At Kalimati/Dholiya village, *in-situ* moisture conservation in castor with ridge and furrow system recorded higher grain and stalk yield (1161 and 2714 kg/ha) compared to flat bed method (967 kg/ha) with higher net returns (Rs.40571/ha), B:C ratio (2.55) and RWUE (1.31 kg/ha-mm) (Table 56).

Table 56: Effect of ridge and furrow method of *in-situ* moisture conservation on yield and economics of castor

Intervention	Yield (kg/ha)			Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed (2019)	Mean seed yield (2011-20)	Stalk			
Ridge & furrow method	1161	1212	2714	40571	2.55	1.31
Flat bed method	967	878	2311	32734	2.28	1.09



Castor under ridge & furrow method



Castor under flat bed method

At Kalimati/Dholiya village, *in-situ* moisture conservation in pearlmillet with compartmental bunding recorded higher grain and fodder yield (1157 and 3084 kg/ha) compared to no compartmental bunding (959 kg/ha), with higher net returns (Rs.22678/ha), B:C ratio (2.00) and RWUE (1.31kg/ha-mm) (Table 57).

Table 57: Effect of *in-situ* moisture conservation on yield and economics of pearlmillet

Intervention	Yield (kg/ha)			Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain (2019)	Mean grain (2011-20)	Fodder			
Compartmental bunding	1157	1447	3084	22678	2.00	1.31
No compartmental bunding	959	1046	2674	17925	1.67	1.08



Pearlmillet under compartmental bunding



Pearlmillet under flat bed method

At Kalimati/Dholiya village, *ex-situ* moisture conservation in castor with supplemental irrigation (60 mm depth each) twice (on 25.10.2019 & 03.12.2019) through micro-irrigation (MIS) after flowering to capsule development in castor from harvested rainwater in farm pond recorded 37.9% significantly higher seed and stalk yields (1492 & 2970 kg/ha, respectively) compared to farmers' practice of no supplemental irrigation (1131 kg/ha), with highest net returns (Rs.55101/ha), B:C ratio (3.19) and WUE (1.69 kg/ha-mm) (Table 58).

Table 58: Effect of supplemental irrigation on of *ex-situ* moisture conservation yield and economics of castor

Intervention	Yield (kg/ha)			Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed (2019)	Mean seed yield (2014-20)	Stalk			
Supplemental irrigation	1492	1453	2970	55101	3.19	1.69
No supplemental irrigation	1131	980	2498	40618	2.83	1.28



Castor with supplemental irrigation



Castor without supplemental irrigation

At Ghanghu village, *in-situ* moisture conservation with ridge and furrow system in castor recorded higher seed and stalk yield (1127 and 2666 kg/ha) compared to local practice of flat bed method (911 kg/ha) with higher net returns (Rs.38932/ha), B:C ratio (2.44) and RWUE (1.27 kg/ha-mm) (Table 59).

Table 59: Effect of ridge & furrow method of *in-situ* moisture conservation on yield and economics of castor

Intervention	Yield (kg/ha)			Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed (2019)	Mean seed yield (2017-20)	Stalk			
Ridge & furrow method	1127	1237	2666	38932	2.44	1.27
Flat bed method	911	1003	2276	30057	2.09	1.03

At Ghanghu village, *in-situ* moisture conservation in pearlmillet with compartmental bunding recorded higher grain and fodder yield (1207 and 3132 kg/ha) compared to local practice of no compartmental bunding (991 kg/ha), with higher net returns (Rs.23807/ha), B:C ratio (2.10) and RWUE (1.37 kg/ha-mm) (Table 60).

Table 60: Effect of *in-situ* moisture conservation on yield and economics of pearlmillet

Intervention	Yield (kg/ha)			Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain (2019)	Mean grain (2017-20)	Fodder			
Compartmental bunding	1207	1135	3132	23807	2.10	1.37
Local practice	991	987	2702	18637	1.73	1.12

At Ghanghu village, *ex-situ* moisture conservation in castor with supplemental irrigation (60 mm depth each) twice (on 25.10.2019 & 03.12.2019) through micro-irrigation (MIS) after flowering to capsule development in castor from harvested rainwater in farm pond recorded 29.3% higher seed yields (1517 kg/ha) compared to farmers' practice of no supplemental irrigation (1173 kg/ha), with highest net returns (Rs.56313/ha), B:C ratio (3.26) and WUE (1.72 kg/ha-mm) (Table 61).

Table 61: Effect of supplemental irrigation on of *ex-situ* moisture conservation yield and economics of castor

Intervention	Yield (kg/ha)			Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed (2019)	Mean seed yield (2014-20)	Stalk			
Supplemental irrigation	1517	1523	3018	56313	3.26	1.72
No supplemental irrigation	1173	1142	2551	42639	2.97	1.33

Cropping systems

Intercropping system (1:1) of castor + greengram (GCH 7 + Gujarat Mung 4) at Kalimati Dholiya recorded 21.5% higher castor equivalent yield (1512 kg/ha), with higher net returns (Rs.54613 kg/ha) B:C ratio (3.18) and RWUE (1.71 kg/ha-mm) compared to sole castor (1244 kg/ha) (Table 62).

Table 62: Effect of castor + greengram intercropping system (1:1) on yield and economics

Farming situation/ soil type	Intervention	CEY (kg/ha)		LER	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		2019-20	Mean (2017-19)				
Loamy sand	Castor + greengram (1:1)	1512	1590	1.49	54613	3.18	1.71
	Castor sole	1244	1063	-	42646	2.69	1.41

CEY: Castor equivalent yield



Castor + greengram intercropping (1:1)



Castor sole

Intercropping system (1:1) of castor + greengram (GCH 7 + Gujarat Mung 4) at Ghanghu village recorded 20.4% higher castor equivalent yield (1617 kg/ha), with higher net returns (Rs.59628 kg/ha), B:C ratio (3.47), RWUE (1.83 kg/ha-mm) compared to sole crop of castor (1344 kg/ha) (Table 63).

Table 63: Effect of castor + greengram intercropping system (1:1) on yield and economics

Farming situation/ soil type	Intervention	CEY (kg/ha)		LER	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		2019-20	Mean (2017-19)				
Loamy sand	Castor + greengram (1:1)	1617	1519	1.52	59628	3.47	1.83
	Castor sole	1344	1135	-	47326	2.99	1.52

CEY: Castor equivalent yield

1.1.8 SOLAPUR

a. Agro-ecological setting

Solapur is in Deccan Plateau of South Western Maharashtra and North Karnataka Plateau (AESR6.1). The climate is hot and semi-arid. Annual average potential evapo-transpiration is 589 mm. Annual rainfall is 721.4 mm. The length of growing period is 90-120 days. Solapur is a rainfall shadow area and has drought occurring once in ten years. Water erosion is of high severity with moderate loss of top soil, affecting 51-100 % area. The soils are shallow and medium loamy black soils (deep clayey black soils). Available water capacity is medium to high. Soil reaction is alkaline.

b. On-station experiments

Experienced weather conditions during 2019-20

During 2018, the onset of monsoon was normal (4 June). An annual rainfall of 782.1 mm was received which was excess by 60.7 mm (8.4%) compared to normal rainfall of 721.4 mm. During *kharif*, 427.1 mm rainfall was recorded against normal of 535.2 mm. *Rabi* season recorded 335.0 mm, which was excess by 209.5 mm compared to normal rainfall of 125.5 mm (Fig. 19).

Normal onset of monsoon	7 June
Onset of monsoon during 2019	4 June
Annual mean rainfall (mm)	721.4 mm
Actual annual rainfall (mm) during 2019-20	782.1 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	535.2 mm and 125.5 mm
Crop seasonal rainfall during 2019-20	427.1 mm and 335.0 mm

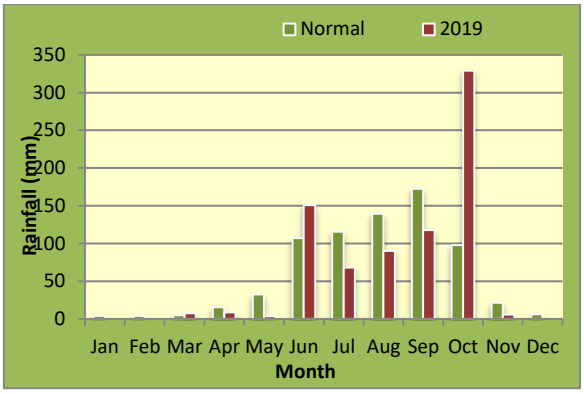


Fig. 19: Normal and actual (2019) monthly rainfall at Solapur

Dry spells during crop growing season (2019-20)

Dry spell		Crop	Stage of the crop
Duration (days)	**Dates & months**		
14	26 June -8 July	Pigeonpea, sunflower, bajra and blackgram	Early growth stage
13	17 - 29 August	Sunflower	Button stage
30	02 November - 02 December	Sorghum and chickpea	Early growth stage

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Mid Season Drought	Pearlmillet, sunflower	Vegetative, flowering, button stage and grain filling	Foliar spray

Salient achievements of on-station experiments

Real time contingency planning

Situation: Mid season drought

A dry spell of 13 days occurred during 17-29 August coinciding with button stage in sunflower. Foliar spray in sunflower var. Phule Bhaskar during dry spell recorded higher seed and stalk (739 and 1907 kg/ ha),with higher net returns (Rs.20447/ha), B:C ratio (2.22) and RWUE (2.19 kg/ha-mm) compared to the foliar spray after relieving dry spells (684 kg/ha). Among different foliar sprays, water soluble complex fertilizer (19:19:19) @ 0.5% + FeSO4 @ 0.5% recorded significantly higher sunflower seed and stalk (976 and 2649 kg/ha), net returns (Rs.32268/ha), B:C ratio (2.90) and RWUE (2.10 kg/ha-mm) compared to other treatments (Table 64).

Table 65. Effect of foliar spray on yield and economics of sunflower

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain Yield	Straw yield				
Main Plot						
Foliar Spray during dry spell	739	1907	16616	20447	2.22	2.19
Foliar Sprays after relieving dry spell	684	1874	16616	17917	2.07	2.03
CD at 5%	**N.S.**	**N.S.**	-	-	-	-

Sub Plot (foliar sprays)						
Urea @ 1%	569	1511	16540	12087	1.73	1.69
Urea @ 2%	613	1436	16580	13877	1.83	1.82
Water soluble complex fertilizer (19:19:19) @ 0.5%	901	2406	16835	28544	2.69	2.67
Water soluble complex fertilizer (19:19:19) @ 0.5% + recommended dose of micronutrient for foliar spray.	976	2649	16973	32268	2.90	2.10
Recommended dose of micronutrient for foliar spray	712	1934	16638	19292	2.16	2.11
Water spray	692	1884	16500	18408	2.11	2.05
Control (No spray of any material of water)	516	1415	16250	9799	1.60	1.53
CD at 5%	**0.37**	**0.99**	**-**	**-**	**-**	**-**



Sunflower with foliar spray 19:19:19 @ 0.5% + $FeSO_4$ @ 0.5%

Foliar spray increased the available N, P and K content in soil at harvest, among the foliar sprays, water soluble complex fertilizer (19:19:19) @ 0.5% + recommended dose of micronutrient i.e. @ 0.5% $FeSO_4$ recorded significantly higher values of available N (200 kg/ha) and P (20.5 kg/ha) (Table 65).

Table 65: Effect of treatments on soil chemical properties at harvest

Treatment	**pH**	**OC (%)**	**Available nutrient (kg/ha)**		
			N	**P**	**K**
Main plot					
Foliar Spray during dry spell	7.57	0.47	194	19.7	621
Foliar Sprays after relieving dry spell	7.59	0.45	190	16.7	611
Sub plot (foliar sprays)					
Urea @ 1%	7.59	0.42	189	15.5	575
Urea @ 2%	7.61	0.43	191	17.5	582
Water soluble complex fertilizer (19:19:19) @ 0.5%	7.48	0.44	195	18.5	649
Water soluble complex fertilizer (19:19:19) @ 0.5% + recommended dose of micronutrient for foliar spray.	7.48	0.46	200	20.5	658
Recommended dose of micronutrient for	7.72	0.48	190	21.5	665

foliar spray					
Water spray	7.68	0.50	190	17.0	603
Control (No spray of any material of water)	7.53	0.49	185	17.0	578
Initial values at start of experiment	7.21	0.42	183	16.8	622

c. On-farm Demonstrations

Village profile

The programme is being implemented in Narotewadi village, North Solapur Tehsil in Solapur district. The total cultivated area is 560.7 ha out of which 450 ha is rainfed. The mean annual rainfall is 546.5 mm with seasonal rainfall of 404.5 mm and 123 mm which was deficit by 16.2 and 114.8 mm during *kharif* and *rabi* seasons respectively as compared to normal rainfall (420.7 mm and 237.8 mm during *kharif* and *rabi* respectively). The major soil types are sandy loam, loam and clay loam. The major rainfed crops in *kharif* are sunflower, pigeonpea and blackgram, sorghum and chickpea in *rabi* season. The number of small, marginal, medium and large farmers are 52, 122, 86 and 22 respectively. The ground water table is 15 to 18 m, the source of irrigation is open dug wells and bore wells covering 15-19% of cultivated area.

Climate vulner*abi*lity in general

The climate of this agro-climatic zone is semiarid. Out of the total annual average rainfall of 546.5 mm, the south-west monsoon contributes 80% and north-east contributes 20%. The historical rainfall data (30 years) indicates that the variability in rainfall during south-west monsoon was 12% deficit of the average rainfall. The onset of southwest monsoon was during 21 SMW and north- east monsoon was during 40 SMW. For the past 15 years, the dry spells during crop season were experienced during August and at flowering stages of the major rainfed crops. The onset of monsoon is normal.

Experienced weather conditions during 2019-20

During 2019, in Narotewadi village, the onset of monsoon was delayed by 30 days (6th July) and a rainfall of 592.0 mm was received which was deficit by 129.4 mm compared to normal (721.4 mm). During *kharif* seasons, 306.0 mm of rainfall was recorded which was deficit by 229.2 mm. During *rabi* 286.0 mm of rainfall was received against the normal rainfall (125.5 mm) (Fig. 20)

Normal onset of monsoon	7 June
Onset of monsoon during 2019	6 July
Annual mean rainfall (mm)	721.4 mm
Actual annual rainfall (mm) during 2019-20	592.00 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	420.7 mm and 237.8 mm
Crop seasonal rainfall during 2019-20	192.0 mm and 400.0 mm

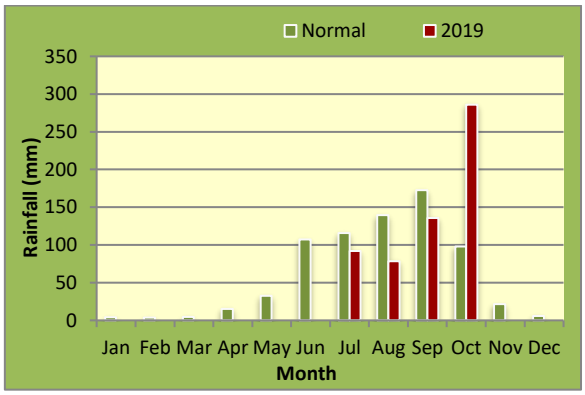


Fig. 20: Normal and actual (2019) monthly rainfall at Narotewadi

Dry spells during crop growing season (2019-20)

Dry spell		Crop	Stage of the crop
Duration (days)	**Dates & months**		
29	07 June – 05 July	Pigeonpea, sunflower, pearlmillet, genogram and blackgram	Early growth stage
23	08 - 30 August	Pigeonpea, sunflower, pearlmillet, genogram and blackgram	Flowering stage, pod formation stage
65	26 October – 31 December	*Rabi* sorghum and chickpea	Pod development and grain filling stage

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Delayed onset of monsoon	Pearlmillet	Initial	Improved verities
Earlyseason drought	*Rabi* sorghum	Primordial stage and grain filling stage	Supplemental irrigation
Midseason Drought	Pearlmillet, sunflower	Vegetative, flowering, button stage and grain filling	Foliar spray

Salient achievements of on-station experiments

Real time contingency planning

Situation: Delayed onset of monsoon

At Narotewadi village (Solapur district, Maharashtra), the onset of monsoon was delayed by 29 days. Improved pearlmillet var. Dhanshakti recorded higher seed yield (920 kg/ha), net returns (Rs.4684/ha) and B:C ratio (1.20) compared to local variety (680 kg/ha) (Table 66).

Table 66: Yield and economics of Pearlmillet (var. Dhanshakti) under delayed onset of monsoon

Farming situation/ Soil type	Normal crop	Change in variety	Yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Medium black soil	Improved practice	Dhanshakti	920	35.29	4.79	4684	1.20
	Farmers' practice	Shardha	680	41.64	3.57	9369	1.38



Pearlmillet var. Dhanshakti

Situation: Early season drought

Two supplemental irrigations of 6 cm depth, through surface irrigation from open well at primordial (28-30 DAS) and grain filling stages (90-95 DAS) increased the grain yield (1240 kg/ha) of sorghum (cv. Phule Suchitra) by 25.63% with higher net returns (Rs.14500/ha), B:C ratio (1.37) and WUE (3.10 kg/ha-mm) over farmers' practice of no supplemental irrigation (987 kg/ha) (Table 67).

Table 67: Effect of supplemental irrigation on yield and economics of *rabi* sorghum

Farming situation/ Soil type	Intervention	Yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	GMR (Rs/ha)	NMR (Rs/ha)	CC (Rs/ha)	B:C ratio
Medium Black Soil	Supplemental irrigation*	1240	25.63	3.10	52700	14500	38200	1.37
	Farmers' practice (no supplemental irrigation)	987	-	2.46	41454	9254	32200	1.28



Supplemental irrigation to sorghum



Farmers'practice (no supplemental irrigation) at Narotewadi

AT Narotewadi village, foliar spray of KNO_3 @1% at flowering stage (42 DAS) on pearlmillet increased the grain yield (925 kg/ha) by 19.40% with higher net returns (Rs.5900/ha), B:C ratio (1.32) and RWUE (4.81 kg/ha-mm) over farmers' practice of without any spray (775 kg/ha) (Table 68).

Table 68: Effect of foliar spray on yield and economics of *pearlmillet*

Farming situation/ Soil type	Change in crop	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Grain	Straw			
Medium black soil	Improved practice	925	1400	4.81	5900	1.32
	Farmers' practice	775	1250	4.03	2400	1.13




Foliar spray of KNO3 @1% on pearlmillet

AT Narotewadi village, foliar spray of KNO_3 @1% at flowering stage (45 DAS) on sunflower (var. Tal-N) increased the grain yield (850 kg/ha) by 25.93% with higher net returns (Rs.26150/ha), B:C ratio (2.58) and RWUE (4.42 kg/ha-mm) over farmers' practice of without any spray (675 kg/ha) (Table 69).

Table 69: Effect of foliar spray on yield and economics of sunflower

Farming situation/ Soil type	Change in crop	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Grain	Straw			
Medium black soil	Improved practice	850	2200	4.42	26150	2.58
	Farmers' practice	675	1800	3.51	17575	2.07




Foliar spray of KNO3 @1% on pearlmillet **Foliar spray of KNO_3 @1% on sunflower**

Preparedness

Rainwater management

At Narotewadi and Banegoan villages, improved practice of preparing compartmental bunds on fallow land during *kharif* season followed by *rabi* sorghum (cv. Phule vasudha) increased the grain yield (1020 kg/ha) by 22.89% with higher net returns (Rs.10470/ha), B:C ratio (1.36) and RWUE (2.55 kg/ha-mm) over farmers' practice of two harrowing's during *kharif* season on fallow land followed by *rabi* sorghum (730 kg/ha) (Table 70).

Table 70: Effect of *in-situ* moisture conservation on yield and economics of *rabi* sorghum

Farming situation/ Soil type	Intervention	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Grain	Stover				
Medium to deep black soil	Improved practice	1020	2306	28600	10470	1.36	2.55
	Farmers' practice	730	1640	22200	5710	1.25	2.07

1.1.9 VIJAYAPURA

a. Agro-ecological setting

Vijayapura is in Karnataka Plateau (AESR 3). The climate is hot arid. Potential evapo-transpiration is 622 mm. The rainfall is 594 mm. The length of growing period is 90-120 days. Drought is common and occurs once in five years. Water erosion is of high severity with strong loss of top soil, affecting 26-50% area. The soils are deep loamy and clayey, mixed red and black soils. Available water capacity is low to medium. The dominant rainfed crops during *kharif* are pigeonpea and during *rabi* are sorghum and chickpea.

b. On-station experiments

Experienced weather conditions during 2019-20

During 2019, the onset of monsoon was early by 3 days (4th June), and a rainfall of 576.8 mm was received which was deficit by 17.6 mm (3.0%) compared to normal (594.3 mm). Out of total rainfall, *kharif* season (June- September) recorded 306.6 mm which was deficit by 80.9 mm (20.9%) than seasonal normal of 387.5 mm. During *rabi*, it was 189.4 mm which was excess by 55.4 mm (41.3%) than normal (134.0 mm) (Fig. 21).

Normal onset of monsoon	7 June
Onset of monsoon during 2019	4 June
Annual mean rainfall	594.3 mm
Annual rainfall during 2019-20	576.8 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	*kharif* 387.5 mm and *rabi* 134.0 mm
Crop seasonal rainfall during 2019-20 (*kharif* & *rabi*)	*kharif* 306.6 mm and *rabi* 189.4 mm

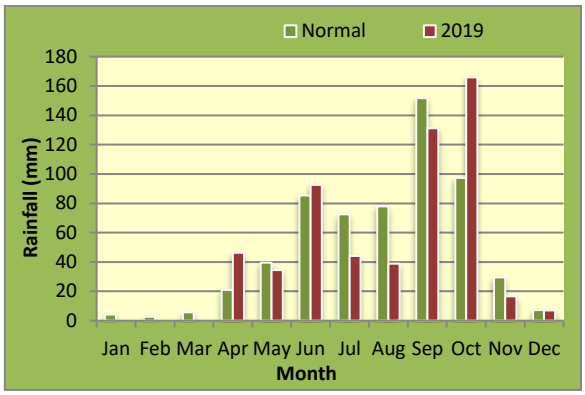


Fig. 21 : Normal and actual (2019) monthly rainfall at Vijayapura

Dry spells during crop growing season (2019-20)

Dry spell		Crop	Stage of the crop
Duration (days)	**Dates & months**		
15 days	8 June - 24 June	Pigeonpea, pearlmillet, greengram and groundnut	Seedling /vegetative stage
26 days	25 June – 21 July	Pigeonpea, pearlmillet, greengram and groundnut	Vegetative stage
23 days	30 July – 23 August	Pigeonpea, pearlmillet, greengram and groundnut	Vegetative, grand growth and flowering stage
29 days	24 August – 24 September	Sunflower, pigeonpea, *rabi* sorghum, chickpea and safflower	Seedling, vegetative and flowering stage
32 days	1 November - till 3 December	Sunflower, pigeonpea, *rabi* sorghum, chickpea and safflower	Flowering and maturity stage

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented
Terminal drought	Pigeonpea	Supplemental irrigation and mulching

Salient achievements of on-station experiments

Real time contingency planning

Situation: Terminal drought

During 2019, a dry spell of 32 days occurred during 1st November to 3rd December affecting the flowering and maturity stage of pigeonpea. Application of one irrigation of 5 cm at critical stage (flowering) along with mulching recorded significantly higher seed yield (2240 kg/ha), net returns (Rs.67333/ha), B:C ratio (3.40) and RWUE (5.29 kg/ha-mm) compared to other treatments (Table 71).

Table 71: Effect of critical irrigation and mulching on pigeonpea yield and economics

Treatment	Yield (kg/ha)		Net returns (Rs/ha)	B:C ratio	WUE (kg/ha-mm)
	Seed	Stover			
Irrigation at critical stage + mulch	2240	2866	67333	3.40	5.29
Irrigation at critical stage	1733	2211	47755	2.84	4.09
Irrigation after more than 20 days dry spell + mulch	1693	2166	40033	2.25	4.53
Irrigation after more than 20 day dry spell	1480	1891	32982	2.10	3.96
Control	1387	1772	37011	2.68	4.28
CD at 5%	523	636	-	-	-



Irrigation at critical stage + mulching in pigeonpea



Control

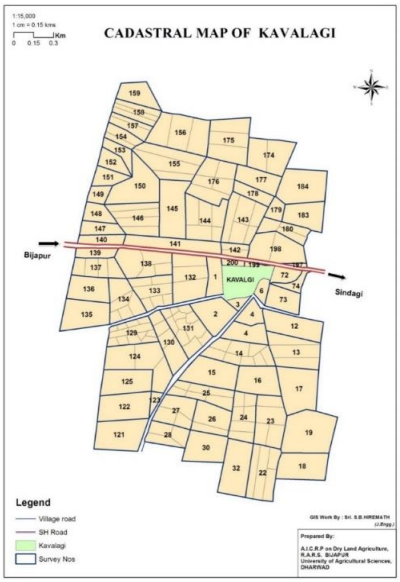
c. On-farm Demonstrations

Village profile

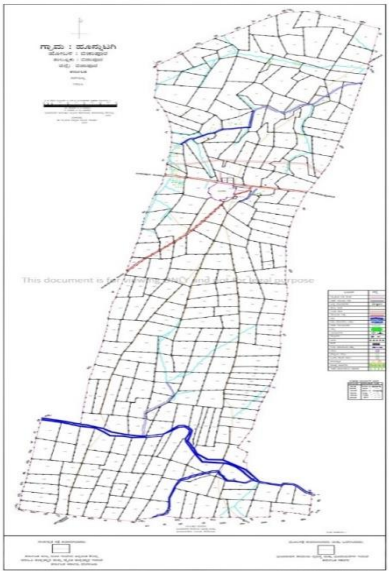
The program is being implemented in Kavalagi village, Vijayapura tehsil and Honnutagi Vijayapura district, Karnataka. The total cultivated area is 1327 ha out of which 1307 ha is rainfed. The mean annual rainfall is 594.4 mm with seasonal rainfall of 387.5 mm during *kharif(*June - September). The major soil types are shallow to medium deep black soils, shallow red soils and gravelly soils. The major rainfed crops during *kharif* are pearlmillet, pigeonpea, greengram, groundnut, maize and sorghum, chickpea, wheat, sunflower and safflower during *rabi* season. The number of small, marginal, medium and large farmers is 144, 53, 200 and 04, respectively. The

ground water table is 70 to 90 m. The source of irrigation is open-wells and bore- wells covering 1.5% of cultivated area only.

The village Kavalagi is located 15 km East of Vijayapura town ($16^0$48' N and $75^0$45' E). The new village Honnutagi is located 17 km East of Vijayapura town (75^0 50' 11.3'' to 75^0 52' 52.5''E and 16^o 45' 46.5" to 16^0 51' 18.6'' N).



Cadastral map of Kavalagi village



Cadastral map of Honnutagi village

Climate vulnerability in general

The climate is dry semi-arid. Out of the total annual average rainfall of 594.4 mm, the south-west monsoon contributes 65%, north-east monsoon contributes 22.5% and 12.5% rainfall is received during summer. The historical data (30 years) indicated that variability in rainfall during south-west monsoon was manifested in delayed onset of monsoon and drought.

Experienced weather conditions during 2019-20

During 2019, in Kavalagi village the onset of monsoon was early by 5 days (2 June). An annual rainfall of 616.57 mm was received which was excess by 22.2 mm (3.6%) than normal (594.3 mm). During *kharif*, there was a rainfall of 279.27 mm, deficit by 108.2 mm (27.9%) than normal (387.5 mm) and in *rabi* season 250.2 mm rainfall was recorded which was excess by 116.2 mm (86.7%) against normal of 134.0 mm (Fig. 22).

Normal onset of monsoon	7 June
Onset of monsoon during 2019-20	2 June
Annual mean rainfall (mm)	594.3 mm
Annual mean rainfall (mm) during 2019-20	616.57 mm
Mean crop seasonal rainfall (mm) during *kharif* and *rabi*	387.5 mm &134.0 mm, respectively
Crop seasonal rainfall (mm) during *kharif* and *rabi* 2019-20	279.27 mm & 250.2 mm, respectively

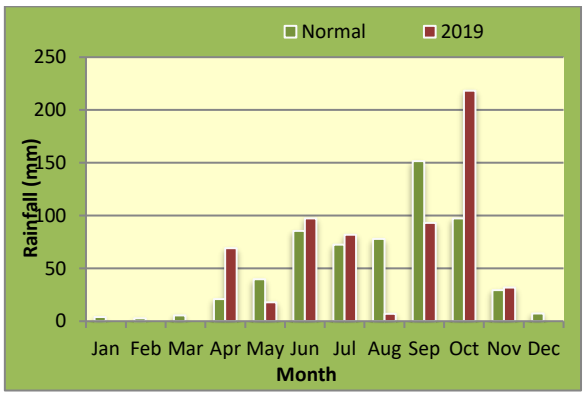


Fig. 22: Normal and actual (2019) monthly rainfall at Kavalagi

Dry spells during crop growing season (2019-20)

Dry spell		Crop	Stage of the crop
Duration (days)	**Dates & months**		
20 days	4 June – 23 June	Pigeonpea, pearlmillet, greengram and groundnut	Seedling /vegetative stage
17 days	2 July – 18 July	Pigeonpea, pearlmillet, greengram and groundnut	Vegetative stage
		Pigeonpea, pearlmillet, greengram and groundnut	Vegetative, grand growth and flowering stage
53 days	30 July – 22 September	Sunflower, pigeonpea, *rabi* sorghum, chickpea and safflower	Seedling, vegetative and flowering stage
11days	19 October – 31 October	Sunflower, pigeonpea, *rabi* sorghum, chickpea and safflower	Flowering and maturity stage

Real time contingency practices (RTCP) implemented

Weather aberration	Farming situation/ soil type	Crop	RTCP implemented
Village: Honnutagi			
Early season drought	Rainfed/ medium deep black soil	Pigeonpea, greengram	Weeding/intercultivation
	Rainfed/ medium deep black soil	Greengram	Thinning
Mid season drought	Rainfed/shallow and medium black soil	Pigeonpea, greengram	Foliar spray of KNO_3 @ 0.5%
	Rainfed/shallow and medium black soil	Pigeonpea, greengram	Protective irrigation
Village: Kavalagi			
Normal onset of monsoon	Rainfed/shallow and medium black soil	Pigeonpea, pearlmillet	Improved varieties
Early season drought	Rainfed/shallow and medium black soil	Pigeonpea,	Weeding/intercultivation
Mid season drought	Rainfed/shallow and medium black soil	Pigeonpea	Foliar spray of KNO_3 @ 0.5%
	Rainfed/ medium deep black soil	Pigeonpea	Protective irrigation

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Early season drought

During 2019, a dry spell of 20 days occurred during 4 June - 23 June coinciding with vegetative stage of *kharif* crops. Further, a dry spell of 17 days during 2 July - 18 July occurred during early vegetative stage of *rabi* crops. Weeding and Intercultivation with bullock drawn hoe at Honnutagi village, increased the yield of pigeonpea by 17.3% (1254 kg/ha), net returns (Rs.51979/ha), B:C ratio (4.06) and RWUE (3.44 kg/ha-mm) as compared to farmers' practice of no weeding and intercultivation. Similarly, at Kavalagi village, weeding/intercultivation increased yield by 18.5% (992 kg/ha), net returns (Rs.37875/ha), B:C ratio (3.28) and RWUE (2.72 kg/ha-mm) as compared to farmers' practice of no weeding and intercultivation (Table 72).

Table 72: Effect of weeding/intercultivation on pigeonpea yield and economics

Village	Farming situation/ soil type	Intervention	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Honnutagi	Rainfed / medium deep black soil	Weeding / interculture	1254	3.44	51979	4.06
		Farmers' practice*	1070	2.94	43827	3.92
Kavalagi	Rainfed / medium deep black soil	Weeding / interculture	992	2.72	37875	3.28
		Farmers' practice*	837	2.30	31017	3.07

*Farmers' practice: No interculture operation



Weeding/interculture in pigeonpea



Farmers' practice (no weeding/ intercultivation)

Weeding and Intercultivation with bullock drawn hoe at Honnutagi village, increased the yield of greengram by 12.2% (575 kg/ha), net returns (Rs.25500/ha), B:C ratio (3.83) and RWUE (5.27 kg/ha-mm) as compared to farmers' practice of no weeding and intercultivation (513 kg/ha) (Table 73).

Table 73: Effect of weeding / interculture on greengram yield and economics

Village	Farming situation/ soil type	Intervention	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Honnutagi	Rainfed / medium deep black soil	Weeding/interculture	575	5.27	25500	3.83
		Farmers' practice*	513	4.70	21750	3.62

*Farmers' practice: No weeding/interculture

Thinning during seedling stage at Honnutagi village, increased the yield of pigeonpea by 12.9% (875 kg/ha), net returns (Rs.32125/ha), B:C ratio (3.01) and RWUE (2.40 kg/ha-mm) as compared to farmers' practice of no thinning (775 kg/ha) (Table 74).

Table 74: Effect of weeding / interculture on greengram yield and economics

Village	Farming situation/ soil type	Intervention	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Honnutagi	Rainfed / medium deep black soil	Thinning	875	2.40	32125	3.01
		Farmers' practice*	775	2.13	27625	2.84

*Farmers' practice: No thinning

Situation: Mid season drought

At Honnutagi and Kavalagi villages, a long dry spell of 64 days occurred during 30 July to September 22 and 19 October to 31 October coinciding with flowering and maturity stage of pigeonpea and greengram. Two supplemental irrigations of 40 mm each with MIS (sprinklers) from

harvested rainwater recharged and stored in open wells gave an average of 54% to 68% and 61% higher yields in pigeonpea and greengram respectively, over farmers' practice of no supplemental irrigation, with higher net returns, B:C ratio and RWUE (Table 75).

Table 75: Effect of supplement irrigation on yield and economics of pigeonpea and greengram

Village	Farming situation/ soil type	Crop	Intervention	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Honnutagi	Rainfed / medium deep black soil	Pigeonpea	Supplemental irrigation	1729	4.75	76604	5.14
			Farmers' practice	1121	3.05	46646	4.11
Kavalagi	Rainfed / medium deep black soil	Pigeonpea	Supplemental irrigation	1625	4.46	70875	4.83
			Farmers' practice	970	2.66	38350	3.56
Honnutagi	Rainfed / medium deep black soil	Greengram	Supplemental irrigation	1250	11.46	65500	7.89
			Farmers' practice	775	7.10	37000	5.47

Farmers' practice: No supplemental irrigation



Pigeonpea with supplemental irrigation



Pigeonpea under farmers' practice

Foliar application of KNO_3 @ 0.5% gave an average of 17-23% higher yields in pigeonpea and greengram over farmers' practice of no foliar spray and recorded higher net returns, B:C ratio and RWUE (Table 76).

Table 76: Effect of foliar application of KNO_3 on yield and economics of different crops

Crop	Village	Farming situation/ soil type	Intervention	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Pigeonpea	Honnutagi	Rainfed / medium deep black soils	Foliar spray	1383	3.80	58583	4.35
			Farmers' practice	1129	3.10	47104	3.95
	Kavalagi	Rainfed / medium deep black soils	Foliar spray	1038	2.85	39896	3.32
			Farmers' practice	858	2.36	32163	3.14
Greengram	Honnutagi	Rainfed / medium deep black soils	Foliar spray	700	6.42	33000	4.67
			Farmers' practice	600	5.50	27000	4.24

*Foliar spray: KNO_3 @ 0.5%; Farmers' practice: No foliar spray

Preparedness

Cropping systems

At Honnutagi, among pigeonpea varieties TS 3R gave 30.6% higher yield (1366 kg/ha) with higher net returns (Rs.57744/ha), B:C ratio (4.28) and RWUE (3.75 kg/ha-mm) compared to farmers practice of Gulyal (1046 kg/ha)). Similarly, at Kavalagi, TS 3R gave 27.6% higher yield (1082 kg/ha) with higher net returns (Rs.42446/ha), B:C ratio (3.47) and RWUE (2.97 kg/ha-mm) compared to farmers practice of Gulyal (848 kg/ha) (Table 77).

Table 77: performance of improved varieties of pigeonpea

Village	Farming situation	Crop	Variety (duration)	Yield (kg/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Honnutagi	Rainfed medium deep black soils	Pigeonpea	TS 3R (135-145 days)	1366	57744	4.28	3.75
			ICPL-87 (150-160 days)	1188	48313	3.84	3.26
		Farmers' practice	Gulyal (140-150 days)	1046	42544	3.78	2.87
Kavalagi		Pigeonpea	TS 3R (135-145 days)	1082	42446	3.47	2.97
			ICPL-87 (150-160 days)	1000	38750	3.39	2.68
		Farmers' practice	Gulyal (140-150 days)	848	31613	3.11	2.31



Pigeonpea improved variety, TS-3R



Pigeonpea local variety, Gulyal

At Honnutagi, greengram variety DDGV-7 gave 21.7% higher yield (806 kg/ha) with higher net returns (Rs.39250/ha), B:C ratio (5.27) and RWUE (7.39 kg/ha-mm) compared to farmers practice of local variety (662 kg/ha) (Table 78).

Table 78: performance of improved varieties of greengram

Village	Farming situation	Crop	Variety (duration)	Yield (kg/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Honnutagi	Rainfed medium deep black soils	Greengram	DDGV-7 (80-90 days)	806	39250	5.27	7.39
			Local variety (90-95 days)	622	28188	4.39	5.70

At Kavalagi, pearlmillet variety DDGV-7 gave 8.4% higher yield (725 kg/ha) net returns (Rs.8450/ha), B:C ratio (2.31) and RWUE (2.51 kg/ha-mm) compared to farmers practice of private hybrid (669 kg/ha) (Table 79).

Table 79: performance of improved varieties of pearlmillet

Village	Farming situation	Crop	Variety (duration)	Yield (kg/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Kavalagi	Rainfed	Pearl millet	VPMH-7 (110-120 days)	725	8450	2.31	2.51
			Private hybrid (110-120 days)	669	7213	1.96	2.31

1.2 Moist Semi-Arid Zone (750-1000 mm)

1.2.1 AKOLA

a. Agro-ecological setting

Akola is in Eastern Maharashtra of Deccan Plateau, hot semi-arid eco-region (AESR 6.3). The climate is hot moist semi-arid. Average annual rainfall is 825 mm. Length of growing period is 120-150 days.

b. On-station experiments

Experienced weather conditions during 2019-20

During 2019, the onset of monsoon was delayed by 7 days (24 June) and an annual rainfall of 933.4 mm was received which was excess by 158.6 mm (20.4%) compared to normal (774.8 mm) (Fig. 23). Out of total rainfall received, 817.9 mm was received during *kharif* season which was excess by 151.6 mm compared to normal of 666.3 mm. During *rabi* season (October-December), 100.1 mm of rainfall was received against the normal (66.8.0 mm).

Normal onset of monsoon	11-17 June (24 SMW)
Onset of monsoon during 2019	24th June
Annual mean rainfall (mm)	774.8 mm
Actual annual rainfall (mm) during 2019-20	933.4 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	666.3 mm and 66.8 mm, respectively
Crop seasonal rainfall during 2019-20	817.9 mm and 100.1 mm, respectively

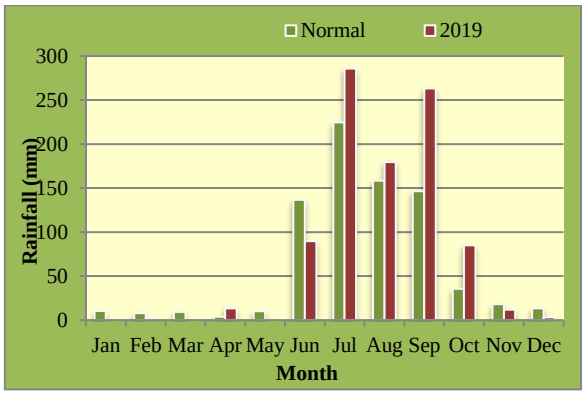


Fig. 23: Normal and actual (2019) monthly rainfall at Akola

Dry spells during crop growing season (2019-20)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & Months		
10	10 - 19 July	Soybean, cotton and pigeonpea	Vegetative Stage
		Greengram	Flowering stage
14	10 - 23 August	Soybean	Flowering stage
		Greengram	Pod development
		Cotton	Square formation
		Pigeonpea	Vegetative
16	04 - 19 October	Soybean	Pod development
		Cotton	Boll development
		Pigeonpea	Flowering

Real Time Contingency Practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Early season drought	Cotton, soybean, sorghum, pigeonpea and greengram	Vegetative	Opening of furrows after each row at 30-35 DAS and foliar spray
Mid Season Drought	Cotton and pigeonpea	Vegetative	

	Soybean	Flowering	
	Sorghum	Flag leaf	
	Greengram	Pod initiation	
Terminal Drought	Soybean and pigeonpea	Pod initiation	Spraying of 19:19:19 mix water soluble fertilizer
	Cotton	Boll development	Spraying of 2% urea at flowering and 2% DAP at boll development stage in cotton

Salient achievements of on-station experiments

Real time contingency planning

Situation: Mid-season drought

During *kharif* 2019, a dry spell of 14 days occurred during 10 - 23 August at pod development stage in in soybean. Foliar spray of 2% water soluble complex fertilizer (19:19:19) at flowering and pod development stage (PDS) recorded higher seed yield (1818 kg/ha), net returns (Rs.39386/ha), B:C ratio (2.10) and RWUE (2.45 kg/ha-mm) followed by foliar spray of 2% urea 35-40 and 2%19:19:19 at PDS recorded (1807 kg/ha) yield compared to control (1704 kg/ha) (Table 80).

Table 80: Effect of *in-situ* moisture conservation and foliar spray on soybean (JS-335) yield and economics.

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed yield	Straw yield				
Opening of furrow at 25-30 DAS	1775	2508	34048	39032	2.15	2.39
Foliar Spray of 2% urea at flowering (35-40 DAS)	1795	2608	34803	39265	2.13	2.42
Foliar spray of 2% 19:19:19 at PDS (70-80 DAS)	1796	2608	34955	39172	2.12	2.42
Foliar spray of 2% urea 35-40 and 2% 19:19:19 at PDS 70-80 DAS.	1807	2670	35699	38978	2.09	2.43
Foliar spray of 2%19:19:19 at flowering (35-40 DAS) and PDS (70-80 DAS).	1818	2675	35712	39386	2.10	2.45
Control	1704	2539	33960	36493	2.07	2.29



Opening of furrows in Soybean



Foliar spray on soybean- JS-335

During *kharif* 2019, a dry spell of 16 days occurred during 4-19 October at flowering pod development stage in pigeonpea (PKV Tara). Foliar spray of 2% water soluble complex fertilizer (19:19:19) at flowering and pod development stage (PDS) recorded higher seed yield (1236 kg/ha),

net returns (Rs.39255/ha), B:C ratio (2.22) and RWUE (1.47 kg/ha-mm) followed by foliar spray of 2% urea 35-40 and 2% 19:19:19 at PDS recorded (1234 kg/ha) yield compared to control (1183 kg/ha) (Table 81).

Table 81: Effect of in-situ moisture conservation on pigeonpea (PKV Tara) yield and economics

Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed yield	Straw yield	Stalk yield				
Opening of furrow at 25-30 DAS	1209	2841	2040	31219	38696	2.24	1.44
Foliar Spray of 2% urea at flowering	1211	2845	2044	31701	38321	2.21	1.44
Foliar spray of 2%19:19:19 at PDS	1212	2848	2046	31703	38386	2.21	1.44
Foliar spray of 2% urea 35-40 and 2%19:19:19 at PDS.	1234	2899	2083	32210	39151	2.22	1.47
Foliar spray of 2%19:19:19 at flowering and PDS	1236	2904	2086	32213	39255	2.22	1.47
Control	1183	2780	1997	31187	37229	2.19	1.41



Pigeonpea (PKV Tara) with foliar spray of 2% 19:19:19 complex fertilizer

c. On-farm demonstrations

Village profile

The old village Warkhed (Bk) and new village Kajleshwar in Barshitakli tahsil of Akola district is situated between77^{0}7'00'' to 77^{0}10'00'' E longitude and 20^{0}32' 30'' to 20^0 35' 00''N latitude and covers an area of 198 ha. The mean elevation of the area is about 325 m above MSL. It is about 32 km southeast of Akola city. The mean annual rainfall is 796.0 mm with seasonal rainfall of 743 during *kharif* (June -September). The major soil types are shallow, medium deep, deep and very deep black soils. The major rainfed crops during *kharif* are cotton, soybean, greengram, sorghum and pigeonpea, and during *rabi* is chickpea. The numbers of small, marginal, medium and large farmers are 84, 84, 29 and 1, respectively. The groundwater table is 7.8 m below ground. The source of irrigation is open wells and bore-wells covering 8.36% of cultivated area.

Climate vulner*abi*lity in general

In general, the climate in this agro-climatic zone is semi-arid. Out of the total annual average rainfall of 818 mm, the south-west monsoon contributes 84%, post-monsoon contributes 9%, winter rains contributes 3% and summer rains contributes 4%. The historical rainfall data (last 30 years) indicated that the variability in rainfall during south-west monsoon was deficit (-16%**)** of the average

rainfall. The onset (south-west) of monsoon is during 24th SMW and post-monsoon rains were uncertain. For the past 10-15 years, dry spells are being experienced during July, August and September coinciding with the vegetative or reproductive stages of the major rainfed crops. The onset of the monsoon was sometimes delayed up to 25th SMW and 26th SMW and early withdrawal observed during 39th SMW. The soil moisture status was often deficit during the reproductive stages of major rainfed crops, particularly cotton and pigeonpea. There has been a shift in the rainfall pattern with decadal trend showing a decrease in June and July rainfall in the last two decades and increase in September rainfall during the same period.

Experienced weather conditions during 2019-20

During 2019, the onset of monsoon was on 27th June (delayed by 10 days). A rainfall of 889.4 mm was received which was excess by 77.5 mm compared to normal (811.9 mm). During *kharif* season (June to September), 761.0 mm of rainfall was received which was excess by 73.0 mm as compared to normal (688.0 mm). During *rabi* season (October-December), 128.4 mm rainfall was received which was excess by 46.4 mm against the normal (82.0 mm) (Fig. 24).

Normal onset of monsoon	11-17 June
Onset of monsoon during 2019	27th June
Annual mean rainfall	811.9 mm
Annual rainfall during 2019-20	761.0 mm
Mean Crop seasonal rainfall during *kharif* and *rabi*	688.0 and 82.0 mm, respectively
Actual Crop seasonal rainfall during 2019-20	761.0 and 128.4 mm, respectively

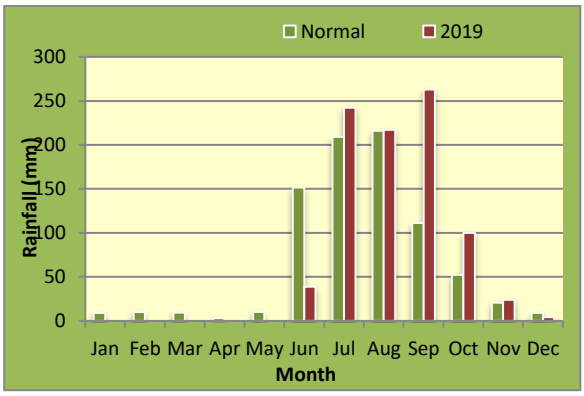


Fig. 24: Normal and actual (2019) monthly rainfall at Warkhed

Dry spells during crop growing season (2019-20)

Dry spell		Crop	Stage of the crop
Duration	**Dates & months**		
09	11- 19 July	Soybean, cotton, pigeonpea and greengram	Vegetative
09	18 – 26 August	Soybean and greengram	Flowering
		Cotton and pigeon pea	Vegetative
22	29 September – 20 October	Soybean	Pod development
		Cotton	Boll development
		Pigeonpea	Vegetative

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Early and mid season drought	Soybean	Vegetative	Opening of furrow in each row
	Cotton		
Terminal drought	Soybean	Pod initiation	Foliar spray
	Cotton	Boll development	Foliar spray
	Pigeonpea	Pod initiation	Mulching
	Chickpea	Flowering and pod development	Protective irrigation

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Early season drought

During *kharif*, a dry spell of 18 days occurred during 11-19 July and 18 26 August at vegetative stage of soybean (JS-335) and cultivated on broad bed furrow, *in-situ* moisture conservation through BBF in soybean in recorded higher seed yield (2195 kg/ha), net returns (Rs.67627/ha), B:C ratio (3.72) and RWUE (2.48 kg/ha-mm) at Warkhed village as compared to farmers' practice (1738 kg/ha) (Table 82).

Table 82: Effect of BBF system of sowing on yield and economics of soybean

Farming situation/ Soil type	Intervention	Yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Deep soil	Broad bed and furrow (BBF) system of sowing	2195	7.73	2.48	67627	3.72
Medium soil	Flat sowing (farmers's practice)	1738		1.96	45726	2.85



Soybean under BBF system of sowing



Flat bed sowing

Situation: Mid season drought

During *kharif*, a dry spell of 18 days occurred during 11-19 July and 18-26 August at vegetative stage of soybean (JS-335) *in-situ* moisture conservation through opening of furrows in each row after 30-35 DAS of soybean recorded higher seed yield (1934 kg/ha), net returns (Rs.54968/ha), B:C ratio (2.19) and RWUE (3.07 kg/ha-mm) at Warkhed village as compared to farmers' practice of without furrow opening (1739 kg/ha) (Table 83). At new village, Kajleshwar, *in-situ* moisture conservation through opening of furrows in each row after 30-35 DAS of soybean recorded higher seed yield (1823 kg/ha), net returns (Rs.50465/ha), B:C ratio (2.06) and RWUE (2.92 kg/ha-mm) compared to farmers' practice of without furrow opening (1606 kg/ha) (Table 84).

Table 83: Effect of conservation furrow on yield and economics of soybean (Warkhed)

Farming situation/ Soil type	Intervention	Yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Deep soil	Opening of conservation furrow	1934	11.24	2.19	54968	3.07
Medium soil	Farmers's practice (without conservation furrow)	1739		1.96	44330	2.69

Table 84: Effect of conservation furrow on yield and economics of soybean (Kajleshwar)

Farming situation/ Soil type	Intervention	Yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Deep soil	Opening of conservation furrow	1823	13.55	2.06	50465	2.92
Medium soil	Farmers's practice (without conservation furrow)	1606		1.82	39154	2.69



Opening of conservation furrow in soybean



Without conservation furrow

During *kharif*, a dry spell of 18 days occurred during 11-19 July and 18 26 August at vegetative stage of cotton (*Mallika Bt*) *in-situ* moisture conservation through opening of furrows in each row after 30-35 DAS of cotton recorded higher seed yield (1976 kg/ha), net returns (Rs.60424/ha), B:C ratio (2.18) and RWUE (2.27 kg/ha-mm) at Warkhed village as compared to farmers' practice of without furrow opening (1786 kg/ha) (Table 85).

At new village, Kajleshwar, *in-situ* moisture conservation through opening of furrows in each row after 30-35 DAS of cotton (*Mallika Bt*) recorded higher seed yield (2046 kg/ha), net returns (Rs.63873/ha), B:C ratio (2.26) and RWUE (2.33 kg/ha-mm) compared to farmers' practice of without furrow opening (1832 kg/ha) (Table 86).

Table 85: Effect of conservation furrow on yield and economics of cotton (Warkhed)

Farming situation/ Soil type	Intervention	Yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Deep soil	Opening of conservation furrow	1976	10.71	2.18	60424	2.27
Medium soil	Farmers's practice (without conservation furrow)	1786		2.02	50333	2.07

Table 86: Effect of conservation furrow on yield and economics of cotton (Kajleshwar)

Farming situation/ Soil type	Intervention	Yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Deep soil	Opening of conservation furrow	**2046**	**11.73**	**2.26**	**63873**	**2.33**
Medium soil	Farmers's practice (without conservation furrow)	**1832**		**2.07**	**52316**	**2.12**



Opening of conservation furrow in cotton



Without conservation furrow

Situation: Mid season drought

At Warkhed village, a dry spell of 22days occurred during 29 September - 20 October coinciding with pod development stage of soybean (JS-335). Application of one protective irrigation (25 mm) from harvested rainwater in farm pond recorded higher seed yield (2177 kg/ha), net returns (Rs. 64825/ha), B:C ratio (3.41) and WUE (2.46 kg/ha-mm) over farmers' practice of without any protective irrigation (1919 kg/ha) (Table 87).

Table 87: Effect of supplemental irrigation on yield and economics of soybean (Warkhed)

Farming situation/ Soil type	Intervention	Yield (kg/ha)	% increase in yield	WUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Deep soil	Supplemental irrigation (25 mm)	2177	13.38	2.46	64825	3.41
Medium soil	Farmers's practice (without supplemental irrigation)	1919		2.17	51366	2.94



Farm pond
(20 m x 20 m x 3 m)



Soybean with one supplemental irrigation



Without any irrigation

Situation: Terminal drought

At Warkhed village, foliar spray of 2% Urea at flowering stage and 2% of DAP at boll development stage in cotton (*Mallika Bt*) recorded higher seed yield (2160 kg/ha), net returns (Rs.69556/ha), B:C ratio (2.44) and RWUE (2.39 kg/ha-mm) over the farmers' practice of without any foliar spray (1983 kg/ha) (Table 89). At Kajleshwar village, foliar spray of 2% Urea at flowering stage and 2% of DAP at boll development stage in cotton (*Mallika Bt*) recorded higher seed yield (1960 kg/ha), net returns (Rs. 59630/ha), B:C ratio (2.26) and RWUE (2.17 kg/ ha-mm) over the farmers' practice of without any foliar spray (1774 kg/ha) (Table 88).

Table 88: Effect of foliar spray of 2% Urea at flowering stage and 2% DAP at boll development stage on yield and economics of cotton.

Village	Farming situation/ Soil type	Intervention	Yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Warkhed	Deep soil	Foliar spray	2160	8.95	2.39	69556	2.44
	Medium soil	Farmers's practice (without any spray)	1983	-	2.24	59706	2.26
Kajleshwar	Deep soil	Foliar spray	1960	10.5	2.17	59630	2.26
	Medium soil	Farmers's practice (without any spray)	1774	-	2.01	49113	2.06

At Warkhed village, foliar spray of complex fertilizer (19:19:19) @ 2% at pod initiation stage in soybean recorded higher seed yield (1684 kg/ha), net returns (Rs. 46240/ha), B:C ratio (2.87) and RWUE (1.86 kg/ha-mm) over the farmers' practice of without any foliar spray (1526 kg/ha) (Table. 90). At Kajleshwar village, foliar spray of complex fertilizer (19:19:19) @ 2% at pod initiation stage in soybean recorded higher seed yield (1754 kg/ha), net returns (Rs. 49118/ha), B:C ratio (2.94) and RWUE (1.94 kg/ha-mm) over the farmers' practice of no foliar spray (1554 kg/ha) (Table 89).

Table 89: Effect of foliar spray on yield and economics of soybean

Village	Farming situation/ Soil type	Intervention	Yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Warkhed	Deep soil	Foliar spray	1684	10.58	1.86	46240	2.87
	Medium soil	Farmers's practice (without any spray)	1526		1.72	37458	2.53
Kajleshwar	Deep soil	Foliar spray	1754	12.91	1.94	49118	2.98
	Medium soil	Farmers's practice (without any spray)	1554		1.76	38565	2.57



Foliar spray of complex fertilizer 19:19:19 on soybean

Preparedness

Rainwater management

In-situ moisture conservation through opening of furrows in each row after 30-35 DAS in soybean recorded higher seed yield (1878 kg/ha), net returns (Rs.60321/ha), B:C ratio (3.25) and RWUE (2.43 kg/ha-mm) as compared to farmers' practice of without furrow opening (1672 kg/ha) (Table 90).

Table 90: Effect of in-situ moisture conservation on yield and economics of soybean over the years

Farming situation soil type	Intervention	Yield (kg/ha)			Net return (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Seed yield 2019-20	Mean seed yield (8 years)	Stover yield			
Med deep soils	Furrow opening	1878	2148	2685	60321	3.25	2.43
	Without furrow opening	1672	1655	2069	41063	2.58	1.87

In-situ moisture conservation through opening of furrows in each row after 30-35 DAS in cotton recorded higher seed yield (2011 kg/ha), net returns (Rs. 42972/ha), B:C ratio (1.94) and RWUE (1.77 kg/ha-mm) as compared to farmers' practice of without furrow opening (1672 kg/ha) (Table 91).

Table 91: Effect of in-situ moisture conservation on yield and economics of cotton over the years

Farming situation soil type	Intervention	Yield (kg/ha)			Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Seed cotton yield 2019-20	Mean seed cotton yield (9years)	Stalk yield			
Med deep soils	Furrow opening	2011	1569	3923	42972	1.94	1.77
	Without furrow opening	1809	1422	3555	35420	1.79	1.61

One supplemental irrigation (25 mm) from harvested rainwater from farm pond at the time pod development stage in soybean *resulted* in higher seed yield (2177 kg/ha), net returns (Rs. 37978/ha), B:C ratio (2.46) and WUE (1.78 kg/ha-mm) as compared to farmers' practice of without any irrigation (1919 kg/ha) (Table 92).

Table 92: Effect of supplemental irrigation on yield and economics of soybean over the years

Farming situation soil type	Intervention	Yield (kg/ha)			Net return (Rs/ha)	B:C ratio	WUE (kg/ha-mm)
		Seed yield 2019-20	Mean yield (4 years)	Straw yield			
Med deep soils	Supplemental irrigation from harvested rainwater	2177	1576	1970	37978	2.46	1.78
	Without any irrigation	1919	1522	1903	35868	2.39	1.72

Cropping systems

Soybean + pigeonpea (4:2) intercropping system recorded 6.4% higher soybean equivalent yield (2637 kg/ha) as compared to farmers' practice of soybean + pigeonpea (6:1) system (2480 kg/ha), with higher net returns (Rs. 49231/ha), B:C ratio (2.64) and RWUE (2.43 kg/ha-mm) (Table 93).

Table 93: Performance of soybean + pigeonpea (4:2) intercropping system

Farming situation soil type	Intervention	Yield (kg/ha)		MCEY (kg/ha)		Net return (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Soy-bean	Pigeon-pea	2019-20	Mean (8 yrs)			
Shallow/Medium deep soils	Soybean + pigeonpea (4:2)	1457	960	2637	2148	49231	2.64	2.43
	Farmers practice (Soybean + pigeonpea (6:1))	1579	734	2480	1655	32095	2.08	1.87

Cotton + greengram (1:1) intercropping system gave 32.5% higher cotton equivalent yield (2354 kg/ha), with higher net returns (Rs. 50594/ha), B:C ratio (1.99) and RWUE (2.02 kg/ha-mm) compared to sole cotton (1780 kg/ha) (Table 94).

Table 94: Effect of intercropping system on productivity of cotton over the years

Farming situation/ Soil type	Intervention	Yield (kg/ha)		MCEY		Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Cotton	Greengram	2019-20	Mean (7 years)			
Medium-deep black soils	Cotton + greengram (1:1)	1495	912	2354	1789	50594	1.99	2.02
	Farmers' practice (sole cotton)	1780	--	1780	1417	35163	1.79	1.60

Nutrient management

Foliar spray 2% Urea at flowering and 2% KCL at boll development stage in farmers' fields to overcome midseason drought and terminal drought over a period of 5 years in cotton gave 7.8% higher cotton equivalent yield (1530 kg/ha), with higher net returns (Rs. 40969/ha), B:C ratio (1.90) and RWUE (1.73 kg/ha-mm) compared to sole cotton (1420 kg/ha) (Table 95).

Table 95: Effect of foliar spray on productivity of cotton over the years

Farming situation/ Soil type	Intervention	Yield (kg/ha)			Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Seed 2019-20	Mean seed yield (5 years)	Stalks				
Medium black soils	Foliar spray	206	1530	3825	45285	40969	1.90	1.73
	Farmers' practice (without any spray)	1878	1420	3550	44735	35318	1.79	1.60

1.2.2 BENGALURU

a. Agro-ecological setting

Bengaluru is located in Deccan (Karnataka) plateau of Central Eastern Ghats (AESR 8.2), dry zone in Karnataka. The climate is hot moist semi-arid. Annual average rainfall is 926 mm. Length of growing period is 120-150 days.

b. On-station experiments

Experienced weather conditions during 2019-20

During 2019, the onset of monsoon was delayed by 4 days (6th June). A rainfall of 899.1 mm was received which was deficit by 24.0 mm (2.5%) compared to normal (923.1mm) (Fig. 25). During *kharif* season (June-September), 481.3 mm rainfall was recorded which was deficit by 35.6 mm (6.8%) against normal of 516.9 mm. In *rabi* season, rainfall was 244.6 mm which was excess by 3.5 mm (1.4%) than the normal of 241.1 mm and in summer, 149.2 mm rainfall was recorded and was deficit by 6.6 mm (4.2%) than normal of 155.8 mm.

Normal onset of monsoon	2 June
Onset of monsoon during 2019	6 June
Annual mean rainfall	923.1 mm
Annual rainfall during 2019-20	899.1 mm
Mean crop seasonal rainfall during *kharif* & *rabi*	516.9 & 241.1 mm, respectively
Crop seasonal rainfall during 2019-20 (*kharif* & *rabi)*	481.3 & 244.6 mm, respectively

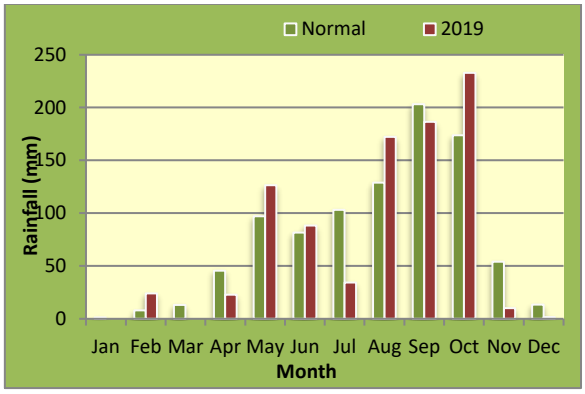


Fig. 25: Normal and actual (2019) monthly rainfall at Bengaluru

Dry spells during crop growing season (2019-20)

Duration (days)	Dates & Months	Crop	Stage of the crop
15 Days	9 June - 23 June	Pigeonpea, cowpea, field bean, groundnut and sesamum	Vegetative stage
22 Days	25 June - 15 July	Finger millet	Germination
		Pigeonpea, cowpea, field bean, groundnut and sesamum	Establishment
17 days	31 August -16 September	Pigeonpea	Peak vegetative
		Finger millet	Seedling to tillering
		Groundnut	Peg initiation
		Cowpea and field bean	Vegetative
23 Days	28 October - 20 November	Pigeonpea	Flowering to seed setting
		Finger millet	Maturity to Harvesting
		Groundnut, cowpea and field bean	Harvesting
38 Days	22 November onwards	Pigeonpea	Pod filling stage to maturity
		Finger millet	Maturity to Harvesting
		Groundnut, cowpea and field bean	Harvesting

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Mid season drought	Fingermillet	Flag leaf	Foliar spray

Salient achievements of on-station experiments

Real time contingency planning

Situation: Mid season drought

Foliar spray in fingermillet during dry spell recorded higher grain (2773 kg/ha) compared to foliar spray after relieving of stress/dry spell (2744 kg/ha). Among different sources of nutrients, foliar spray of 0.5% water soluble complex fertilizer (19:19:19) + recommended dose of micronutrient as foliar spray (Borax @ 75 g/ha and zinc sulphate @ 75 g/ha) recorded higher grain yield (3230 kg/ha), net returns (Rs.66306/ha), B:C ratio (3.15) and RWUE (5.23 kg/ha-mm) compared to control (1050 kg/ha). The interaction effect among different foliar sprays on grain yield of finger millet was found non-significant (Table 96).

Table 96: Performance of fingermillet under different foliar sprays during mid season drought

Treatment	Grain yield (kg/ha)		Straw yield (kg/ha)		Net returns (Rs/ha)	B:C	RWUE (kg/ha-mm)
	2019	Pooled (3 years)	2019	Pooled (3 years)			
Main plot							
M_1: Foliar spray during dry spell	2773	3000	3862	3948	53921	2.82	4.49
M_2: Foliar spray after relieving of stress/ dry spell	2744	2736	3786	3591	53056	2.80	4.44
CD at 5%	NS	NS	NS	NS	-	-	-
Sub plot							
T_1: Urea @1%	2547	2681	3515	3608	47781	2.66	4.12
T_2: Urea @ 2%	2722	3009	3756	427	53004	2.84	4.40
T_3: Water soluble complex fertilizer (19: 19: 19) @ 0.5%	2639	2611	3641	3503	50203	2.72	4.27
T_4: T_3+ rec. dose of micronutrient as foliar spray*	3230	3108	4458	3973	66304	3.15	5.23
T_5: Rec. dose of micronutrient as foliar spray	2860	3007	3947	3800	55549	2.82	4.63
T_6: Water spray	2717	2878	3749	3850	52417	2.79	4.40
T_7: Control (no spray of any nutrient/ water)	2592	2781	3576	3380	49158	2.71	4.19
CD at 5%	NS	NS	NS	NS	-	-	-

*Recommended dose of micronutrient as foliar spray: Borax@75 g/ha and zinc sulphate@75 g/ha



T_4:Water soluble complex fertilizer (19:19:19) @ 0.5% + rec. dose of micronutrient as foliar spray



T_7:Control

c. On-farm demonstrations

Village profile

The programme is being implemented in Chikkamaranahalli cluster villages (Mudalapalya, Hosapalya, Chikkamaranahalli, Chikkamaranahalli colony and Chikkaputtayanapalya), Nelamangala taluk, Bengaluru rural district, Karnataka. The total cultivated area is 409.2 ha out of which 367.4 ha is rainfed. The mean annual rainfall is 750 mm with seasonal rainfall of 442 mm during *kharif* (June-September). The major soil type is sandy clay loam. The major rainfed crops during *kharif* are fingermillet, groundnut and pigeonpea. The numbers of small, marginal, medium and large farmers are 48, 144, 7 and 2, respectively. The ground water table is 350 feet below surface. The source of irrigation is bore wells covering 4.39 ha of cultivated area.

Climate vulner*abi*lity in general

The climate in this agro-climatic zone is semi-arid. Out of the total annual average rainfall of 750 mm, the south-west monsoon contributes 55.5%, north-east monsoon 33.3% and summer 11.13%. The historical rainfall data (of 30 years) indicates that the variability in rainfall during south-west monsoon is 8% surplus of the average rainfall. The onset (south-west) of monsoon is during 23rd SMW (Standard meteorological week, June 1st week) has shifted to June 2nd week, followed by erratic rainfall and north-east monsoon is 40th SMW. For the past 15 years, the dry spells during crop season were experienced in June, July, August, September and October and at vegetative and reproductive stages of the major rainfed crops. The soil moisture status is deficit during vegetative and reproductive stages of major rainfed crops. The extreme events like unusual and high intensity rainfall/ hail storm in short span are occurring during *kharif* and *rabi* seasons.

Experienced weather conditions during 2019-20

During 2019, in Chikkamaranahalli village, the onset of monsoon was timely (3rd June). A rainfall of 714.4 mm was received which was deficit by 23.4 mm (3.17%) compared to normal (737.4 mm). Out of total rainfall, *kharif* season received 463.0 mm, which was excess by 53.3 mm (13.0%) compared to normal of 409.7 mm (Fig. 26). *Rabi* season received 135.0 mm which was deficit by 107.2 mm (44.3%) compared to normal of 242.2 mm and in summer, it was 116.0 mm against normal of 81.9 mm which was excess by 34.1 mm (41.6%).

Normal onset of monsoon	2 June
Onset of monsoon during 2018	3 June
Annual mean rainfall	737.4 mm
Annual rainfall during 2019-20	714.0 mm
Mean crop seasonal rainfall during *kharif* & *rabi*	409.7 & 242.2 mm, respectively
Crop seasonal rainfall during 2019-20 (*kharif* & *rabi)*	463.0 mm & 135.0 mm, respectively

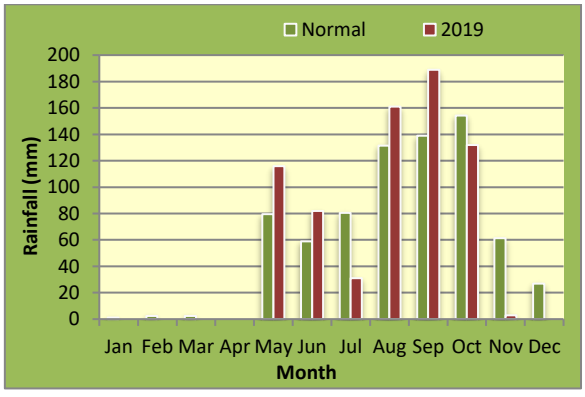


Fig. 26: Normal and actual (2019) monthly rainfall at Chikkamaranahalli

Dry spells during crop growing season (2019-20)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
10	6 - 15 July	Field bean	Vegetative stage
		Cowpea	
		Groundnut	
17	31 August - 16 September	Finger millet	Seedling to tillering
		Pigeonpea	Peak vegetative to flowering
		Groundnut	Pod formation to maturity
		Field bean	Grain filling
		Cowpea	Grain filling
22	31 October - 21 November	Finger millet	Flowering
		Pigeonpea	Grain filling
41	22 November onwards	Finger millet	Maturity/ harvest
		Pigeonpea	Maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Farming situation/ soil type	Crop	RTCP implemented
Early season drought	Upland-loamy sand	Fingermillet, groundnut , pigeonpea	Fingermillet (MR-1) + pigeonpea (BRG-5) (8:2) with conservation furrow

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Early season drought

Intercropping of fingermillet (MR-1) + pigeonpea (BRG-5) (8:2) with conservation furrow between paired rows of pigeonpea recorded (22.4%) higher fingermillet equivalent yield (2799 kg/ha), net returns (Rs.49768/ha), B:C ratio (2.35) and RWUE (5.54 kg/ha-mm) compared to farmers' practice of growing fingermillet + mixed cropping (*Akkadi)* (2286 kg/ha) (Table 97).

Table 97: Performance of *in-situ* moisture conservation in fingermillet + pigeonpea (8:2) intercropping system

Farming situation/ soil type	Intervention	Fingermillet equivalent yield (kg/ha)		Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		2019	Mean (8 years)			
Upland-loamy sand	Fingermillet + pigeonpea (8:2) with *in-situ* moisture conservation	2799	2714	49768	2.35	5.54
	Fingermillet + *akkadi*	2286	1816	32253	1.84	4.53



Fingermillet + pigeonpea (8:2) with conservation furrow



Finger millet + *Akkadi*

Preparedness

Cropping systems

Transplanted fingermillet (MR-1) recorded (22.4%) higher grain yield (2917 kg/ha), net returns (Rs.56655/ha), B:C ratio (2.87) and RWUE (2.87 kg/ha-mm) as compared to direct sown finger millet (2381 kg/ha) (Table 98).

Table 98: Performance of establishment technique on yield and economics of fingermillet

Farming situation/ soil type	Intervention	Yield (kg/ha)		Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		2019	Mean (8 years)			
Upland-loamy sand	Transplanting	2917	3996	56655	6.27	2.87
	Direct sown	2381	2976	45011	5.11	2.56



Fingermillet direct sown



Transplanted fingermillet

Among the pulse based intercropping systems at Chikkamaranahalli village, pigeonpea (BRG-1) + field bean (HA-4) recorded higher pigeonpea equivalent yield (675 kg/ha), net returns (Rs.20932/ha), B:C ratio (1.63) and RWUE (1.33 kg/ha-mm) compared to the farmers' practice of sole pigeonpea (562 kg/ha) (Table 99).

Table 99: Yield and economics of pigeonpea based intercropping systems

Farming situation/ soil type	Crop	PEY (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		2019	Mean (8 years)			
Upland-loamy sand	Pigeonpea + cowpea (1:1)	486	987	0.88	6409	1.20
	Pigeonpea + field bean (1:1)	675	1075	1.33	20932	1.63
	Sole pigeonpea	562	608	1.11	15080	1.50

PEY: Pigeonpea equivalent yield



Pigeonpea + cowpea (1:1)



Pigeonpea + field bean (1:1)

Fingermillet (MR-1) + pigeonpea (BRG-5) (8:2) intercropping system recorded 20.2% higher fingermillet equivalent yield (2833 kg/ha), net returns (Rs.50335/ha), B:C ratio (2.30) and RWUE (5.95 kg/ha-mm) as compared to farmers' practice of fingermillet + *akkadi* (multiple crops) (2356 kg/ha) (Table 100).

Table 100: Yield and economics of fingermillet + pigeonpea (8:2) intercropping system

Farming situation/ soil type	Intervention	FMEY (kg/ha)		Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		2019	Mean (8 years)			
Upland-loamy sand	Fingermillet + pigeonpea (8:2)	2833	2714	50335	2.30	5.95
	Fingermillet + *akkadi*	2356	1927	34444	2.11	4.88

FMEY= Finger millet Equivalent Yield



Finger millet + pigeonpea (8:2)



Finger millet + *Akkadi*

Groundnut (ICGV 91114) + pigeonpea (BRG-1) (8:2) intercropping system recorded higher groundnut equivalent yield (1336 kg/ha), net returns (Rs.25791/ha), B:C ratio (1.63) and RWUE (2.64 kg/ha-mm) as compared to farmers' practice of sole groundnut (810 kg/ha) (Table 101).

Table 101: Yield and economics of groundnut + pigeonpea (8:2) intercropping system

Farming situation/ soil type	Intervention	GNEY (kg/ha)		Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		2019	Mean (7 years)			
Upland-loamy sand	Groundnut + pigeonpea (8:2)	1336	1640	25791	1.63	2.64
	Sole groundnut	810	1016	2225	1.05	1.60

GNEY= Groundnut Equivalent Yield



Groundnut + pigeonpea (8:2)

Nutrient management

Application of 100% RDF + 12.5 kg/ha of $ZnSO_4$ in fingermillet (MR-1) + pigeonpea (BRG-5) (8:2), intercropping system recorded 11.5% higher grain equivalent yield (3199 kg/ha), net returns (Rs.65504/ha), B:C ratio (2.67) and RWUE (6.4 kg/ha-mm) compared to application of 100% RDF alone (2870 kg/ha) (Table 102).

Table 102: Effect of nutrient management in finger millet + pigeon pea (8:2) intercropping

Farming situation/ soil type	Intervention	FEY (kg/ha)		Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		2019	Mean (8 years)			
Upland-loamy sand	100% RDF + $ZnSO_4$ @ 12.5 kg/ha	3199	2829	65504	2.67	6.40
	100% RDF	2870	2318	31418	2.13	5.68

FEY: Fingermillet equivalent yield; 100% RDF: 50:40:37.5 kg NPK/ha

Energy management

Sowing finger millet with modified bullock drawn seed drill recorded 16.48% higher grain yield (2663 kg/ha), net returns **(**Rs.53753/ha), B:C ratio (2.86) and RWUE (6.4 kg/ha-mm) compared to sowing finger millet without improved implement (2286 kg/ha) (Table 103).

Table 103: Benefit of modified bullock drawn seed drill for sowing of finger millet

Crop	Yield (kg/ha)		Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	IP	FP			
Finger millet	2663	2286	53753	5.32	2.86

IP: Sowing fingermillet with modified bullock drawn seed drill; FP: Farmer's practice

1.2.3 INDORE

a. Agro-ecological setting

Indore centre is located in Central highlands (Malwa) Gujarat plain Kathiawar peninsula semiarid eco region (AESR 5.1) and Malwa plateau in Madhya Pradesh. The climate is hot dry semi-arid and annual rainfall is 944 mm.

b. On-station experiments

Experienced weather conditions during 2019-20

During 2019, the onset of monsoon was delayed by 12 days (24th June), and an annual rainfall of 1545.4 mm was received which was excess by 587.4 mm compared to normal (958.0 mm). During south-west monsoon (*kharif)*, the rainfall received was 1390.3 mm against the normal (854.5 mm) which was excess by 535.8 mm. During *rabi* (October-December), the rainfall received was 155.1 mm against the normal (64.5 mm). During summer, no rainfall was received compared to normal (30.6 mm) (Fig. 27).

Normal onset of monsoon	12-18 June
Onset of monsoon during 2019	24 June
Annual mean rainfall	958 mm
Annual rainfall during 2019-20	1545.4 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	854.5 and 64.5 mm, respectively
Crop seasonal rainfall during 2019-20 (*kharif* and *rabi)*	1390.3 and 155.1 mm, respectively

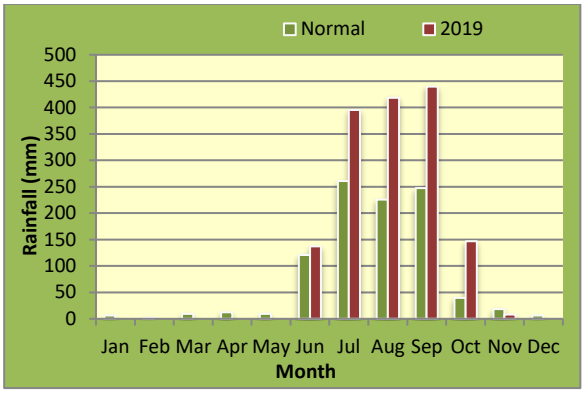


Fig. 27: Normal and actual (2019) monthly rainfall at Indore

Dry spells during crop growing season (2019-20)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
12	8 - 19 July	Soybean	Vegetative stage
10	13-22 October	Soybean	Flowering and maturity stage

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Delayed onset of monsoon	Soybean	Germination and vegetative	Short duration varieties
Mid season drought	Soybean	Vegetative	Foliar spray

Salient achievements of on-station experiments

Real time contingency planning

Situation: Delayed onset of monsoon

During 2019, at Indore, the onset of monsoon was delayed by 12 days. Soybean variety JS 20-34 gave higher yield (1036 kg/ha) with higher net returns (Rs.21459/ha) and B:C ratio (2.07) compared to other varieties (Table 104).

Table 104: Performance of soybean varieties under delayed onset of monsoon

Variety	Seed yield (kg/ha)	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net Return (Rs/ha)	B:C ratio	Days to flower initiation	Days to maturity
JS 335	755	20000	30209	10209	1.51	36	100
RVS 2001-4	547	20000	21875	1875	1.09	38	100

JS 20-98	271	20000	10833	-9167	0.54	40	100
JS 95-60	430	20000	17188	-2812	0.86	33	91
JS 20-29	938	20000	37500	17500	1.88	29	93
JS 20-96	987	20000	39480	19480	1.97	41	100
NRC -86	1009	20000	40365	20365	2.02	39	96
RVS 24	1016	20000	40626	20626	2.03	35	93
RVS 18	667	20000	26667	6667	1.33	40	91
JS 20-34	1036	20000	41459	21459	2.07	35	104

Situation: Mid season drought

A dry spell occurred during 13-22 October coinciding with the flowering stage of soybean, f**o**liar spray of urea @ 2% in soybean during branching and initiation of flowering recorded highest seed yield (1000 kg/ha), net returns (Rs.20000/ha) and B:C ratio (2.00) followed by f**o**liar spray of NPK 19:19:19 @ 2% (992 kg/ha) (Table 105).

Table 105: Effect of foliar spray on soybean (JS-20-34) yield and economics

Treatment	Seed yield (kg/ha)	Cost of cultivation (Rs/ha)	Net Return (Rs/ha)	B:C ratio
T_1: Urea 2% at 30 DAS	1000	20000	20000	2.00
T_2: Spray of 19:19:19 NPK @ 2% + insecticide	955	20000	18182	1.91
T_3: Spray of 19:19:19 NPK @ 2%	992	20000	19697	1.98
T_4: Spray of $ZnSO_4$ 0.5%	968	20000	18727	1.94

c. On-farm Demonstrations

Village profile

The program is being implemented in Nignoti village, Indore district, Madhya Pradesh. The total cultivated area is 248 ha out of which 100 ha is rainfed. The mean annual rainfall is 958 mm with seasonal rainfall of 854.5 mm during *kharif* (June- September). The major soil types are medium deep to deep black soils. The major rainfed crops during *kharif* are soybean, maize, sorghum, and wheat and chickpea during *rabi* season. The number of small, marginal and large farmers is 65, 47 and 137, respectively. The ground water table is 20 m. The sources of irrigation are open well, bore well, tube well, farm ponds, *nallah* etc., covering 60% of cultivated area.

Climate vulner*abi*lity in general

In general, the climate in this zone is semiarid. The south-west monsoon contributes 90– 94%, winter rains contribute 3-6% and summer rain contribute 3-4% of the total annual average rainfall of 958 mm. The normal onset (southwest) of monsoon is during 24 SMW. The dry spells during crop season were experienced in September and at seed formation stage of soybean and maize. The onset of the monsoon is normal or shifts about 8-10 days *i.e.*, 26 SMW (June end) and the withdrawal is early (37 SMW). The data on normal and actual maximum and minimum temperatures follow the same trend from 19 SMW to 49 SMW. Thereafter, from 50 SMW to 20 SMW the actual values were lower than the corresponding normal values. Thus, the maximum and minimum temperatures have decreased for *rabi* crops. The extreme events like unusual and high intensity rainfall in short span had been increasing as the rains have accrued between 22-42 SMW with two peaks of more than 250 mm per week during 34 and 35 SMW. Further, there had been three peaks of more than 100 mm per week and these are 28, 30 and 32 SMW during *kharif* and no rains were received during *rabi* season. The region has been experiencing other extreme events like frost. There were four events of occurrence of

frost that was on 14th, 15th, 22nd January and 9th February 2012. There has been considerable shift in the rainfall pattern and sowing window for soybean is from 23-25 SMW. For the last eight decades (1930 to 2010), the maximum and minimum temperatures showed increasing trend, while decreasing trend of rainfall was observed for the same period at Indore.

Experienced weather conditions during 2019-20

During 2019, the onset of monsoon was normal (17 June) and annual rainfall of 645.9 mm was received which was deficit by 312.1 mm compared to normal (958.0 mm) (Fig.). During south-west monsoon (*kharif*), 645.9 mm of rainfall was received against the normal of 854.5 mm, and was deficit by 208.6 mm (24.4%). During *rabi*, no rainfall was received against the normal of 64.5 mm and in summer also no rainfall was received against normal rainfall of 30.7 mm (Fig. 28).

Normal onset of monsoon	12-18 June
Onset of monsoon during 2018	17 June
Annual mean rainfall	958.0 mm
Annual rainfall during 2018-19	645.9 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	854.5 and 64.5, respectively
Crop seasonal rainfall during 2018-19 (*kharif* and *rabi*)	645.9 and 0.0 mm, respectively

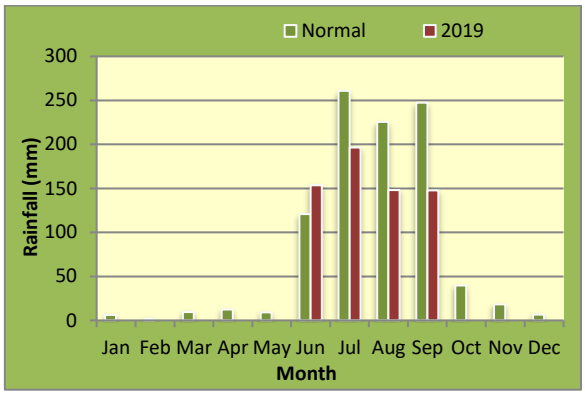


Fig. 28: Normal and actual (2019) monthly rainfall at Nignoti

Dry spells during crop growing season (2019-20)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
13	7 - 18 July	Soybean	Vegetative stage
11	11-21 October	Soybean	Flowering and maturity stage

Real time contingency practices (RTCP) implemented: Nil

Salient achievements of on-farm demonstrations

Preparedness

Cropping systems

During *kharif* 2019, new soybean variety JS 95-60 produced higher seed yield (972 kg/ha), net returns (Rs.16449/ha), B:C ratio (0.82) and RWUE (0.82 kg/ha-mm) compared to and JS6124 (800 kg/ha) and JS 20-34 (800 kg/ha) (Table 106).

Table 106: Performance of new Soybean varieties

Variety	Yield (kg/ha)	Yield Without Intervention Average	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
JS 95-60	972	771	16449	0.82	0.82
JS 6124	875	824	12509	0.63	0.75
JS 20-34	800	771	10067	0.50	0.68

1.2.4 PARBHANI

a. Agro-ecological setting

Parbhani centre is located in Central and Western Maharashtra plateau eco-sub-region. Marathwada region of Maharashtra state comprises 8 districts with average annual precipitation of 807 mm. The region is dominated by medium black cotton soils (60%), followed by heavy and shallow soils 15-20% each. Though the majority area falls under assured rainfall zone, it is characterized by 2-3 prolonged dry spells during crop growth. During recent past soybean, cotton and pigeonpea are major crops in dryland areas.

b. On-station experiments

Experienced weather conditions during 2019-20

During 2019, the onset of monsoon was delayed by 14days (24th June). A rainfall of 968.6 mm was received which was excess by 5.6 mm (0.58%) compared to normal (963.0 mm). During *kharif* 701.9 mm rainfall was recorded which was deficit by 98.6 mm (12.3%) than normal rainfall of 835.0 mm (Fig. 29).

Normal onset of monsoon	10 June
Onset of monsoon during 2019	24 June
Annual mean rainfall	963.0 mm
Annual mean rainfall during 2019-20	968.6 mm
Mean crop seasonal rainfall during *kharif*	800.5mm
Crop seasonal rainfall during 2019 (*kharif*)	701.9 mm

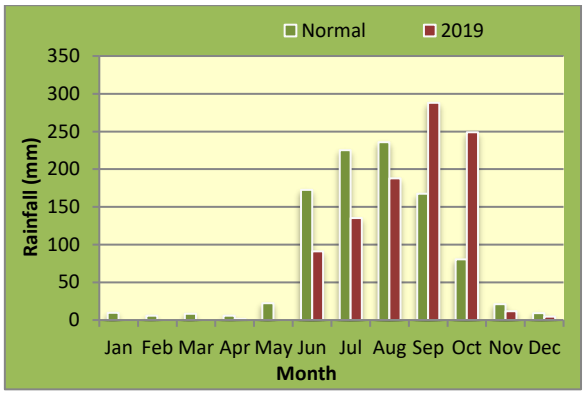


Fig. 29: Normal and actual (2019) monthly rainfall at Parbhani

Dry spells during crop growing season (2019-20)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & Months		
10	01 - 10 July	Soybean, pigeonpea, green gram, cotton	Vegetative stage
13	14 - 26 July	Soybean, pigeonpea, green gram, cotton	Vegetative stage flowering & pod formation stage
16	15 - 30 August	Soybean, pigeonpea, green gram, cotton	Grain filling stage in soybean Pod formation in greengram and harvesting stage
18	02 - 19 October	Pigeonpea, cotton	Soybean: harvesting stage Pigeonpea: flowering and pond formation stage

Realtime contingency practices (RTCP) implemented

Weather aberations	Crop	Stage of the crop	RTCP implemented
Delayed onset of monsoon	Soybean	-	Improved varieties
Mid season drought	Cotton, soybean	Vegetative	Foliar spray

Salient achievements of on-station experiments

Real time contingency planning

Situation: Delayed onset of monsoon

During 2019, onset of monsoon was delayed by 14 days. The seed yield of all crops was highest with first fortnight of July sowings and as the date of sowing delayed, the reduction in seed yield was observed with subsequent date of sowings (D3 and D4). Sowing could not be undertaken due to delayed monsoon in the second fortnight of June (D1) and early withdrawal of monsoon during second fortnight of August i.e. 22nd August (D5) (Table 107).

Table 107: Performance of different crops under various dates of sowings

Date of sowing / crops	D1: Second fortnight of June	D2: First fortnight of July	D3: Second fortnight of July	D4: First fortnight of August	D5: Second fortnight of August
C1: Cotton (Ajit 155)	No sowing undertaken due to delayed monsoon	1380	920	610	Sowing could not be undertaken due to insufficient moisture in upper soil zone and long dryspell of 16 days
C2: Soybean (MAUS 158)		980	750	520	
C3: Maize (Pioneer)		3280	2830	2130	
C4: Sorghum (CSV 27)		1922	1550	945	
C5: Pearlmillet (AIMP 92901)		1877	1554	1145	
C6: Pigeonpea (BDN 711)		988	750	475	
C7: Greengram (BM 2003-02)		565	--	--	

Due to delayed onset of monsoon, the reduction in cotton equivalent yield was to the extent of 20% and 45.56% due to delayed sowings from first fortnight of July (913 kg/ha) to second fortnight of July (730kg/ha) and first fortnight of August (497kg/ha), respectively. Further, the net returns (Rs.26486/ha), B:C ratio (1.91) and RWUE (1.60) when sown during first fortnight of July compared to delayed sowings (D3 and D4). Among crops, cotton followed by maize and pigeonpea recorded higher cotton equivalent yield (970, 871 and 771 kg/ha) compared to remaining crops (Table 108).

Table 108: Performance of different crops under different sowing window

Treatment	CEY (kg/ha)	GMR (Rs/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE kg/ha-mm
Main plot: Date of sowing						
D_1: Second fortnight of June	Sowing could not be undertaken due to delayed monsoon					
D_2: First fortnight of July	913	50672	26486	24186	1.91	1.60
D_3: Second fortnight of July	730	40515	26138	14377	1.55	1.28
D_4: First fortnight of August	497	27584	26881	703	1.02	0.87
D_5: Second fortnight of August	Sowing could not be undertaken due to insufficient moisture					
Sub plot: Crops						
C_1: Cotton (Ajit 155)	970	53835	32500	21335	1.66	1.70
C_2: Soybean (MAUS 158)	501	27825	24500	3325	1.14	0.88
C_3: Maize (Pioneer)	871	48341	28500	19841	1.70	1.52
C_4: Sorghum (CSV 27)	682	37839	26500	11339	1.43	1.19
C_5: Pearlmillet (AIMP 92901)	550	30507	24500	6007	1.25	0.96
C_6: Pigeonpea (BDN 711)	771	42785	26500	16285	1.61	1.35
C_7: Greengram (BM 2003-02)	718	39849	22400	17449	1.78	1.26

CEY: Cotton equivalent yield

Situation: Mid season drought

During *kharif* 2019, a dry spell of 16 days from 15-30 August occurred at boll development stage of cotton. Foliar spray during dry spell significantly improved the seed cotton yield (1418 kg/ha), net returns (Rs.42160/ha), B:C ratio (2.15) and RWUE (2.48 kg/ha-mm) as compared to foliar spray after relieving of stress/dry spell. Further, foliar spray of KNO_3 was found at par with foliar spray of water soluble complex fertilizer (19:19:19) @ 0.5% + $ZnSO_4$ @ 0.5% (1390 kg/ha) and $ZnSO_4$ @ 0.5% spray alone (1382 kg/ha) and recorded significantly higher seed cotton yield (1479 kg/ha), net returns (Rs.45419 /ha), B:C ratio (2.24) and RWUE (2.59 kg/ha-mm) as compared to rest of the treatments (Table 109).

Table 109: Effect of foliar spray on cotton yield and economics

Treatments	Seed cotton yield (kg/ha)	GMR (Rs/ha)	Cost of cultivation (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Main plot						
T_1 : Foliar spray during dry spell	1418	78699	36539	42160	2.15	2.48
T_2 : Foliar spray after relieving of stress /dry spell	1199	66544	36539	30005	1.82	2.10
CD at 5%	162	937		918	0.27	0.36
Sub plot						
F_1 : Urea @ 1%	1231	68320	35280	33040	1.93	2.16
F_2 : Urea @ 2%	1270	70485	35360	35125	1.99	2.22
F_3 : Water soluble complex Fertilizer (19:19:19) @ 0.5%	1351	74980	36740	38240	2.04	2.37
F_4 : Water soluble complex Fertilizer (19:19:19) @ 0.5% + recommended dose of micronutrient for foliar spray	1390	77145	38270	38875	2.01	2.43
F_5 : Recommended dose of micronutrient for foliar spray	1382	76701	39800	36901	1.93	2.42
F_6 : Water Spray	1277	70873	35200	35673	2.01	2.24
F_7 : KNO_3	1479	82084	36665	45419	2.24	2.59
F_8 : Control (No spray of any material/water)	1085	60217	35000	25217	1.72	1.90
CD at 5%	126	6425	-	5698	-	-
Interaction (T X F)						
CD at 5%	NS	NS	-	NS	-	-

Foliar spray on physio-chemical properties of soil indicated that foliar spray after relieving of stress /dry spell significantly improved the soil nutrient content (266, 13.7 and 522 kg NPK/ha, respectively) compared to foliar spray during dry spell (255,12.74 and 469kg NPK/ha, respectively). There was no significant response with respect to pH, OC and DTPA extractable micronutrients. However, K content in soil was reduced and Zn content increased under all treatments over initial soil test values. Foliar spray of water soluble complex fertilizer (19:19:19) @ 0.5% + $ZnSO_4$ @ 0.5% followed by KNO_3 @ 1.5%improved the soil OC content over initial soil values compared to other treatments (Table 110).

Table 110: Effect of treatments on soil chemical properties

Treatment	pH	Organic carbon (%)	Av. major Nutrient (kg/ha)			DTPA extractable micronutrients (mg/kg)		
			N	P	K	Zn	Fe	Cu
Main plot								
T_1 : Foliar spray during dry spell	7.80	0.49	255	12.74	469	1.86	3.63	6.84
T_2 : Foliar spray after relieving of stress /dry spell	7.77	0.42	266	13.70	522	1.69	3.76	5.76
CD at 5%	NS	NS	17.25	0.65	22.94	NS	NS	NS
Sub plot								
F_1 : Urea @ 1%	7.65	0.42	229	14.60	487	2.01	3.11	6.17
F_2 : Urea @ 2%	7.84	0.47	240	13.64	478	1.26	4.22	5.61
F_3 : Water soluble complex Fertilizer (19:19:19) @ 0.5%	7.73	0.43	259	13.85	445	1.96	3.20	5.21
F_4 : Water soluble complex Fertilizer (19:19:19) @ 0.5% + recommended dose of micronutrient for foliar spray	7.63	0.57	223	13.38	448	1.31	3.15	5.51
F_5 : Recommended dose of micronutrient for foliar spray	7.58	0.46	219	14.10	445	2.10	4.21	5.61
F_6 : Water Spray	7.91	0.39	257	15.10	496	1.32	4.20	5.50
F_7 : KNO3	7.71	0.50	222	13.09	428	1.41	3.12	6.12
F_8 : Control (No spray of any material/water)	7.83	0.35	251	15.12	472	1.63	3.58	5.85
CD at 5%	0.12	0.14	20.84	NS	47.20	0.65	NS	NS
Interaction (T X F)								
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
Initial	7.56	0.46	225	12.10	510	0.82	4.2	5.4

All foliar treatments improved relative water content (RWC), chlorophyll content and NDVI compared to control. Foliar application of KNO_3 recorded higher relative water content, chlorophyll content and NDVI in cotton during dry spells (Table 111)

Table 111: Effect of foliar spray on RWC, Chlorophyll content and NDVI values in cotton

Treatment	% RWC		Chlorophyll content		NDVI
	T1	T2	T1	T2	T1
F_1 : Urea @ 1%	33.24	27.98	47.27	51.65	0.83
F_2 : Urea @ 2%	35.68	26.42	48.58	48.92	0.84
F_3 : Water soluble complex fertilizer (19:19:19) @ 0.5%	47.14	32.39	49.94	51.16	0.85
F_4 : Water soluble complex fertilizer (19:19:19) @ 0.5% + recommended dose of micronutrient for foliar spray	60.32	40.12	51.86	50.62	0.85
F_5 : Recommended dose of micronutrient for foliar spray	51.38	33.62	48.92	48.38	0.85
F_6 : Water spray	21.25	19.52	47.52	48.56	0.84
F_7 : KNO3	66.93	43.69	51.98	51.96	0.87
F_8 : Control (No spray of any material/water)	13.78	18.86	44.94	47.8	0.83

During *kharif* 2019, a dry spell of 16 days from 15-30 August occurred at pod development stage of soybean. Foliar spray during dry spell significantly improved the soybean seed yield (905 kg/ha), net returns (Rs. 14317/ha), B:C ratio (1.89) and RWUE (1.58 kg/ha-mm) as compared to foliar spray after relieving of stress/dry spell. Further, foliar spray of KNO_3 was found at par with foliar spray of water soluble complex fertilizer (19:19:19) @ 0.5% + $ZnSO_4$ @ 0.5% (957 kg/ha), $ZnSO_4$ @ 0.5% spray (934 kg/ha) and water soluble complex fertilizer (19:19:19) @ 0.5% alone (928 kg/ha) and recorded significantly higher soybean seed yield (965 kg/ha), net returns (Rs.16327/ha), B:C ratio (2.02) and RWUE (1.69 kg/ha-mm) as compared to rest of the treatments (Table 112).

Table 112: Effect of foliar spray on soybean seed yield and economics

Treatment	Seed yield (kg/ha)	GMR (Rs/ha)	NMR (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Main plot					
T_1 : Foliar spray during dry spell	905	30317	14317	1.89	1.58
T_2 : Foliar spray after relieving of stress /dry spell	798	26733	10733	1.67	1.40
CD at 5%	96	2196	1674	-	-
Sub plot					
F_1 : Urea @ 1%	825	27637	11637	1.73	1.44
F_2 : Urea @ 2%	858	28743	12743	1.79	1.50
F_3 : Water soluble complex Fertilizer (19:19:19) @ 0.5%	928	31088	15088	1.94	1.62
F_4 : Water soluble complex Fertilizer (19:19:19) @ 0.5% + recommended dose of micronutrient for foliar spray	957	32059	16059	2.00	1.67
F_5 : Recommended dose of micronutrient for foliar spray	934	31289	15289	1.95	1.63
F_6 : Water Spray	798	26733	10733	1.67	1.40
F_7 : KNO_3	965	32327	16327	2.02	1.69
F_8 : Control (No spray of any material/water)	727	24354	8354	1.52	1.27
CD at 5%	87	3114	2706	-	-
Interaction (T X F)					
CD at 5%	N.S.	N.S.	N.S.	-	-

Foliar spray on physio-chemical properties of soil indicated that foliar spray after relieving of stress /dry spell significantly improved the soil available nutient content (262, 13.08 and 490 kg NPK/ha, respectively) compared to foliar spray during dry spell (245,12.70 and 448 kg NPK/ha, respectively). There was no significant response with respect to pH, OC and DTPA extractable micro nutrients with respect to time of foliar spray. Further N, P content in soil was increased and K content reduced under all treatments over initial soil test values. Foliar spray of KNO_3 @ 1.5% followed by urea@ 1% and water soluble complex fertilizer (19:19:19) @ 0.5% + $ZnSO_4$ @ 0.5% improved the soil OC content over initial soil values compared to other treatments. The soil pH slightly increased under all the treatments as compared to initial soil test values (Table 113).

Table 113: Effect of treatments on soil chemical properties in soybean

Treatment	pH	OC (%)	Av. major nutrient (kg /ha)			DTPA extractable micronutrients (mg/kg)		
			N	P	K	Zn	Fe	Cu
T_1 : Foliar spray during dry spell	7.74	0.46	245	12.70	448	1.84	3.60	1.81
T_2 : Foliar spray after	7.86	0.43	262	13.08	490	1.67	3.78	1.77

relieving of stress /dry spell								
CD at 5%	NS	NS	19.10	1.88	36.30	NS	NS	NS
Sub Plot:								
F_1 : Urea @ 1%	7.72	0.50	261	13.80	438	2.03	3.13	1.15
F_2 : Urea @ 2%	7.68	0.46	268	13.30	467	1.24	4.24	1.64
F_3 : Water soluble complex Fertilizer (19:19:19) @ 0.5%	7.61	0.40	235	12.78	485	1.94	3.17	1.23
F_4 : Water soluble complex Fertilizer (19:19:19) @ 0.5% + recommended dose of micronutrient for foliar spray	7.73	0.49	231	12.49	458	1.33	3.19	1.54
F_5 : Recommended dose of micronutrient for foliar spray	7.60	0.45	249	13.09	452	2.14	4.23	1.63
F_6 : Water Spray	7.78	0.44	254	15.13	484	1.28	4.18	1.48
F_7 : KNO3 @ 1.5%	7.61	0.51	237	12.92	438	1.40	3.13	1.15
F_8 : Control (No spray of any material/water)	7.84	0.41	252	15.10	471	1.62	3.57	1.88
CD at 5%	0.10	0.10	25.55	NS	55.10	0.75	0.65	NS
Interaction (T X F)								
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
Initial	7.56	0.46	225	12.10	510	1.86	3.62	6.82

C. On-farm Demonstrations

Village profile

The program is being implemented in Babulgaon village in Jintur Taluka, and new village Ujalamba, Taluka, Parbhani, Parbhani district, Maharashtra. The total cultivated area is 951.06 ha out of which 880.00 ha is rainfed. The mean annual rainfall is 880 mm with seasonal rainfall of 812.1 mm during *kharif* (June-September). The major soil types are medium deep to deep black soils. The major rainfed crops during *kharif* are soybean, sorghum, cotton, pigeonpea, greengram, blackgram and during *rabi* are sorghum, safflower and linseed. The source of irrigation is open wells covering 5% of cultivated area.

Climate vulner*abi*lity in general

The climate in this agro-climatic zone is semi-arid. Out of the total annual average rainfall of 880mm, the south-west monsoon contributes 80 to 85%, winter rains contribute 10 to 15% and summer rainfall contributes about 5%. The historical rainfall data (of 30 years) indicated that the variability in rainfall during south-west monsoon is 10-15% deficit of the average rainfall. The onset (south-west) of monsoon is during 22-23 SMW. For the past 15 years, the dry spells during crop season were experienced during August and at vegetative or reproductive stages of the major rainfed crops. The onset of monsoon was normal. The soil moisture status was deficit during maturity stages of major rainfed crops. The maximum and minimum temperatures during crop season are 41 and 21^0C, respectively. The extreme events like unusual and high intensity rainfall in short span are increasing during *kharif* and *rabi* seasons. There had been a considerable shift in the rainfall pattern and it is observed that during last 5 years the onset of effective monsoon was in the 1st fortnight of July instead of last week of June.

Dry spells during crop growing season (2019-20)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & Months		
10	01 -10 July	Soybean, pigeonpea, greengram, cotton	Vegetative stage
13	14 - 26 July	Soybean, pigeonpea, greengram, cotton	Vegetative stage flowering & pod formation stage
16	15 - 30 August	Soybean, pigeonpea, greengram, cotton	Grain filling stage in soybean pod formation in greengram and harvesting stage
18	02 - 19 October	Pigeonpea, cotton	Soybean: harvesting stage Pigeonpea: flowering and pond formation stage

Real time contingency practices (RTCP) implemented in Babhulgaon and Ujalamba (New Village)

Weather aberration	Farming situation/ soil type	RTCP implemented	
		Crop	RTCP implemented
Delayed onset of monsoon	**No delayed of monsoon during the year 2019**		
Early season drought	light and medium soil	Soybean	Dust mulching and straw mulching
	light and medium soil	Pigeonpea	Dust mulching
Mid season drought	light and medium soil	Soybean	Foliar sprays of KNO_3 and water sprays
	light and medium soil	Pigeonpea	Foliar sprays of KNO_3 and water sprays
Terminal drought	light and medium soil	Cotton	Protective irrigation
	light and medium soil	Pigeon pea	Protective irrigation

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Early season drought

In both the villages, Babhulgaon and Ujalamba, a dry spell of 10 days occurred during 01 to10 July coinciding seedling stage of crops. *In-situ* moisture conservation through dust mulch and straw mulching @ 5 MT/ha recorded 16% and 13% increased yields under soybean variety MAUS 162 as compared to farmers practice of without mulching with higher net returns (Rs.16351 and 19245/ha) and B:C ratio (2.02 and 2.20), respectively (Table 114).

Table 114: Effect of mulching on soybean seed yield and economics

Farming situation/ Soil type	Crop	Variety	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
			Straw mulching @ 5 MT/ha	Without mulching (farmers practice			
Babhulgaon							
Light to medium black	Soybean	MAUS 162	872	752	1.53	16351	2.02
		MAUS 71	748	685	1.31	11751	1.73
Ujalamba							
Light to medium black	Soybean	MAUS 162	950	840	1.66	19245	2.20
		MAUS 71	860	780	1.50	15906	1.99

In Babhulgaon village, weeding followed by hoeing or inter-culture at 21 to 25 DAS recorded 9.6 to 11.1% higher seed yield in soybean cultivars MAUS 71 and MAUS 162 and 11.3 to 14.1% in pigeonpea cultivars BDN 711and BSMR 736 while in Ujalamba village 15.6 - 18.3% in soybean and 14.6 -19.3% in pigeonpea cultivars, respectively (Table). Further, pigeonpea BDN 711 recorded higher net returns (Rs.32260 and 36900/ha) in Babjulgaon and Ujalamba villages, respectively (Table 115).

Table 115: Effect of weeding/interculture on soybean and pigeonpea yield and economics

Farming situation/ Soil type	Crop	Recommended variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)
			With weeding/ interculture	Without weeding/ interculture			
Babhulgaon							
Light to medium Black	Soybean	MAUS 71	798	728	9.61	1.40	13605
		MAUS 162	832	749	11.08	1.45	14867
	Pigeon pea	BDN 711	970	850	14.11	1.69	32260
		BSMR 736	835	750	11.33	1.46	24430
Ujalamba							
Light to medium Black	Soybean	MAUS 71	890	770	15.58	1.55	17019
		MAUS 162	970	820	18.29	1.69	19987
	Pigeon pea	BDN 711	1050	880	19.31	1.83	36900
		BSMR 736	940	820	14.63	1.64	30520

Situation: Mid season drought

During *kharif* 2019, a dry spell of 13 days during 14 to 26 July occurred at vegetative and flowering stage of crops at both the villages. *In-situ* moisture conservation through opening of furrow after every 4 rows in soybean and after every 2 rows in pigeonpea at 30 to 35 DAS enhanced yield by 11.1 to 22.8% in Babhulgaon and 14.6 to 19.8 % in Ujalamba village, respectively. Further, pigeonpea recorded higher net returns (Rs.31564 and 39220/ha) in both the villages, respectively compared to soybean (Table 116)

Table 116: Effect of opening of furrow on soybean and pigeonpea yield and economics

Farming situation/ Soil type	Crop	Recommended variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
			Opening of furrow	Farmers practice				
Babhulgaon								
Light to medium black	Soybean	MAUS 71	924	832	11.05	1.62	16280	1.90
	Pigeon pea	BDN 711	958	780	22.82	1.67	31564	2.31
Ujalamba								
Light to medium black	Soybean	MAUS 71	1020	890	14.60	1.78	21842	2.36
	Pigeon pea	BDN 711	1090	910	19.78	1.90	39220	2.63

One supplemental irrigation of 5 cm depth with sprinkler system from harvested rain water in farm pond at pod filling stage of soybean increased seed yield by 67.7 % (1395 kg/ha) and 54.08% (1510 kg/ha) with higher net returns (Rs.33754 and 38021/ha) and B:C ratio (2.87 and 3.11) compared to farmers practice of no supplemental irrigation(832 and 980 kg/ha) in Babhulgaon and Ujalamba villages, respectively (Table 117).

Table 117: Effect of Supplemental irrigation from harvested rainwater to soybean

Farming situation/ soil type	Crop	Recommended variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
			With SI	Without SI				
Babhulgaon								
Light to medium black	Soybean	MAUS 71	1395	832	67.66	2.44	33754	2.87
Ujalamba								
Light to medium black	Soybean	MAUS 71	1510	980	54.08	2.64	38021	3.11

SI: Supplemental irrigation

Foliar sprays of KNO_3 @1% in soybean and 2% in pigeonpea at pod filling stage (60 DAS) increased the seed yield by 15.5% (892 kg/ha) and 24.61% (972 kg/ha) in Babhulgaon where as 19% (940 kg/ha) and 21% (980 kg/ha) in Ujalamba village, respectively as compared to control. However, pigeonpea recorded higher net returns (Rs.31876 and 32840 /ha) and B:C ratio (2.30 and 2.36) with foliar sprays of KNO_3 in both the villages, respectively. There was not much improvement with water spray in both crops during dry spell (Table 118).

Table 118: Effect of foliar spray on soybean and pigeonpea yields and economics

Farming situation/ soil type	Crop	Recommended variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
			With foliar spray	Without foliar spray				
Babhulgaon								
Light to medium black soil	KNO_3	Soybean	892	772	15.54	1.56	17093	2.06
	Water spray		810		4.92	1.41	15051	2.00
	KNO_3	Pigeon pea	972	780	24.61	1.70	31876	2.30
	Water spray		865		10.89	1.51	26670	2.13
Ujalamba								
Light to medium black soil	KNO_3	Soybean	940	790	18.98	1.64	18874	2.17
	Water spray		830		5.06	1.45	14793	1.92
	KNO_3	Pigeonpea	980	810	20.98	1.71	32840	2.36
	Water spray		910		12.34	1.59	28780	2.20

Situation: Terminal drought

During *kharif* 2019, a dry spell of 18 days during 2 to 19 October occurred at flowering and boll formation stage of cotton. Foliar spray of KNO_3 @ 1.5% during 10-15 October increased the seed cotton yield by 20.5% (1350 kg/ha) and 15.7% (1400 kg/ha) with higher net returns (Rs.44925 and 47700/ha) and B: C ratio (2.49 and 2.59), respectively in Babhulgaon and Ujalamba villages (Table 119).

Table 119: Effect of foliar spray on soybean and pigeonpea yield and economics

Farming situation/ soil type	Normal crop/any change in crop	Recommended variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
			With foliar spray	Without foliar spray				
Babhulgaon								
Light to medium black soil	KNO_3	Cotton	1350	1120	20.53	2.36	44925	2.49

Ujalamba								
Light to medium black soil	KNO_3	Cotton	1400	1210	15.70	2.45	47700	2.59

Preparedness

Rainwater management

In-situ rainwater conservation with brad bed and furrow method (BBF) in soybean resulted in higher seed yield (1150 and 1170 kg/ha), net returns (Rs.24465 and 25207/ha) and B:C ratio (2.34 and 2.38) in Babhulgaon and Ujalamba villages, respectively compared to farmer's practice of flat bed sowing (Table 120).

Table 120: Effect of *in-situ* rainwater management on yield and economics of soybean

Farming situation/ soil type	Intervention	Yield (kg/ha)			Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
		Seed yield (2019)	Mean (3yrs)	Stalk yield			
Babhulgaon							
Light to medium black soil	BBF	1150	1368	2040	18200	24465	2.34
	Farmer's practice	940	1198	1975	19000	15874	1.83
Ujalamba							
Light to medium black soil	BBF	1170	1340	2010	18200	25207	2.38
	Farmer's practice	930	1160	1870	19000	15503	1.81

In Babhulgaon village, supplemental irrigation from harvesting rain water from farm pond to pigeonpea and chickpea produced highest seed yield (1180 and 842 kg/ha), net returns (Rs.43440 and 22847/ha) and B:C ratio (2.73 and 2.25), respectively as compared to farmers practice. Similarly, in Ujalamba village also, supplemental irrigation from farm pond water recorded highest pigeonpea and chickpea seed yield (1240 and 786 kg/ha), net returns (Rs.46920 and 20117/ha) and B:C ratio (2.87 and 2.10), respectively as compared to farmers practice (Table 121)

Table 121: Effect of supplemental irrigation in pigeonpea and gram yield and economics

Farming situation/ soil type	Crop	Intervention	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
			Seed (2019)	Mean (3yrs)			
Babhulgaon							
Light to medium black soil	Pigeonpea	Supplemental irrigation	1180	970	25000	43440	2.73
		Farmers' practice*	875	759	23000	16725	1.72
	Chickpea	Supplemental irrigation	842	672	18200	22847	2.25
		Farmers' practice*	590	522	17500	11262	1.64
Ujalamba							
Light to medium black soil	Pigeon pea	Supplemental irrigation	1240	1060	25000	46920	2.87
		Farmers' practice*	920	812	23000	30360	2.32
	Chickpea	Supplemental irrigation	786	661	18200	20117	2.10
		Farmers' practice*	522	508	17500	7947	1.45

Cropping systems

Intercropping system of soybean + pigeonpea (4:2) gave higher soybean equivalent yield (1508 and 1560 kg/ha), net returns (Rs.31447 and 33376 /ha) and B:C ratio (2.28 and 2.36) with LER of 1.23 in Babhulgaon and Ujalamba villages respectively as compared to farmers practice of sole soybean with lowest yield (985 and 960 kg/ha), net returns (Rs.17544 and 16616 /ha) and B:C ratio (1.92 and 1.87) (Table 122).

Table 122: Yields and economics of soybean + pigeonpea (4:2) intercropping system

Farming situation/ Soil type	Intervention	Yield (kg/ha)		SEY		LER	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
		Main crop	Intercrop	2019-20	Mean (last 3 years)				
Babhulgaon									
Light to medium black soil	Soybean + pigeonpea (4:2)	930	370	1508	1545	1.23	24500	31447	2.28
	Farmers' practice* Sole soybean	985		985	1172	-	19000	17544	1.92
Ujalamba									
Light to medium black soil	Soybean + pigeon pea (4:2)	950	390	1560	1550	1.23	24500	33376	2.36
	Farmers' practice* Sole Soybean	960		960	1101	-	19000	16616	1.87

Energy management

Sowing of soybean with BBF planter produced higher seed yield (1185 and 1250 kg/ha), net returns (Rs.24463 and 26875/ha) and B:C ratio (2.25 and 2.37), respectively in Babhulgaon and Ujalamba villages as compared to bullock drawn seed drill on flat bed under farmers practice with lowest seed yield (930 and 940 kg/ha), net returns (Rs.13003 and 13374 kg/ha) and B:C ratio (1.60 and 1.62), respectively in both the villages. Sowing of soybean with BBF planter requires very less field efficiency (4.5 hr/ha) and higher input and output energy (10105 and 23020 MJ/ha) compared to bullock drawn seed drill (18.0 hr/ha), 9449 and 20380 MJ/ha) in both villages (Table 123 & 124).

Table 123: Effect of BBF planter sowing on crop yield and economics in soybean

Farming situation/ Soil type	Intervention	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
		Seed (2019)	Mean (3yrs)			
Babhulgaon						
Light to medium black soil	BBF planter for soybean	1185	1377	19500	24463	2.25
	Farmers' practice* normal sowing with seed drill on flat bed	930	1234	21500	13003	1.60
Ujalamba						
Light to medium black soil	BBF planter for soybean	1250	1335	19500	26875	2.37
	Farmers' practice* normal sowing with seed drill on flat bed	940	1136	21500	13374	1.62

Table 124: Effect of tractor drwn tillage on energy use efficiency

Farming situation/ Soil type	Intervention	Field efficiency (hr/ha)	Energy (MJ/ha)	
			Input	Output
Babhul gaon and Ujalamba				
Medium to deep black soil	Tractor drawn tillage sowing	4.5	10105	23020
	Animal drawn tillage sowing	18	9449	20380

1.2.5 JHANSI

a. Agro-ecological setting

Jhansi is located in Bundelkand uplands (AESR 4.4) and Bundelkand agro-climatic zone in Uttar Pradesh. The climate is hot, moist semi-arid.

b. On-station experiments

Experienced weather conditions during 2019-20

During 2019, the onset of monsoon was normal (26th June). A rainfall of 713.8 mm was received which was deficit by 103.7 mm (12.7%) compared to normal (817.5 mm). During *kharif*, 649.8 mm rainfall was received which was deficit by 92.5 mm than normal (742.3 mm). During *rabi* (October- December), 31.6 mm of rainfall was received against normal rainfall of 29.8 mm and during summer (March-May), 6.4 mm of rainfall was received which was deficit by 17.8 mm compared to normal (24.2 mm) (Fig. 30).

Normal onset of monsoon	3rd week of June
Onset of monsoon during 2019	26 June
Annual mean rainfall	817.5 mm
Annual mean rainfall during 2019-20	713.8 mm
Mean crop seasonal rainfall during *kharif* & *rabi*	742.3 and 29.8 mm, respectively
Crop seasonal rainfall during 2019 (*kharif* & *rabi*)	649.8 and 31.6 mm during *kharif* and *rabi*, respectively

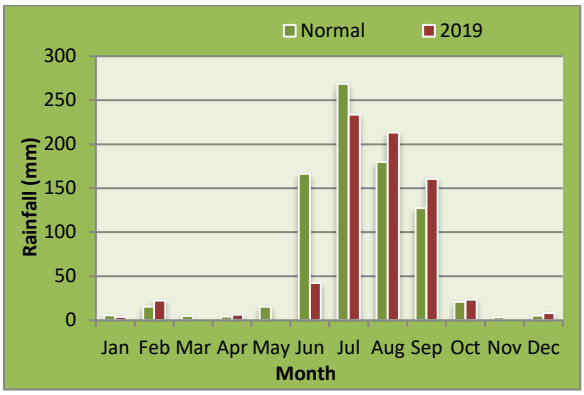


Fig. 30: Normal and actual (2019) monthly rainfall at Jhansi

Real time contingency practices (RTCP) implemented: Nil

c. On- farm demonstrations

Village profile

The program is being implemented in Kadesara Kalan village Talbehat Block/Mandal/Taluk/ Tehsil of Lalitpur district. The general topography is undulating to gentle sloping plain. The total cultivated area is 875.1 ha out of which 292.64 ha is rainfed. The major soil types are loamy sand, sandy loam and sandy clay loam. The major rainfed crops during *kharif* are groundnut, sesame and blackgram, and wheat, chickpea and mustard during *rabi* season. The source of irrigation is ground level pump set covering 45% of cultivated area.

Climate vulner*abi*lity in general

In general, the climate in this agro-climatic zone is semi-arid. The south-west monsoon contributes 82.39%, north-east monsoon contributes 7.75% and summer contributes 0.5% of the total annual rainfall of 818 mm. The major climatic vulner*abi*lities of the region are delayed onset of

monsoon, intermittent dry spells of >10 days, excess runoff causing moisture stress during reproductive phase of *rabi* crops, terminal heat causing reduced maturity period in wheat, terminal drought at grain filling stage of wheat. For the past 15 years, the dry spells during crop season had been experienced, during August & September and at different growth stages of the major rainfed crops. The onset of monsoon has shifted (27th SMW) in July. The soil moisture status was deficit during pod filling in *kharif* crops, germination to harvesting in *rabi* crops depending on rainfall. The extreme events like unusual and high intensity rainfall in short span were increasing during *kharif* and *rabi* seasons. The region is also experiencing other extreme events like cold waves. There has been a considerable shift in rainfall pattern and amount has been decreasing at the rate of 2.0 mm/year during *kharif* season.

Experienced weather conditions during 2019-20

During 2019, in Kadesara kalan village, the onset of monsoon was early by 10 days (16th June). A rainfall of 756.4 mm was received which was deficit by 394.7 mm compared to normal of 1151.1 mm. During south-west monsoon (*kharif*), 711.8 mm rainfall was received which was 185.1 mm deficit compared to normal of 896.9 mm and during *rabi* (October to December), there was no rainfall as against normal of 46.6 mm. During summer, no rainfall was received against normal of 106.5 mm (Fig. 31).

Normal onset of monsoon	25 June (26th SMW)
Onset of monsoon during 2019	27 June (26th SMW)
Annual mean rainfall	1151.1 mm
Annual mean rainfall during 2019-20	756.4 mm
Mean crop seasonal rainfall during *kharif*	742.3 and 29.8 mm, during *kharif* and *rabi*, respectively
Crop seasonal rainfall during 2019 (*kharif*)	711.8 and 0 mm, during *kharif* and *rabi*, respectively

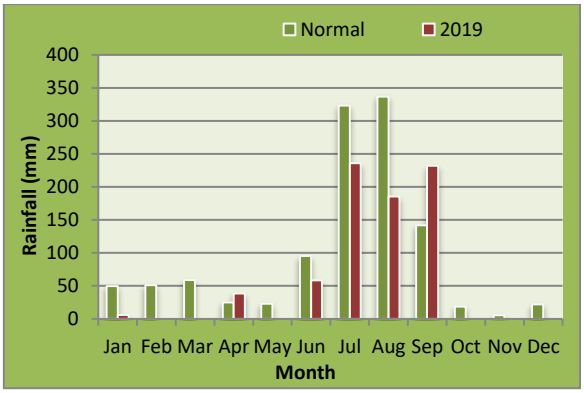


Fig. 31: Normal and actual (2019) monthly rainfall at Kadesara Kalan

Dry spells during crop growing season (2019-20)

Dry spell		Crop	Stage of the crop
Duration (days)	**Dates &months**		
8 & 5 Days	10-17 July and 19-23 July	Blackgram	Plant establishment and branching
		Groundnut	Plant establishment and branching
		Sesamum	Plant establishment

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of the crop	RTCP implemented
Mid season drought	Groundnut	Pod development	Inter culturing
	Blackgram	Pod filling	Inter culturing & foliar spray

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Mid season drought

At Kadesara Kalan village, a dry spell occurred coinciding with the pod development stage of the groundnut crop. *In-situ* moisture conservation interculturing with khurpi increased groundnut yield by 63.0% (998 kg/ha) with higher net returns (Rs.36168/ha) and B:C ratio (3.21) compared to farmers' practice of no weeding and interculture (612 kg/ha). Similarly, *in-situ* moisture conservation weeding and interculturing with hand hoe and khurpi increased the yield of balckgram by (513 kg/ha), net returns (Rs.18561/ha), B:C ratio (2.13) and RWUE (0.78 kg/ha-mm) compared to farmers' practice (436 kg/ha) (Table 125).

Table 125: Effect of intercultural operations on performance of groundnut & blackgram

Crop	Farming situation/ soil type	Intervention	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Groundnut	Shallow alluvial soils	Weeding/ interculture	998	1.52	36168	3.21
		Farmers' practice	612	0.93	16129	1.98
Blackgram		Weeding/ interculture	513	0.78	18561	2.13
		Farmers' practice	436	0.66	12893	1.79

At Kadesara Kalan village, foliar spray of 2% urea at branching and pod formation stage of the blackgram increased the seed yield 10.45% (481.9 kg/ha), with higher net returns (Rs.15921/ha) and B:C ratio (1.97) compared to farmers' practice of no foliar spray (436.3 kg/ha) (Table 126).

Table 126: Effect of foliar spray on yield and economics of blackgram

Farming situation/ soil type	Intervention	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Medium black soil	Foliar spray of 2% urea	481	0.73	15921	1.97
	Farmers' practice (no foliar spray)	436	0.66	12893	1.79

Preparedness

Rainwater management

At Kadesara Kalan village, *in-situ* moisture conservation practice of bunding recorded higher pod yield by 63.0% (998 kg/ha), with higher net returns (Rs.34851/ha) and B:C ratio (3.13) compared to farmers' practice (612.3 kg/ha) (Table 127).

Table 127: Effect of bunding on performance of groundnut

Farming situation/ soil type	Intervention	Yield (kg/ha)		Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Pod	Haulm			
Shallow alluvial soils	Improved practice (bunding)	998	1147	34851	3.13	1.48
	Farmers' practice	612	660	16649	1.98	0.93

At Kadesara Kalan village, supplemental irrigations at 50 DAS and 85-90 DAS (55 mm each from check dam) increased the pod yield of groundnut by 64.3% (1006 kg/ha) with higher net returns (Rs.36652/ha) and B:C ratio (3.24) compared to without supplemental irrigation (612 kg/ha) (Table 128).

Table 128: Effect of supplemental irrigation on yield and economics of groundnut

Farming situation/ soil type	Intervention	Pod yield (kg/ha)		Net returns (Rs/ha)	B:C ratio	WUE (kg/ha-mm)
		Pod	Haulm			
Medium deep black soil	Supplemental irrigation	1006	1203	36652	3.24	1.53
	Farmers' practice (no supplemental irrigation)	612	896	16649	1.98	0.93

Energy management

At Kadesara Kalan village, sowing of blackgram with bullock drawn seed drill gave higher seed yield (501 kg/ha), net returns (Rs.17505/ha) and B:C ratio (2.07) compared to farmers' practice (436 kg/ha) (Table 129).

Table 129: Yield and economics of wheat and blackgram as affected by sowing method

Farming situation/ soil type	Intervention	Yield (kg/ha)		Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Seed/grain	Stover/stalk			
Medium black soil	Black gram sowing with bullock drawn seed drill	501	925	17505	2.07	0.76
	Farmers' practice	436	654	12893	1.79	0.66

Farmers' practice: Broadcasting

Alternate land use

During the 8th year, plant height, collar diameter and DBH of Aonla were maximum in contour staggered trenches (6.2 m, 23.5 and 14.9 cm). Aonla fruit yield was significantly higher (11400 kg/ha) with contour staggered trenches followed by continuous trenches (10330 kg/ha) and vegetative barriers (9770 kg/ha). This year the yield was reduced due delayed and continuous rainfall that was non favorable for good production of aonla. Due to continuous rain the forage production was also low as compared to last year (2018-19). It also may be low production of legume (*Stylosanthes seabrana*). Over all the dry fodder yield was also maximum in staggered trenches (5.1 t/ha) which was 17.24 per cent higher over control (4.35 t DM/ha) (Table 130).

Table 130: Growth and productivity of Aonla and forage under different soil and water conservation measures

Treatment	Plant growth				Yield			
	Height (m)	Collar diameter (cm)	DBH (cm)	Canopy spread (m)	Fruit (kg/ha)	*C. ciliaris* (DMt/ha)	*S. saebrana* (DMt/ha)	Total Forage (DMt/ha)
T_1	6.2	23.5	14.9	6.7	11400	4.74	0.36	5.1
T_2	5.4	21.0	14.1	6.2	10330	4.30	0.40	4.7
T_3	4.6	15.2	10.1	5.2	7610	4.01	0.29	4.3
T_4	4.8	17.7	13.8	5.5	9770	4.02	0.33	4.35
T_5	4.8	17.5	12.7	5.2	9760	4.13	0.22	4.35
CD @ 5%	NS	2.671	2.701	0.1045	1536	1.253	0.166	0.945

T_1 - contour staggered trenches; T_2 - continuous contour trenches; T_3 - deep basin stone mulch; and T_4 - vegetative barrier; T_5 - control

1.2.6 RAKH DHIANSAR

a. Agro-ecological setting

Rakh Dhiansar is situated at latitude of 32°39' North and longitude of 74°53' East and at an elevation of 332 meters above mean sea level. The depth of the soil varies from 70 cm to 130 cm. Soil organic carbon varies from 0.22 to 0.50% and available nitrogen ranges from 144 to 207 kg/ha. The soils are low to very low in moisture retention.

b. On-station experiments

Experienced weather conditions during 2019-20

During 2019, the onset of monsoon was delayed by 11 days (9th July). The annual rainfall recorded during the year was 904.3 mm which was deficit by 243.7 mm than the normal (1148.0 mm). Out of the total rainfall received, 526.7 mm was received during the *kharif* season (June to September) which was deficit by 359.1 mm (40.5%) as against normal of 885.8 mm. In *rabi*, 174.8 mm rainfall was received which was excess by 127.2 mm (8.7%) than normal of 47.6 mm. (Fig. 32).

Normal onset of monsoon	27 June
Onset of monsoon during 2019	9 July
Annual mean rainfall (mm)	1148.0 mm
Actual annual rainfall (mm) during 2019-20	904.3 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	885.8 mm and 47.6 mm
Crop seasonal rainfall during 2019-20	526.7 mm and 174.8 mm

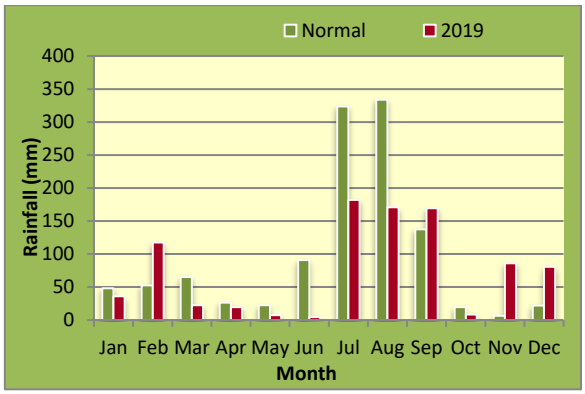


Fig. 32: Normal and actual (2019) monthly rainfall at Rakh Dhiansar

Dry spells during crop growing season (2019-20)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
16	19 June - 4 July	Maize	Early growth stage
11	14 -24 July	Maize	Early growth stage
8	27 August - 3 September	Maize	Silking/Tussling
15	2-16 October	Maize	Maturity
31	30 November - 31 December	Wheat	Vegetative

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Delayed onset on monsoon	Miaze	-	Improved varieties
Mid Season Drought	Maize var. Double dekalb	Vegetative, flowering, and grain filling	Foliar spray

Salient achievements of on-station experiments

Real time contingency planning

Situation: Delayed onset of monsoon

During the year 2019 onset of monsoon was delayed by 17 days (Normal 27th Jun, Actual 13th Jul), improved maize hybrid (var. Double dekalb) gave higher grain yield (3585 kg/ha), net returns (Rs.51427/ha), B:C ratio (3.19) and RWUE (6.76 kg/ha-mm) followed by hybrid maize Top-Top with yield (3100 kg/ha) when compared to farmers' practice (local var. Mansar) which yielded (2310 kg/ha) only (Table 131).

Table 131: Performance of improved maize varieties

Maize Hybrid	Yield (kg/ha)			Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2019	Mean (3 years)	Stover				
Double dekalb	3585	3565	6812	23500	51427	3.19	6.76
Tip-Top	3100	3120	6045	22780	42320	2.86	5.85
PMH-2	3070	2915	6294	25000	40084	2.60	5.79
K-517	3205	3194	6154	22400	44713	3.00	6.04
Farmers practice (local var. Mansar)	2310	2336	5290	21500	28281	2.30	4.36

Rate of Maize grain = Rs. 17.10/kg, Rate of Maize Stover = Rs. 2.00/kg



Performance of maize hybrid (var. Double dekalb) under delayed onset of monsoon

Situation: Mid season drought

There were four dry spells during 11 days (14-24 Jul), 8 days (27 Aug- 3 Sep) and 15 days (4th September to 14th October coinciding with silking/tussling and maturity stage of maize var. Double dekalb. Foliar spray of 0.5% water soluble complex fertilizer (19:19:19) + recommended dose of Zn at vegetative and flowering stage recorded higher seed yield (3480 kg/ha), net returns (Rs.49580/ha), B:C ratio (3.11) and RWUE (6.56 kg/ha-mm) followed by foliar spray of 0.5% water soluble complex fertilizer (19:19:19) recorded (3400 kg/ha) yield compared to control (3280kg/ha) (Table 132).

Table 132: Effect of foliar spray on yield and economics in maize (var. Double dekalb)

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2019	Mean (2 years)				
Urea 1%	3440	3295	23500	48396	3.06	6.49
Urea 2%	3385	3238	23500	46908	3.00	6.38
Water soluble complex fertilizer (19:19:19) @ 0.5 %	3400	3255	23500	47900	3.04	6.41

Water soluble complex fertilizer (19:19:19) @ 0.5 % + recommended dose of Zinc	3480	3325	23500	49580	3.11	6.56
Recommended dose of Zinc	3360	3223	23500	46590	2.98	6.34
Water spray	3300	3165	23500	46988	3.00	6.22
Control	3280	3135	23500	46364	2.97	6.19

Market price of Maize grain = Rs. 17.10/kg : Rate of Maize Stover: Rs. 2.00/kg



Maize crop under foliar spray

c. On-farm Demonstrations

Village profile

The programme is being implemented in Khaner village, Purmundal block, Tensil and district Samba, Jammu and Kashmir. The total cultivated area is 55 ha and 100% of the area is rainfed. The mean annual rainfall is 1150.9 mm with seasonal rainfall of 514.2 mm. The major soil types are sandy loam. The major rainfed crops during *kharif* are maize, blackgram, greengram, sesame, fodder pearl millet, fodder sorghum and during *rabi* season are wheat, chickpea and mustard. The number of small, marginal and medium farmers is 40, 18 and 32, respectively. The ground water table is 150-200 meters. There is no source of irrigation in the village.

Climatic vulner*abi*lity in general

In general, the climate in this agro-climatic zone is sub-humid. The rainfall is received through south-west monsoon, western disturbances (winter season) and summer (pre monsoon) and contributes about 75, 13 and 12 % of the annual rainfall. The historical rainfall data indicated that the variability among normal rainfall during south-west monsoon is 26.2 and 17.5% surplus and deficit respectively. The normal onset of monsoon was during 26th SMW. The chances of occurrence of normal and moderate drought were 7 and 12% during *kharif* season and 8 and 8% during *rabi* season, respectively.

Experienced weather conditions during 2019-20

During the year 2019, the onset of monsoon was delay by 12 days (10th July). The annual rainfall recorded during the year was 904.3 mm which was deficit by 246.6 mm than the normal (1151.1 mm). Out of the total rainfall received, 526.7 mm was received during the *kharif* season (June to September) which was deficit by 370.2 mm (41.3%) as against normal of 896.9 mm. In *rabi*, 174.8 mm rainfall was received which was excess by 128.2 mm (275.1%) than normal of 46.6 mm. (Fig. 33).

Normal onset of monsoon	27 June
Onset of monsoon during 2019	10 July
Annual mean rainfall (mm)	1151.1 mm
Actual annual rainfall (mm) during 2019-20	904.3 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	896.9 mm and 46.6 mm
Crop seasonal rainfall during 2019-20	526.7 mm and 174.8 mm

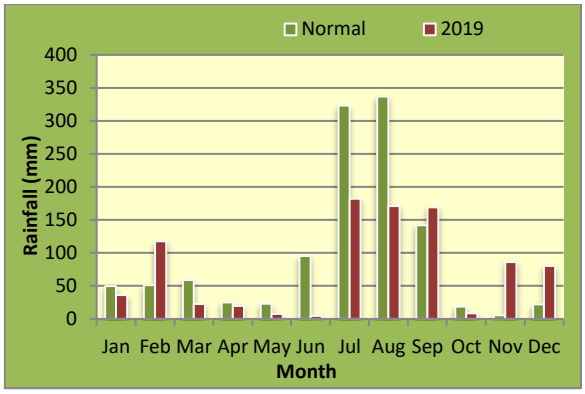


Fig. 33: Normal and actual (2019) monthly rainfall at Khaner village

Dry spells during crop growing season (2019-20)

Dry spell		Crop	Stage of the crop
Duration (days)	**Dates & months**		
16	19 June - 4 July	Wheat	Early growth stage
11	14 - 24 July	Wheat	Early growth stage
8	27 August - 3 September	Wheat	Silking/Tussling
15	2-16 October	Wheat	Maturity
31	30 November - 31 December	Wheat	Vegetative

Salient achievements of on-farm demonstrations

Real time contingency practices (RTCP) implemented: Nil

Preparedness

Rainwater management

At Kahner village, maize hybrid vari. Double dekalb sown across the slope gave higher grain yield (2465 kg/ha), net returns (Rs.28812/ha), B:C ratio (2.23) and RWUE (4.65 kg/ha-mm) as compared to farmers' practice of sowing along the slope (2125 kg/ha) (Table 133).

Table 133: Effect of sowing methods on yield and economics of maize

Farming situation/ Soil type	Intervention	Yield (kg/ha)			Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		2019	Mean (02 years)	Stalk				
Loamy sand	Sowing across the slope	2465	2413	5080	23500	28812	2.23	4.65
	Farmers' practice	2125	2086	4378	21500	23593	2.0	4.0

Farmers practice local var. Kanchan-517

Cropping systems

At Khaner, among the cropping sequences (maize-wheat, maize-mustard, balck gram-wheat and sesame-chickpea), Maize crop under maize-mustard cropping sequence gave higher grain yield (2883 kg/ha), net returns (Rs.37088/ha) and B:C ratio (2.58) and RWUE (5.44 kg/ha-mm) when compared to farmers' practice (2125 kg/ha). Similarly, higher mean yield of maize was observed under maize-mustard cropping sequence was 2727 kg/ha (Table 134)

Table 134: Performance of different cropping systems and their economics

Farming situation/ Soil type	Intervention	Yield (kg/ha)	MCEY		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Crop	2019	Mean (2 years)				
Medium deep soils	Maize-wheat	2805	-	2648	23500	36065	2.53	5.34
	Maize-mustard	2883	-	2727	23500	37088	2.58	5.44
	Blackgram-wheat	393	1492	1360	17500	8013	1.46	0.74
	Sesame - chickpea	343	2203	1773	14500	23175	2.60	0.65
	Farmers' practice	2125	-	2105	21500	23593	2.00	4.00

Farmers' practice sole wheat

At Madana, among the cropping sequences (maize-wheat, maize-mustard, balck gram-wheat and sesame-chickpea), Maize crop under maize-mustard cropping sequence gave higher grain yield (2833 kg/ha), net returns (Rs.36553/ha) and B:C ratio (2.56) and RWUE (5.34 kg/ha-mm) when compared to farmers' practice (2275 kg/ha). Higher mean yield of maize was observed under maize-mustard cropping sequence (2682 kg/ha) (Table 135).

Table 135: Relative performance of different cropping systems under rainfed condition

Farming situation/ Soil type	Intervention (Change in cropping sequence)	Yield (kg/ha)		MCEY		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Crop 1	Crop 2	2019-20	Mean 02 years)				
Medium deep soils	Maize-wheat	2833	-	-	2682	23500	36553	2.56	5.34
	Maize-mustard	2989	-	-	2800	23500	39563	2.68	5.65
	Black gram-wheat	435	-	1654	1536	17500	10775	1.62	0.82
	Sesame - chickpea	363	-	2332	3834	14500	25375	2.75	0.68
	Farmers' practice*	2275	-	-	2203	21500	26457	2.23	4.29

Farmers' practice sole wheat

At Khaner village an intercropping system of maize + blackgram (1:1) (additive series) gave 26.8% higher maize equivalent yield (2854 kg/ha) with higher net returns (Rs.33100/ha), B:C ratio (2.29) and RWUE (5.38 kg/ha-mm) as compared to farmers' practice of sole maize (2138kg/ha). Similarly, at Madana village, intercropping system of maize + blackgram (1:1) gave 28.5% higher maize equivalent yield (2679 kg/ha) with higher net returns (Rs.30974/ha), B:C ratio (2.21) and RWUE (5.18 kg/ha-mm) as compared to farmers' practice of sole maize (2165 kg/ha) (Table 136).

Table 136: Yield and economics of maize + blackgram (1:1) intercropping system

Village	Farming situation/ Soil type	Intervention	Yield (kg/ha)		MCEY		LER	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
			Main crop	Inter crop	2019	Mean (2 yrs)				
Khaner	Medium deep soils	Maize + black gram (1:1)	2285	150	2854	2797	1.20	33001	2.29	5.38
		Sole maize (Farmers' practice)	2250	-	-	2138	-	25795	2.20	4.24

Madana	Medium deep soils	Maize + black gram (1:1)	2220	139	2749	2679	1.12	30974	2.21	5.18
		Sole maize (Farmers' practice)	2200	-	-	2165		25448	2.18	4.15

Farmers' practice (Sole maize); Rate of Maize grain = Rs. 17.10/kg; Mash= Rs 65/kg; Maize Stover = Rs. 2.00/kg

Energy management

Sowing of maize with maize planter gave 30.0 and 25.0% higher grain yield over farmers' practice in Khaner and Madana villages respectively with net returns of Rs. 37793 and 41158/ha, B:C ratio (2.83 and 2.75) and RWUE (5.4 and 5.7 kg/ha-mm). The energy use input and output ranged from 6841-6790 MJ/ha and 126829-129431 MJ/ha respectively with energy use efficiency of 18.5 and 19.1 in Khaner and Madana villages (Table 137).

Table 137: Effect of maize planter for sowing on yield and economics of maize

Farming situation/ Soil type	Village	Mean Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio	Energy (MJ/ha)		Energy use efficiency
		Improved	Farmers practice				Input	Output	
Medium deep soils	Khaner	2176	1672	5.4	37793	2.83	6841	126829	18.5
	Madana	2810	2240	5.7	41158	2.75	6790	129431	19.1

Alternate land use

The yield of maize on farmers' fields under anole + maize system recorded with an increase of 30.5% (2505 kg/ha), net returns (Rs.29328/ha), B:C ratio (2.27) and RWUE (4.78 kg/ha-mm) when compared to farmers' practice (1920 kg/ha). The yield of mixed fodder on farmers' fields under anola + mixed fodder system, recorded an increase of 19.0% (29500 kg/ha), net returns (Rs.23740/ha), B:C ratio (2.76) and RWUE (61.96 kg/ha-mm) when compared to farmers' practice (24800 kg/ha) (Table 138).

Table 138: Yield and economics of alternate land use systems

Farming situation/ Soil type	Intervention	Grain/ Fodder crop	Yield (kg/ha)		% increase in yield	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
			Inter crop (Maize/ mixed fodder)	Farmers practice (sole pearl millet)				
Shallow soils	Anola+maize with 100% RDF	Maize	2505	1920	30.50	29328	2.27	4.78
	Anola + mixed fodder with RDF	Maize + sorghum+ pearlmillet	29500	24800	19.00	23740	2.76	61.96

1.3 Dry Sub-humid Zone (1000-1250 mm)

1.3.1 BALLOWAL SAUNKHRI

a. Agro-ecological setting

Ballowal Saunkhri is located in Kandi zone in Punjab. Annual average rainfall is 1012 mm. Annual potential evapotranspiration is 739 mm.

b. On-station experiments

Experienced weather conditions during 2019-20

During 2019, the onset of monsoon was normal (3rd July). The annual rainfall during the year was 1004.6 mm, which was deficit by 89.7 mm than the normal annual rainfall of 1094.3 mm. Out of the total rainfall, 818.3 mm was received during the *kharif* season (June to September) which was deficit by 57.3 mm (6.5%) as against normal of 75.6 mm. In *rabi*, 88.3 mm rainfall was received which was 26.4 mm excess (42.64%) than normal of 61.9 mm (Fig. 34).

Normal onset of monsoon	1 July
Onset of monsoon during 2019	3 July
Annual mean rainfall	1094.3 mm
Annual rainfall during 2019-20	1004.6 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	875.6 and 61.9 mm, respectively
Crop seasonal rainfall during 2019-20 *(kharif* and *rabi)*	818.3.0 and 88.3 mm, respectively

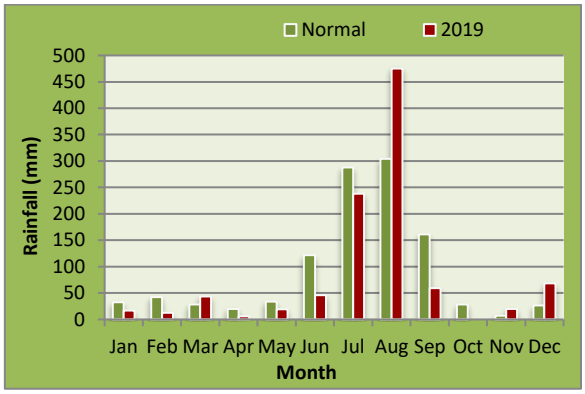


Fig. 34: Normal and actual (2019) monthly rainfall at Ballowal Saunkhri

Salient achievements of on-station demonstrations

Dry spells during crop growing season (2019-20): Nil

Real time contingency practices (RTCP) implemented: Nil

c. On-farm Demonstrations

Village profile

The program is being implemented in Achalpur, Nainwan and Bhawanipur (new) villages in Garhshankar tehsil in Hoshiarpur district, Punjab. The total cultivated area is 145.2 ha in Achalpur and 320 ha in Nainwan, out of which the rainfed area is 102 ha in Achalpur and 288.5 ha in Nainwan. The mean annual rainfall is 1081 mm with the seasonal rainfall of 903.7 mm during *kharif* (June - September). The major soil types are silt loam (silty clay loam). The major rainfed crops during *kharif* season are maize and sorghum and in *rabi* are wheat, raya and taramira. The small, marginal, medium and large farmers are 86, 11, 3 and 0% in Achalpur and 76, 13, 6 and 5% in Nainwan, respectively. Only one tube well is available in each village as a source of irrigation, which is covering 10% of cultivated area approximately.

Climate vulnerability in general

The climate in this agro-climatic zone is semi- arid. Out of the total annual average rainfall of

1081 mm, the south-west monsoon contributes 80%, north-east monsoon contributes 12% and summer contributes 8%. The historical rainfall data (of 30 years) indicated that the variability in rainfall during south-west monsoon was 43% deficit of the average rainfall. (South-west) of monsoon was during 24 SMW. For the past 15 years, the dry spells during crop season were experienced in the month of September at grain filling stage of *kharif* crops. The normal onset of the monsoon was first July and generally delayed by one week influencing the sowing of maize and its productivity. The soil moisture was generally deficit at sowing and at reproductive stages of *rabi* crops. The maximum and minimum temperature during *kharif* season ranged from 31.9 to 40.8^{0}C and 21.4 to 26.2^{0}C, whereas during *rabi* season it varied from 16.0 to 38.9^0 C and 2.3 to 20.4^{0}C, respectively in the past 10 years. The area has been experiencing extreme events like hail storm and frost during *rabi* season.

Experienced weather conditions during 2019-20

During 2019, the onset of monsoon was delayed by seven days (8th July). The annual rainfall during the year was 1191.0 mm, which was 139.9 mm excess than the normal annual rainfall of 1051.8 mm. Out of total rainfall, 767.5 mm was received during the *kharif* season (June to September) which was deficit by 61.2 mm (7.3%) as against normal of 828.7 mm. In *rabi*, 87.8 mm rainfall was received which was excess by 45.1 mm than normal of 60.5 mm (Fig. 35)

Normal onset of monsoon	1 July
Onset of monsoon during 2019	8 July
Annual mean rainfall	1051.8 mm
Annual mean rainfall during 2019-20	1191.7 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	828.7 and 60.5 mm, respectively
Crop seasonal rainfall during 2019-20 (*kharif* and *rabi*)	767.5 and 87.8 mm, respectively

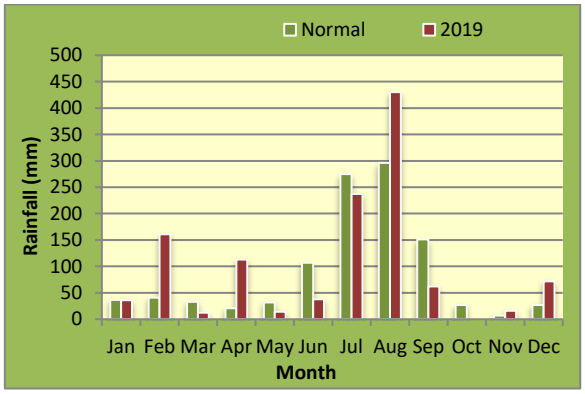


Fig. 35: Normal and actual (2019) monthly rainfall at Achalpur

Salient achievements of on-farm demonstrations

Dry spells during crop growing season (2019-20): Nil

Real time contingency practices (RTCP) implemented: Nil

Preparedness

Rainwater management

Sowing of maize on ridges proved to be superior to flatbed sowing in all three villages. The increase in grain yield of maize with ridge planting was 36.3, 29.8 and 30.3% compared to farmers' practice of flatbed sowing in Achalpur, Nainwan and Bhawanipur, respectively. Similarly, the increase in net returns with ridge sowing as compared to flatbed sowing was 54.6, 50.6 and 54.1% in Achalpur, Nainwan and Bhawanipur villages (Table 139).

Table 139: Effect of planting methods on yield and economics of rainfed maize

Intervention	Yield (kg/ha)		Cost of Cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Stalk				
Achalpur						
Ridge planting	4957	16763	34354	56764	2.65	6.21
Flatbed sowing	3637	13610	31460	36705	2.17	4.77
CD at 5%	1235	2635	-	-	-	-
Nainwan						
Ridge planting	4753	15573	34196	52672	2.54	6.52
Flatbed sowing	3663	11503	31480	34968	2.11	5.02
CD at 5%	948	2429	-	-	-	-
Bhawanipur						
Ridge planting	4527	15729	34020	49614	2.46	6.21
Flatbed sowing	3475	11405	31334	32196	2.03	4.77
CD at 5%	516	1828	-	-	-	-



Cropping systems

During *kharif* 2019, maize hybrids PMH 1 and PMH 11 recorded significantly higher grain and stalk yields compared to var. Megha and local variety in all the three villages except Nainwan where statistically similar yield was recroded for PMH-11 and Megha. Among all the varieties, higher yield was recorded for hybrid PMH 1 at all the locations except Bhawanipur where PMH 11 performed better than PMH 1. The increase in grain yield of PMH 1 was 51. 9, 27.8 and 65.3% as compared to local variety in Achalpur, Nainwan and Bhawanipur, respectively (Table 140).

Table 140: Performance of improved varieties of maize

Variety	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Stalk				
Achalpur						
PMH-1	4663	11317	37182	76721	3.06	6.40
PMH-11	4519	10417	37018	72817	2.97	6.20
Megha	3119	8377	34017	67930	3.00	4.28
Local	3070	7499	33733	65866	2.95	4.21
CD at 5%	644	1321	-	-	-	-
Nainwan						
PMH-1	3946	10771	36364	61219	2.68	5.41
PMH-11	3681	9943	36061	54864	2.52	5.05
Megha	2723	8605	33401	56894	2.70	3.74

Local	3088	8587	33761	67466	3.00	4.24
CD at 5%	527	1712	-	-	-	-
Bhawanipur						
PMH-1	4160	12270	36608	67182	2.84	5.71
PMH-11	4357	12296	36833	71317	2.94	5.98
Megha	2840	7838	33583	59455	2.77	3.90
Local	2517	8222	32873	50859	2.55	3.45
CD at 5%	589	1694	-	-	-	-

Among the blackgram varieties demonstrated, var. Mash 338 recorded higher seed yield as compared to Mash 114 at all the locations. The increase in seed yield with var. Mash 338 was 20.3, 24.3 and 20.7% as compared to Mash 114 in Achalpur, Nainwan and Bhawanipur, respectively with higher net returns, B:C ratio and RWUE (Table 141).

Table 141: Performance of improved varieties of blackgram

Variety	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Stover				
Achalpur						
Mash 114	759	3456	27803	17398	1.63	1.20
Mash 338	913	2414	27803	24826	1.89	1.44
CD at 5%	133	912	-	-	-	-
Nainwan						
Mash 114	903	3104	27803	24966	1.90	1.42
Mash 338	1122	2602	27803	36509	2.31	1.77
CD at 5%	190	418	-	-	-	-
Bhawanipur						
Mash 114	798	3340	27803	19427	1.70	1.26
Mash 338	963	2720	27803	27882	2.00	1.52
CD at 5%	161	435	-	-	-	-





Among the greengram varieties, at all the locations, var. ML 2056 performed better than local variety. The increase in seed yield with var. ML 2056 was 43.1, 35.1 and 65.3% as compared to local variety in Achalpur, Nainwan and Bhawanipur, respectively with higher net returns, B:C ratio and RWUE (Table 142).

Table 142: Performance of improved varieties of greengram

Variety	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Stover				
Achalpur						
ML 2056	783	3171	28653	17583	1.61	1.34
Local	547	2707	28653	4139	1.14	0.94
Nainwan						
ML 2056	680	3849	28653	12596	1.44	1.17
Local	503	2888	28653	1900	1.07	0.86
Bhawanipur						
ML 2056	752	4128	28653	16835	1.59	1.29
Local	455	3243	28653	-385	0.99	0.78

Among the sesame varieties demonstrated, at Achalpur and Bhawnipur villages, significantly higher seed yield was recorded by var. Punjab Til No 2 compared to var. RT 346. However, at Nainwan village, both the varieties recorded similar yield. The increase in seed yield of var. Punjab Til No 2 was 23.5, 6.7 and 22.3% as compared to RT 346 in Achalpur, Nainwan and Bhawanipur, respectively. Highest net returns, B:C ratio and RWUE were also recorded by var. Punjab Til No 2 as compared to var. RT 346 at all the locations (Table 143).

Table 143: Performance of improved varieties of sesame

Variety	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Stalk				
Achalpur						
PB Til No 2	552	3842	23061	45939	2.99	0.87
RT 346	447	2538	23061	32814	2.42	0.70
CD at 5%	59	674	-	-	-	-
Nainwan						
PB Til No 2	696	4363	23061	63939	3.77	1.10
RT 346	653	3802	23061	58564	3.54	1.03
CD at 5%	NS	NS	-	-	-	-
Bhawanipur						
PB Til No 2	575	4184	23061	48814	3.12	0.91
RT 346	470	3868	23061	35689	2.55	0.74
CD at 5%	85	NS	-	-	-	-

Pigeonpea var. AL 882 gave higher seed yield than var. PAU 881 due to its determinate growth habit and early maturity than PAU 881. At Achalpur, Nainwan and Bhawanipur villages, var. AL 882 gave 11.2, 6.6 and 14.4% higher seed yield than var. PAU 881 with respective net returns of Rs.20181/ha, Rs.26650/ha and Rs.31093/ha, and B:C ratio 1.69, 1.92 and 2.08 (Table 144).

Table 144: Performance of improved varieties of pigeonpea

Variety	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Stalk				
Achalpur						
PAU 881	1092	8244	29553	16911	1.57	1.50
AL 882	1229	6719	29553	20181	1.68	1.69
Nainwan						

PAU 881	1311	7868	29553	24200	1.82	1.80
AL 882	1403	7098	29553	26650	1.90	1.92
Bhawanipur						
PAU 881	1293	7980	29553	23682	1.80	1.77
AL 882	1513	7691	29553	31093	2.05	2.08





Energy management

Among different sowing methods in maize, higher grain yield was recorded with *kera* method followed by maize planter at Achalpur and Bhawanipur villages. However, at Nainwan village, sowing with maize planter recorded higher yield as compared to other methods of sowing. Similar trend was observed for net returns and B:C ratio (Table 145).

Table 145: Effect of sowing methods on yield and economics of maize

Village	Yield (kg/ha)		RWUE (Kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Grain	Stalk			
Achalpur					
Broadcasting	3760	12274	5.16	55778	2.42
Maize planter	4538	15514	6.22	76149	2.94
Kera method	4706	16358	6.46	78044	2.87
Nainwan					
Broadcasting	3589	12814	4.92	52751	2.35
Maize planter	4512	14829	6.19	74922	2.91
Kera method	4422	16393	6.07	72155	2.74
Bhawanipur					
Broadcasting	3612	13197	4.95	53614	2.37
Maize planter	4259	15068	5.84	69884	2.8
Kera method	4713	16890	6.47	78722	2.88

1.3.2. CHIANKI

a. Agro-ecological setting

Chianki centre is located in Chhattisgarh Mahanadi basin (11.0) and western plateau zone in Jharkhand. The climate is hot moist sub-humid. Annual normal rainfall is 1179 mm. The length of growing period is 150-180 days. The annual normal potential evapotranspiration is 1400–1600 mm. In some parts of the region, partial waterlogging in early stages of the crop growth followed by seasonal drought during the rest of the period is observed.

b. On-station experiments

Experienced weather conditions during 2019-20

During 2019, the onset of monsoon was normal (9 June). The annual rainfall of 1209.3 mm was received which was excess by 29.0 mm compared to normal (1180.3 mm) (Fig. 36). During *kharif* (June–September), 1102.1 mm of rainfall was received compared to normal (1038.0 mm). During *rabi* season, 45.8 mm rainfall was received which was deficit by 20.1 mm compared to normal (65.9 mm).

Normal onset of monsoon	4-10 June
Onset of monsoon during 2019	9 June
Annual mean rainfall	1180.0 mm
Annual rainfall during 2019-20	1209.3 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	1038.0 and 65.9 mm, respectively
Crop seasonal rainfall during 2019-20 (during *kharif* and *rabi*)	1102.1 mm and 45.8 mm, respectively

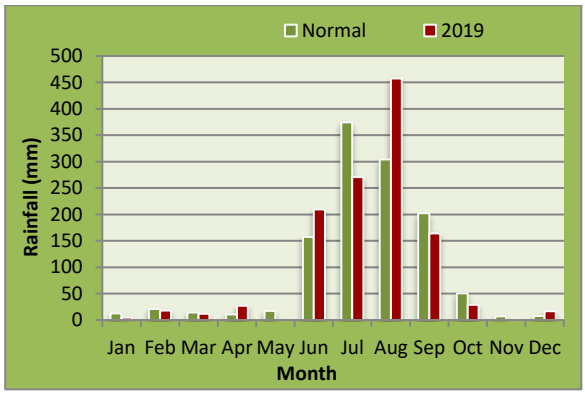


Fig. 36: Normal and actual (2019) monthly rainfall at Chianki

Dry spells during crop growing season (2019-20)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
12	13-24 July	Rice, maize, sesame	Vegetative

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Early season drought	Rice	Vegetative	Foliar spray

Salient achievements of on-station experiments

Real time contingency planning

Situation: Early season drought

During *kharif* 2019, a dry spell of 12 days occurred during 13-24 July coinciding with vegetative stage in rice. Since the crop experienced only a dry of 12 days, different treatments had no significant effect on crop yield. However, foliar spray of water soluble complex fertilizer (19:19:19) @ 0.5% + $ZnSO_4$ @ 0.5% during the dry spell recorded marginally higher grain yield (4790 kg/ha) and net returns (Rs.39060/ha) than other treatments (Table 146).

Table 146: Effect of foliar spray on yield and economics of rice

Treatment	Grain yield (kg/ha)		Straw yield (kg/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2019-20	Mean (3 yrs)				
T_1S_1	4710	3190	6170	37940	1.35	6.57
T_2S_1	4680	3200	6150	37520	1.34	6.53
T_3S_1	4750	3270	6210	38500	1.37	6.62
T_4S_1	4790	3560	6280	39060	1.39	6.68
T_5S_1	4710	3480	6320	37940	1.35	6.57
T_6S_1	4640	3180	6360	36960	1.32	6.47
T_7S_1	4600	3100	6210	36400	1.30	6.42
T_1S_2	4700	3290	6240	37800	1.35	6.55
T_2S_2	4610	3290	6190	36540	1.30	6.43
T_3S_2	4680	3350	6220	37520	1.34	6.53
T_4S_2	4700	3700	6150	37800	1.35	6.55
T_5S_2	4700	3630	6260	37800	1.35	6.55
T_6S_2	4640	3270	6190	36960	1.32	6.47
T_7S_2	4600	3190	6180	36400	1.30	6.42
CD at 5%	NS	195	NS	NS	NS	NS

T_1: Urea @ 1%; T_2: Urea @ 2%; T_3: Water soluble complex fertilizer (19:19:19) @ 0.5%; T_4: Water soluble complex fertilizer (19:19:19) @ 0.5% + $ZnSO_4$ @ 0.5%; T_5: $ZnSO_4$ @ 0.5%; T_6: Water spray; T_7: Control (no spray); S_1: Foliar spray during dry spell; S_2: Foliar spray after relieving of dry spell

c. On-farm Demonstrations

Village profile

The program is being implemented in Kumbhi and Bankheta villages in Garhwa district, Jharkhand. The total cultivated area is 215 ha, out of which 150 ha is rainfed. The normal rainfall is 1152.4 mm. The major soil types are sandy loam, clay loam and loam. The major rainfed crops during *kharif* are rice, maize, pigeonpea, sesame, etc and *rabi* crops are chickpea, wheat, lentil, linseed and mustard. The number of small, marginal large farmers is 131, 69 and 27, respectively. The source of irrigation is harvested rainwater (dam and *ahars*) covering 30% of cultivated area. The NICRA program was also expanded to adjoining village Chiraunjia, Meral block of Garhwa disrtict.

Experienced weather conditions during 2019-20

During the year 2019, the onset of monsoon was delayed by 17 days (27 June). A rainfall of 1238.4 mm was received which was excess by 86.0 mm compared to normal of 1152.4 mm (Fig. 37). During *kharif* (June - September), 1085.0 mm rainfall was received which was excess by 92.7 mm (9.3%) compared to normal (992.5 mm). During *rabi* season, 101.0 mm rainfall was received against normal rainfall of 77.6 mm.

Normal onset of monsoon	4-10 June
Onset of monsoon during 2019	27 June
Annual mean rainfall	1152.4 mm
Annual rainfall during 2019-20	1238.4 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	992.5 and 77.6 mm, respectively
Crop seasonal rainfall during 2019-20 (*kharif* and *rabi*)	1085.2 and 101.0 mm,, respectively

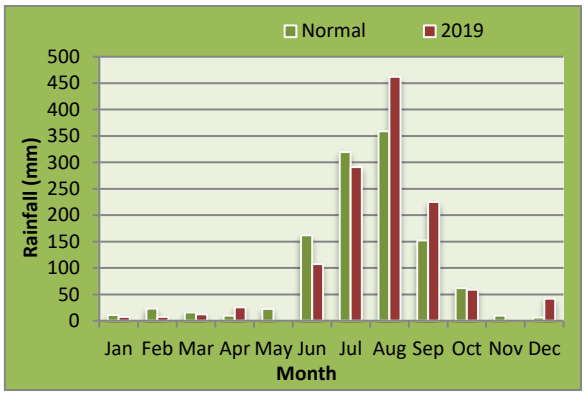


Fig. 37: Normal and actual (2019) monthly rainfall at Kumbhi and Bankheta

Dry spells during crop growing season (2019-20): Nil

Real time contingency practices (RTCP) implemented: Nil

1.3.3 FAIZABAD

a. Agro-ecological setting

Faizabad centre is located in Northern plain, Rohilkhand, Avadh and South Bihar plains (AESR 9.2) and Eastern plain agro-climatic zone in Uttar Pradesh. The climate is hot dry sub-humid. Annual normal potential evapo-transpiration is about 549 mm. Annual normal rainfall is 1040 mm. Length of growing period is 150-180 days. Drought occurs once in ten years.

b. On-station experiments

Experienced weather conditions during 2019-20

During 2019, the onset of monsoon was delayed by 14 days (8th July). A rainfall of 1033.2 mm was received which was deficit by 6.9 mm compared to normal rainfall (1040.1 mm). During south-west monsoon (*kharif*), 939.7 mm rainfall was received which was excess by 24.6 mm (2.7%) compared to normal of 915.1 mm. During *rabi*, 32.0 mm rainfall was received against the normal rainfall of 65.6 mm. (Fig. 38).

Normal onset of monsoon	24 June
Onset of monsoon during 2019	8 July
Annual mean rainfall	1040.1 mm
Annual rainfall during 2019-20	1033.2 mm
Mean crop seasonal rainfall	915.1 mm (*kharif*) & 65.6 mm (*rabi*)
Crop seasonal rainfall during 2019-20	939.7 mm (*kharif*) & 32.0 mm (*rabi*)

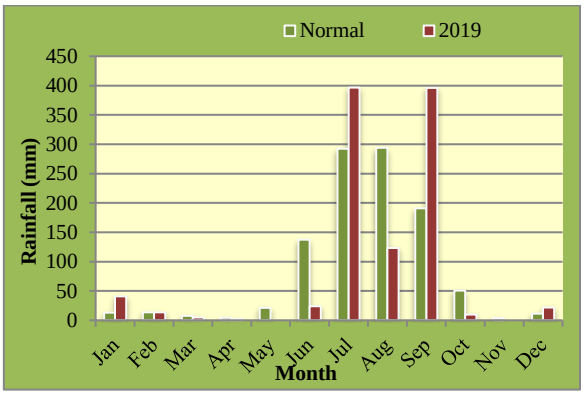


Fig. 38: Normal and actual (2019) monthly rainfall at Faizabad

Dry spells during crop growing season (2019-20)

Dry spell		Crop	Stage of the crop
Duration (days)	**Dates & months**		
13 days	27 August to 8 September	Paddy Pigeonpea Blackgram Maize Sorghum & Sesame	Panicle initiation stage Growth stage Grain formation Silking/ tasseling stage Growth stage

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Mid season drought	Rice	Panicle initiation stage	Foliar spray

Salient achievements of on-station experiments

Real time contingency planning

Situation: Mid season drought

During *kharif* 2019, a dry spell of 13 days from 27 August to 8 September occurred at panicle initiation stage of rice. Foliar spray during dry spell significantly improved the rice grain yield (2489 kg/ha), net returns (Rs.26517/ha), B:C ratio (1.34) and RWUE (2.63 kg/ha-mm) as compared to foliar spray after relieving of stress/dry spell (2247 kg/ha). Further, foliar spray of Water soluble complex fertilizer (19: 19: 19) @ 5% zinc sulphate @ 0.5% + Borex @ 0.25 % was found superior and recorded significantly higher rice grain yield (2711 kg/ha), net returns (Rs.30830 /ha), B:C ratio (1.56) and RWUE (2.87 kg/ha-mm) as compared to rest of the treatments (Table 147).

Table 147: Effect of foliar sprays on yield and economics of rice (NDR-97)

Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain/ seed in 2019	Stover/ talk	Mean seed/ grain yield (no. of years)				
Main plot							
F_1: Foliar Spray during dry spell	2489	3107	2375	19774	26517	1.34	2.63
F_2: Foliar Spray after relieving of stress (with favourable soil moisture)	2247	2818	2157	18999	22867	1.21	2.37
CD (5%)	100	122					
Subplot							
N_1: Urea @ 1%	2281	2843	1914	19315	23164	1.20	2.41
N_2:Urea @ 2%	2416	3025	2015	19405	25604	1.32	2.55
N_3: Water soluble complex fertilizer (19: 19: 19) + @ 5%	2546	3155	2084	19465	27930	1.43	2.70
N_4: Water soluble complex fertilizer (19: 19: 19) @ 5% zinc sulphate @ 0.5% + Borex @ 0.25 %	2711	3404	2239	19670	30830	1.56	2.87
N_5: Zinc Sulphate @ 0.5% + Borex @ 0.25 %	2476	3092	2050	19492	26621	1.36	2.61
N_6: water Spray	2095	2638	1817	19415	19614	1.04	2.21
N_7: Control (No spray)	2054	2580	1758	18930	19082	1.00	2.16
CD (5%)	187	229.51	-				



Rice with foliar spray of water soluble complex fertilizer (19: 19: 19) @ 0. 5% + $ZnSO_4$ @ 0.5% + borax @ 0.25%

c. On-farm demonstrations

Village profile

The programme is being implemented in Hardoya village, Uttar Pradesh. The total cultivated area is 397 ha out of which 138 ha is rainfed. The major soil types are silty loam and silty clay. The major rainfed crops during *kharif* are upland rice, maize, pigeonpea, blackgram, sorghum and pearlmillet and *rabi* crops are chickpea, lentil, mustard, linseed and barley. The numbers of landless, marginal, small and medium farmers are 55, 445 and 155, respectively. The ground water table is 6 meter. The source of irrigation is tube well and ponds covering 65% of cultivated area. The activities and interventions were extended to new village, Amavachitan, block- Haringtonganj, tehsil-Milkipur in Faizabad district.

Climate vulnerability in general

In general, the climate in this agro-climatic zone is sub-humid. The south-west monsoon contributes 90% of the total annual average rainfall of 1001.7 mm. The historical rainfall data (30 years) indicated that the variability in rainfall during southwest monsoon is 15-20% deficit of the average rainfall. The onset (south-west) of monsoon is during 25 SMW. The dry spells during crop season are experienced (for the past 10/15 years) during September at grain setting and maturity stages of major rainfed crops. The soil moisture status is deficit during growth and flowering stages of major rainfed crops.

Experienced weather conditions during 2019-20

The rainfall data of Faizabad centre was taken.

Real time contingency practices (RTCP) implemented

Weather aberration	Farming situation/ Soil type	RTCP implemented			
		Crop	RTCP implemented	No. of farmers fields covered	Area covered (ha)
Delayed onset of monsoon	Sowing of short duration varieties	Rice	NDR-97, Susksamrat, Vandana, Baranideep	3	0.75
		Pigeonpea	NDA-1, NDA-2, Bahar, MA-13	4	1.00
		Maize	Naveen	3	0.75
		Blackgram	NDU-1	2	0.25
		Sesame	T-3	2	0.25
Terminal drought	Live saving irrigation from harvested water/foliar spray	Rice	NDR-97	3	0.75
		Pigeonpea	NDA-1		
		Maize	Naveen		

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Delayed onset of monsoon

During 2019, the onset of monsoon was delayed by 14 days (8th July). Among rice varieties, NDR-97 gave higher grain yield (1975 kg/ha) and stover yield (2485 kg/ha), net returns (Rs.

15660/ha), B:C ratio (0.77) and RWUE (2.09 kg/ha-mm) followed by var. Baranideep (1798 kg/ha) compared to local variety (1355 kg/ha**)** (Table 148).

Table 148: Performance of short duration varieties of rice

Variety	Grain yield (kg/ha)	Straw yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
NDR-97	1975	2485	2.09	15660	0.77
Baranideep	1798	2295	1.90	12461	0.61
Suskasamrat	1715	2198	1.81	10953	0.54
Vandna	1595	2185	1.69	8900	0.44
Local variety	1355	1980	1.44	4815	0.24



Rice var. NDR-97 (right) and farmers local variety (left)

Among different alternate crops, blackgram (var.NDU-1) gave higher net returns (Rs.25696/ha) and B:C ratio (2.02) followed by sesame (var.T-3) (Rs.24540/ha) compared to farmers' practice of rice cultivation with local variety (Rs.3830/ha**)** (Table 149).

Table 149: Performance of alternate crops under delayed onset of monsoon

Crop	Variety	Crop duration (days)	Seed/grain yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Rice	NDR-97	94	1951	2.06	14718	0.72
Maize	Naveen	92	2265	2.39	20170	0.98
Blackgram	NDU-1	85	662	0.70	25696	2.02
Sesame	T-3	93	556	0.59	24540	1.99
Farmers' practice (Rice)	Local variety	115	1335	1.41	3830	0.19



Maize var. Naveen



Sesame var. T-3



Blackgram var. NDU 1

Situation: Terminal drought

During kharif 2019, during dryspell application of 2% Urea spray recorded higher rice grain yield (2235/ha), net returns (Rs.19830/ha), B:C ratio (0.97) and RWUE (2.36 kg/ha-mm) compared to farmers practice of no foliar spray (1945 kg/ha). Similarly, application of 2% urea during dryspell recorded higher maize yield (2415 kg/ha), net returns (Rs.22870/ha), B:C ratio (1.11) and RWUE (2.55 kg/ha-mm) compared to farmers practice of no foliar spray (2045 kg/ha) (Table 150).

Table 150: Effect of foliar spray on yield and economics of rice and maize crops

Crop	Farming situation/ Soil type	Intervention	Yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Rice	**Silty loam**	Foliar spray*(Urea 2%)	2235	14.91	2.36	19830	0.97
		Farmers' practice (no foliar spray)	1945	-	2.05	15110	0.75
Maize		Foliar spray*(Urea 2%)	2415	15.27	2.55	22870	1.11
		Farmers' practice (no foliar spray)	2045	-	2.21	17610	0.87

Preparedness

Rainwater management

Yield increased in all crops (maize and sorghum) with mulch than without mulching. In khrif mulching tested in Maize, and Sorghum. With the application of paddy straw mulch, yield increase 29.55% in maize, 20.57% in sorghum. Maximum grain yield 2455 kg/ha, percent increase 29.55% and water use efficiency 2.59 kg/mm/ha recorded with maize crop, while maximum net return Rs.2354 and B:C ratio 1.14 also recorded with maize.

In-situ moisture conservation practice with paddy straw mulching in maize and sorghum revealed that mulching in maize (var. Naveen) recorded the 29.55% higher grain yield (2455 kg/ha), net returns (Rs.23540/ha), B:C ratio (1.14) and RWUE (2.59 kg/ha-mm) compared to without mulching (1895 kg/ha). Similarly in sorghum, mulching recorded 20.57% higher grain yield (1670 kg/ha), net returns (Rs.19710/ha), B:C ratio (1.05) and RWUE (1.76 kg/ha-mm) compared to without mulching (1385 kg/ha) (Table 151).

Table 151: Effect of mulching on yield and economics of *kharif* crops

Normal crop	Intervention	Yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
Maize	Mulch	2455	29.55	2.59	20650	23540	1.14
	Without mulch	1895	-	2.00	18500	13715	0.74

Sorghum	Mulch	1670	20.57	1.76	18700	19710	1.05
	Without mulch	1385	-	1.46	16600	13870	0.83

In-situ moisture conservation practice bunding, increased the yield of upland and lowland rice by 28.5% and 22.6%, respectively when compared to without bunding. Bunding in upland rice recorded higher grain yield (2975 kg/ha), net returns (Rs.31325/ha), B:C ratio (1.41) and RWUE (3.14 kg/ha-mm) compared to without bunding (2315 kg/ha). Similarly in loland rice, bunding recorded higher grain yield (3525 kg/ha), net returns (Rs.41245/ha), B:C ratio (1.85) and RWUE (3.75 kg/ha-mm) compared to without bunding (2875 kg/ha) (Table 152).

Table 152: Effect of Bunding on the yield and economics of rice in upland and lowland condition crops

Normal crop	Intervention	Yield (kg/ha)	Stover yield	% increase in yield	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
Upland Rice	Bunding	2975	3050	28.50	3.14	22280	31325	1.41
	Without bunding	2315	2400		2.46	20280	21475	1.06
Lowland Rice	Bunding	3525	3600	22.60	3.75	22280	41245	1.85
	Without bunding	2875	2925		3.04	20280	30520	1.50

Cropping systems

Among drought tolerant rice varieties demonstrated, var. NDR-97 recorded higher seed yield (2455 kg/ha), net returns (Rs.23960/ha), B:C ratio (1.18) and RWUE (2.59 kg/ha-mm) followed by variety Baranideep (2305 kg/ha) compared to farmers' practice of local variety (1335 kg/ha) (Table 153).

Table 153: Performance of drought tolerant varieties of rice

Varieties	Seed yield (kg/ha)	Straw yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net Returns (Rs/ha)	B: C
NDR-97	2455	2505	2.59	20280	23960	1.18
Baranideep	2305	2375	2.44	20280	21280	1.04
Suskasamrat	2195	2210	2.32	20280	19245	0.94
Vandna	1815	1902	1.91	20280	12477	0.61
Farmer practices (local varieties)	1335	1645	1.41	20280	4060	0.20

Among intercropping systems demonstrated, maize + blackgram intercropping system recorded higher main crop equivalent yield (3285 kg/ha) and RWUE (3.47 kg/ha-mm) compared to other intercropping systems and farmers practice of sole rice. Whereas, sorghum + blackgram intercropping system recorded higher MAI (12516), net returns (Rs.40954/ha) and B:C ratio (2.08) (Table 154).

Table 154: Performance of inter cropping systems

Farming situation/ Soil type	Intervention	Yield (kg/ha)		MCEY	LER	MAI	Net return (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Main crop	Inter crop						
Silty Loam	Blackgram + Sesame (1:1)	562	225	819	1.11	4626	31083	1.99	0.86
	Sorghum+ Blackgram (1:2)	1845	352	2757	1.26	12516	40954	2.08	2.91

	Maize + Blackgram (1:1)	1987	387	3285	1.26	10168	28575	1.38	3.47
	Farmers' practice (sole rice)	1680	-	-	-	-	8280	0.41	1.77

LER: Land equivalent ratio; MCEY: Main crop equivalent yield; MAI: Monetary advantage index

1.3.4 REWA

a. Agro-ecological setting

Rewa centre is located in Keymore plateau and Satpura hill zone in Madhya Pradesh under Dry sub humid zone.

b. On-station experiments

Experienced weather conditions during 2019-20

During 2019, the onset of monsoon was normal (21st June). A rainfall of 1352.4 mm was received which was excess by 262.2 mm compared to normal rainfall of 1090.2 mm. The rainfall during *kharif* season was 1260.0 mm as against normal rainfall of 965.1 mm. During *rabi* season, the rainfall was 30.6 mm compared to normal rainfall of 50.1 mm (Fig. 39).

Normal onset of monsoon	23 June
Onset of monsoon during 2019	21 June
Normal annual rainfall	1090.2 mm
Annual rainfall during 2019-20	1352.4 mm
Normal crop seasonal and rainfall during *kharif* & *rabi*	965.1 & 50.1 mm, respectively
Crop seasonal rainfall during 2019-20 (*kharif* & *rabi)*	1260.0 & 30.6 mm, respectively

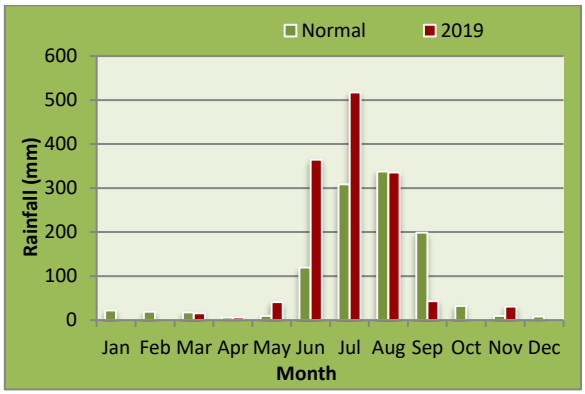


Fig. 39: Normal and actual (2019) monthly rainfall at Rewa

Dry spells during crop growing season (2019-20)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
9	12-20 July	Soybean, rice, blackgram, greengram, sesame	Germination

Real time contingency practices (RTCP) implemented: Nil

Salient achievements of on-station experiments

Real time contingency planning: Nil

Preparedness

Rainwater management

Foliar application of water soluble complex fertilizer (19:19:19) @ 0.5% + recommended dose of micronutrients ($ZnSO_4$ @ 100 ppm) during dry spell recorded significantly higher seed yield

(709 kg/ha), net returns (Rs. 9257/ha), B:C ratio (1.54) and RWUE (0.58 kg/ha-mm) followed by foliar spray of urea @ 2% (677 kg/ha) compared to control (507 kg/ha) (Table 155).

Table 155: Effect of foliar sprays on yield and economics of soybean

Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed (2019)	Mean seed (3 yrs)	Stalk				
Urea @ 1%	613	602	1566	16820	5922	1.35	0.50
Urea @ 2%	677	711	1848	16850	8266	1.49	0.55
Water soluble complex fertilizer (19:19:19) @ 0.5%	568	533	1385	17030	4047	1.24	0.47
Water soluble complex fertilizer (19:19:19) @ 0.5% + $ZnSO_4$ @ 100 ppm	709	671	1743	17050	9257	1.54	0.58
$ZnSO_4$ @ 100 ppm	598	499	1298	16800	5381	1.32	0.49
Water spray	527	446	1159	16585	2969	1.18	0.43
Control (no spray)	507	405	1054	16550	2263	1.14	0.42
CD at 5%	49	-	-	-	-	-	-

c. On-farm demonstrations

Village profile

The program is being implemented in the village Raura and Patuna, Block and Tehsil Raipur, Karchulian in district Rewa. The total cultivated area is 643.986 ha **(**477.785 ha + 166.201ha) out of which 250.997 ha (129.210 ha + 121.787 ha) is rainfed. The mean annual rainfall is 1080 mm with seasonal rainfall of 950 mm during *kharif* (June- September). The major soil types are silty loam and silty clay loam. The major rainfed crops are rice, soybean, pigeonpea and blackgram in *kharif* season and wheat, chickpea, lentil and linseed in *rabi* season. The number of small, marginal, medium and large farmers are 347 (310+ 37), 192 (110 + 82) and 137 (127 +10) in Raura and Patuna villages, respectively. The programme was extended to new village Khira, Block and Tehsil Raipur, Karchulian in district Rewa. The total cultivated area is 150.350 ha out of which 80.950 is rainfed. The number small, marginal, medium and large farmers are 25, 75 and 15 in Khira villages respectively.

Climate vulnerability in general

In general, the climate in this agro-climatic zone is sub-humid. The south-west monsoon contributes 85% and north-east monsoon 15% of the total annual average rainfall of 1080 mm. The historical rainfall data (30 years) indicated that the variability in rainfall during south-west monsoon was 15-35% deficit of the average rainfall. The onset (south-west) of monsoon was during 25 SMW (standard meteorological week) and north-east monsoon is 47 SMW. The dry spells were experienced during the crop season for the past 10/15 years during August and September at flowering and grain formation stages of the major rainfed crops. The onset of the monsoon is normal. The soil moisture status is deficit during flowering and grain development stages of major rainfed crops.

Experienced weather conditions during 2019-20

During 2019, the onset of monsoon was delayed by 14 days (7th July). An annual rainfall of 943.4 mm was received against normal rainfall of 1090.2 mm. The rainfall was deficit by 15.6% during *kharif* season compared to seasonal rainfall (965.1 mm). However, during *rabi*, 48.0 mm rainfall was received against normal of 50.1 mm (Fig. 40).

Normal onset of monsoon	23 June
Onset of monsoon during 2019	7 July
Annual mean rainfall	1090.2 mm
Annual rainfall during 2019-20	943.4 mm
Mean crop seasonal rainfall (*kharif* and *rabi)*	965.1 mm & 50.1 mm, respectively
Crop seasonal rainfall during 2019-20 *(kharif* and *rabi)*	852.2 mm & 48.0 mm, respectively

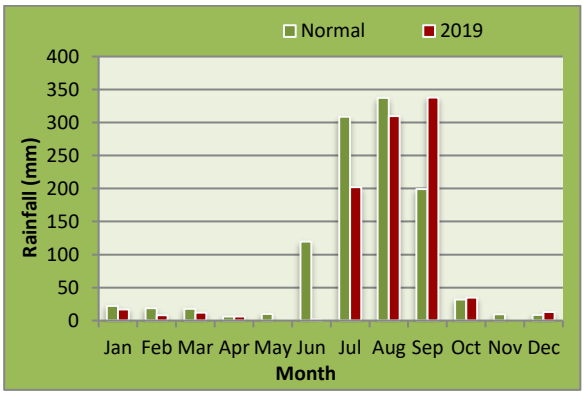


Fig. 40: Normal and actual (2019) monthly rainfall at Raura and Patauna

Dry spells during crop growing season (2019-20): Nil

Real time contingency practices (RTCP) implemented

Weather aberrations	Crop	RTCP implemented
Delayed onset of monsoon	Blackgram, pigeonpea, rice	Improved varieties

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Delayed onset of monsoon

The onset of monsoon was delayed by 14 days during 2019. Pigeonpea var. Asha recorded higher seed yield (855 kg/ha), net returns (Rs.36590/ ha), B:C ratio (2.81) and RWUE (0.93 kg/ha-mm) compared to local variety (687 kg/ha). In blackgram, variety LBG-20 gave higher seed yield (320 kg/ha), net returns (Rs. 3240/ha), B:C ratio (1.21) and RWUE (0.36 kg/ha-mm) followed by variety JU-30 (300 kg/ha) compared to local variety (200 kg/ha) (Table 156).

Table 156: Performance of improved varieties of pigeonpea and blackgram

Farming situation/soil type	Crop	Variety	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Medium land black soil	Blackgram	LBG-20	320	0.36	3240	1.21
		JU-3	300	0.34	2100	1.14
		Local	200	-	-2100	0.89
	Pigeonpea	Asha	855	0.93	36590	2.81
		Local	687	-	28346	2.46



Pigeonpea var. Asha



Local variety of pigeonpea

Rice var. DRT-42 recorded higher grain yield (2280 kg/ha), straw yield (3415 kg/ha), net returns (Rs.25382/ha), B:C ratio (2.59) and RWUE (2.58 kg/ha-mm) followed by varieties Danteshwari (2120 kg/ha) and Sahbhagi (2050 kg/ha) compared to var. IR-64 (1550 kg/ha) (Table 157).

Table 157: performance of improved varieties of rice

Farming situation	Variety	Yield (kg/ha)		Net returns (Rs/ha)	B:C ratio
		Grain	Stover		
Medium land black soils	Sahbhagi	2050	3075	21210	2.33
	Danteshwari	2120	3140	22478	2.41
	DRT-42	2280	3415	25382	2.59
	IR-64	1550	2525	12132	1.76

Preparedness

Cropping systems

Under medium land black soils, blackgram + pigeonpea (4:2) intercropping system gave higher main crop equivalent yield (580 kg/ha), net returns (Rs. 18760/ha), B:C ratio (2.31) and RWUE (0.66 kg/ha-mm) compared to farmers' practice of mixed cropping of blackgram + pigeonpea (412 kg/ha) (Table 158).

Table 158: Performance of blackgram + pigeonpea (4:2) intercropping system

Farming situation	Intercropping system	MCEY (kg/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Medium land black soils	Blackgram + pigeonpea (4:2)	580	14300	18760	2.31	0.66
	Mixed cropping of blackgram + pigeonpea (farmers' practice)	412	12500	10984	1.88	0.47

MCEY: Main crop equivalent yield

1.3.5 VARANASI

a. Agro-ecological setting

Varanasi centre is located in Northern Plain, Rohilkhand, Avadh and south Bihar Plains (AESR 9.2) and Eastern plateau and vindhyan zone in Uttar Pradesh. The climate is hot dry sub-humid. Annual normal potential evapo-transpiration is 577 mm. Annual normal rainfall is 1078 mm. Length of growing period is 150-180 days. Drought occurs once in six years.

b. On-station experiments

Experienced weather conditions during 2019-20

During 2019, the onset of monsoon was normal (21st June). A rainfall of 1130.2 mm was received which was excess by 4.5 mm (4.5%) compared to normal (1081.7 mm). During south-west monsoon (*kharif*), 1000.8 mm of rainfall was received which was excess by 56.3 mm compared to normal (944.5 mm), During *rabi*, 87.6 mm of rainfall was received against the normal rainfall of 60.9 mm (Fig. 41).

Normal onset of monsoon	22 June
Onset of monsoon during 2019	21 June
Annual mean rainfall	1081.7 mm
Annual mean rainfall during 2019-20	1130.2 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	944.5 mm and 60.9 mm, respectively
Crop seasonal rainfall during 2019-20 (*kharif* and *rabi*)	1000.8 mm and 87.6 mm, respectively

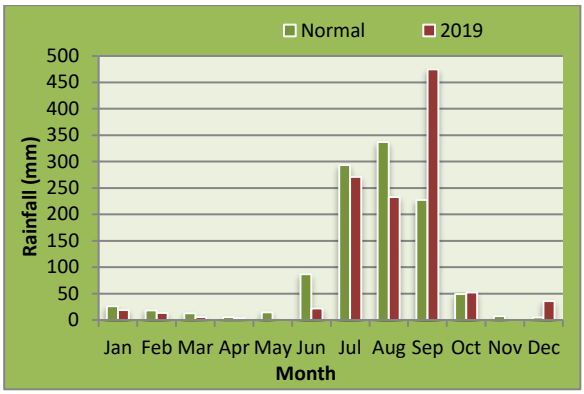


Fig. 41: Normal and actual (2019) monthly rainfall at Varanasi

Dry spells during crop growing season (2019-20)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates and months		
11	13-23 July	Rice	Germination
13	6-18 October	Rice and pigeonpea	Maturity stage

Real time contingency practices (RTCP) implemented: Nil

Real time contingency planning: Nil

c. On-farm interventions

Village profile

The program is being implemented in Tedha village, Mirzapur District, Uttar Pradesh. The total cultivated area is 290 ha out of which 210 ha is rainfed. The mean annual rainfall is 1191 mm with seasonal rainfall of 945 mm during *kharif* (June- September). The major soil types are sandy loam and loamy sand. The major rainfed crops during *kharif* are rice, maize, pearlmillet, greengram, pigeonpea, and wheat, chickpea, sesame, pea and linseed during *rabi*. The numbers of small, marginal, medium and large farmers are 0, 45, 85, and 120, respectively. The irrigated area is 15-25% of cultivated area. New village adopted is Patharaha (Hinauti), Mirzapur Dist., Uttar Pradesh.

Experienced weather conditions during 2019-20

During 2019, at Tedha village, the onset of monsoon was delayed by 12 days (2nd July). A rainfall of 1130.2 mm was received which was excess by 48.5 mm (4.9%) compared to normal (1081.7). During south-west monsoon (*kharif*), 1000.8 mm of rainfall was received which was excess by 56.3 mm compared to normal (944.5 mm). During *rabi*, 87.6 mm rainfall was received against the

normal of 60.9 mm.

Normal onset of monsoon	12 June (±5 days)
Onset of monsoon during 2019	2 July
Annual mean rainfall	1081.7 mm
Annual mean rainfall during 2019-20	1130.2 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	944.5 mm and 60.9 mm, respectively
Crop seasonal rainfall during 2019-20 *kharif* and *rabi*	1000.8 mm and 60.9 mm, respectively

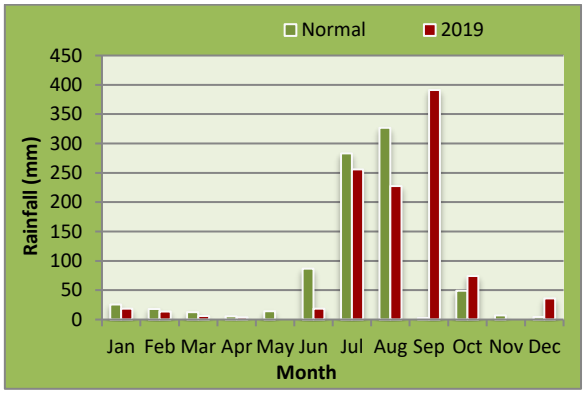


Fig. 42: Normal and actual (2019) monthly rainfall at Tedha

Dry spells during crop growing season (2019-20)

Dry spell		Crop	Stage of the crop
Duration (days)	**Dates & months**		
3 days	04-06 July	Rice	Not sown
9 days	13-21 July	Rice	Germination
7 days	12-18 October	Rice and maize	Rice at maturity Maize at harvesting
12 days	20-31 October	Rice	Maturity

Real Time Contingency practices (RTCP) implemented

Weather aberration	**Farming situation/ Soil type**	**RTCP implemented**			
		Crop	**RTCP implemented**	**No. of farmers fields covered**	**Area covered (ha)**
Delayed onset of monsoon	Shallow and medium Alluvial soils	Sowing of short duration crops and varieties	Crops/varieties: Rice: Shushank Samrat, HUR-3022, NDR97, Lentil: HUL-57, Pant L-406, Local cultivar Bottle guard	10	2
Early season drought	Shallow and medium Alluvial soils	Rice, Lentil	Life saving irrigation from harvested rainwater	8	2ha
Mid season drought	Shallow and medium Alluvial soils	Rice, Lentil	Life saving irrigation from harvested rainwater	42	10.3
Terminal drought	Shallow and medium Alluvial soils	Crops: Rice, lentil	Life saving irrigation from harvested rainwater	33	8.3

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Delayed onset of monsoon

The onset of monsoon was delayed by 13 days during 2019. Rice var. HUR-105 recorded higher grain yield (4256 kg/ha), net returns (Rs.48468/ ha), B:C ratio (2.7) and RWUE (5.64 kg/ha-mm) followed by NDR-97 (4015 kg/ha) compared to local variety BPT 2295 (3733 kg/ha) (Table 159).

Table 159: Performance of improved varieties of rice

Farming situation/ Soil type	Normal crop/ any change in crop	Normal variety /any change in variety (duration)	Yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Short duration variety of rice	HUR -105 (110 days)	4256	14.01%	5.64	48468	2.7:1
		NDR-97 (112 days)	4015	7.55%	5.32	44733	2.5:1
	Farmers' practice	BPT 2295 (135 days)	3733	-	-	-	-

1.4 Moist Sub-humid zone (1250-1500 mm)

1.4.1 JAGDALPUR

a. Agro-ecological setting

Jagdalpur centre is located in Garjat hills, Dandakarannya and Eastern ghats eco-sub-region (AESR 12.1) and Bastar plateau agro-climatic zone in Chhattisgarh. The climate is hot moist sub-humid. Annual normal rainfall is 1297 mm. The length of growing period is 180-210 days.

b. On-station experiments

Experienced weather conditions during 2019-20

During 2019, the onset of monsoon was delayed by 12 days (17 June). A total rainfall of 2313.0 mm was received which was excess by 908.6 mm compared to normal of 1404.4 mm. During south-west monsoon (*kharif*), there was 1924.7 mm rainfall which was excess by 803.2 mm (71.6%) as against normal rainfall of 1121.5 mm. During *rabi*, 244 mm of rainfall was received which was excess by 129.2 mm as that of normal (115.0 mm) (Fig. 43).

Normal onset of monsoon	5 June
Onset of monsoon during 2019	17 June
Annual mean rainfall	1404.4 mm
Annual rainfall during 2019-20	2313.0 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	1122.0 and 115.0 mm, respectively
Crop seasonal rainfall during 2019-20 *(kharif* and *rabi)*	1924.7 and 244 mm, respectively

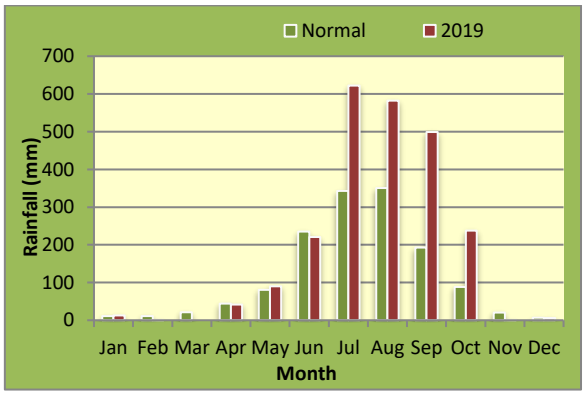


Fig. 43: Normal and actual (2019) monthly rainfall at Jagdalpur

Dry spells during crop growing season (2019-20)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
9	22 - 30 September	Rice, horsegram	Seed formation
30	1 - 30 November	Pigeonpea	Pod formation

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Mid season drought	Rice	Milking	Foliar spray

Salient achievements of on-station experiments

Real time contingency planning

Situation: Delayed onset of monsoon

During 2019, the onset of monsoon was delayed by 12 days. Among different cultivars of rice evaluated under delayed onset of monsoon, cv. Dagat deshi produced significantly higher grain yield (4342 kg/ha) with higher net returns (Rs 39519/ha), B:C ratio (2.60) and RWUE (4.41 kg/ha-mm)

under rainfed situation as compared to other drought tolerant varieties except D X D (124)-66 (4271 kg/ha) and D X D (124)-102 (4107 kg/ha) (Table 160).

Table 160: Performance of rice cultivars under delayed onset of monsoon

Treatment	Grain yield (kg/ha)		Straw yield (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2019-20	Mean (2 yrs)					
R.RF-75 (140-132)	2740	2710	5439	9590	15490	1.64	2.78
IR 88839-10-1.1.2	2853	2822	5552	9986	17177	1.71	2.89
IR 83929-BB-132.2	3626	3586	6958	12691	28782	2.17	3.68
D X D (124)-16	2979	2946	5421	10427	19069	1.78	3.02
D X D (124)-81	3971	3927	7882	13899	33946	2.38	4.03
D X D (124)-7	3115	3081	6235	10903	21114	1.86	3.16
D X D (124)-66	4271	4224	7845	14949	38445	2.56	4.33
D X D (124)-102	4107	4062	7958	14375	35991	2.46	4.16
Danteshwari	2812	2781	5582	9842	16563	1.69	2.85
Dagat deshi	4342	4294	7982	15197	39519	2.60	4.41
Sahbhagi dhaan	2764	2734	4851	9674	15848	1.66	2.80
OTL-1.1-71	2935	2903	5826	10273	18404	1.76	2.98
CD at 5%	232.00	231.00	135.00	821.00	3525.00	0.14	0.23

Situation: Mid season drought

During 2019, a dry spell of 9 days occurred during 22-30 September coinciding with the milking stage of rice. During the stress condition, foliar spray of water soluble fertilizer (19:19:19) @ 0.5% along with 0.5% $ZnSO_4$ recorded significantly higher grain and straw yield (2536 and 3485 kg/ha), net returns (Rs.17600/ha), B:C ratio (1.61) and RWUE (1.26 kg/ha-mm) compared to other treatments except foliar spray of water soluble fertilizer (19:19:19) @ 0.5% (2418 kg/ha) (Table 161).

Table 161: Effect of different foliar treatments on yield and economics of rice

Treatment	Yield (q/ha)			Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Mean grain (3 years)	Straw			
M_1S_1	2142	2066	3438	10650	1.37	1.06
M_1S_2	2188	2129	3490	12190	1.43	1.10
M_1S_3	2418	2339	3540	14310	1.50	1.17
M_1S_4	2536	2453	3485	17600	1.61	1.26
M_1S_5	1860	1760	3225	7140	1.25	0.97
M_1S_6	1884	1737	3164	8140	1.29	0.98
M_1S_7	1248	1114	2846	-3740	0.86	0.65
M_2S_1	1684	1642	2878	6050	1.21	0.93
M_2S_2	1742	1701	2938	6510	1.23	0.95
M_2S_3	1644	1662	3030	6790	1.24	0.96
M_2S_4	1812	1716	3142	6600	1.23	0.96
M_2S_5	1510	1395	2910	60	1.00	0.78
M_2S_6	1485	1372	2656	-600	0.98	0.74
M_2S_7	1380	1215	2782	-3440	0.88	0.66

M_1: Foliar spray during dry spell; M_2: Foliar spray after relieving dry spell; S_1: Urea @ 1%; S_2: Urea @ 2%; S_3:19:19:19 @ 0.5%; S_4:19:19:19 @ 0.5% + $ZnSO_4$ @ 0.5%; S_5: $ZnSO_4$ @ 0.5%; S_6: Water spray @ 500 l/ha; S_7: Control (no spray)

c. On-farm interventions

Village profile

The program is being implemented in Tahkapal, Tandpal, Jhartarae and Gumiyapal villages in Tokapal Tehsil, Bastar district, Chhattisgarh. The total cultivated area is 511.25 ha out of which 500 ha is rainfed. The mean annual rainfall is 1399 mm with seasonal rainfall of 1118.7 mm during *kharif* (June - September). The major soil types are shallow, medium to deep black mixed red and black soils. The major rainfed crops during *kharif* are rice, maize and minor millets, while during *rabi* are vegetables, chikpea, kulthi (horsegram) and niger. The number of marginal, small, medium and for the past 32 years (5 dry spells in September and 11 dry spells in October) and at panicle initiation and reproductive stages of rice. The soil moisture status is deficit during reproductive stages of major rainfed crops. The extreme events like unusual and high intensity rainfall in short span are increasing during July-August (30, 32 and 34 SMWs) and October (41 and 44 SMWs). The area has also been experiencing extreme events like hail storms, floods and cold waves (occasionally). There has been a considerable shift in the rainfall pattern and the quantum of rainfall during SW monsoon (6%) and North-east monsoon (32%) has increased during last 10 years and sowing window of the dominant rainfed crops is delayed from large farmers are 61, 269, 86 and 20, respectively. 24th to 25th SMW. The ground water table is 6 to 15 m depending upon topography and season. The source of irrigation is farm ponds and wells covering 2% of cultivated area.

Climate vulnerability in general

In general, the climate in this agro-climatic zone is moist sub-humid. The south-west monsoon contributes 80% of the total annual average rainfall of 1399 mm. The historical rainfall data (30 years) indicated that the variability in rainfall during south-west monsoon was 14% deficit of the average rainfall. The onset (south-west) of monsoon is during 24 SMW.

Experienced weather conditions during 2019-20

During 2019, in Tahkapal village, onset of monsoon was delayed by 12 days (17th June). A rainfall of 2203.0 mm was received during the year which was excess by 798.7 mm compared to normal rainfall of 1404.4 mm. During south-west monsoon (*kharif)*, there was 1833.2 mm rainfall which was excess by 711.8 mm (63.4%) as against normal rainfall of 1122 mm. During *rabi*, 232.4 mm of rainfall was received which was excess by 117.6 mm as that of normal (115.0 mm) (Fig. 44).

Normal onset of monsoon	5 June
Onset of monsoon during 2019	12 June
Annual mean rainfall	1404.4 mm
Annual rainfall during 2019-20	2203.0 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	1122.0 and 115.0 mm, respectively
Crop seasonal rainfall during 2019-20 *(kharif* and *rabi)*	1833.2 and 232.4 mm, respectively

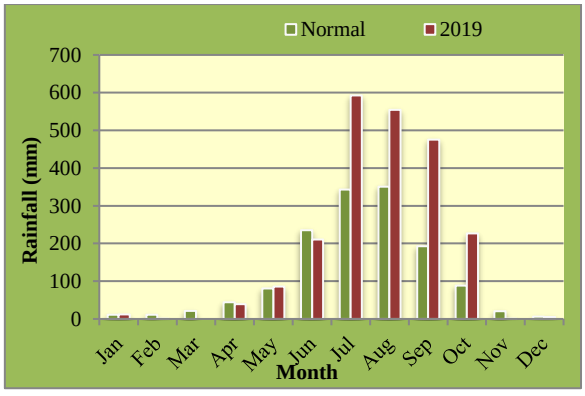


Fig. 44: Normal and actual (2019) monthly rainfall at Tahkapal village

Dry spells during crop growing season (2019-20)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
9	22 - 30 September	Rice, horsegram	Seed formation
30	1 - 30 November	Pigeonpea	Pod formation

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Delayed onset of monsoon	Rice	-	Drum seeding of rice, improved varieties
Mid season drought	Rice	Flowering	Scooping, supplemental irrigation
Terminal drought	Rice	Grain filling	Supplemental irrigation

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Delayed onset of monsoon

At Tahkapal village, the onset of monsoon was delayed by 7 days in 2019. Demonstrations on improved rice var. MTU-1010 gave 36.3% higher grain yield (4957 kg/ha) with higher net returns (Rs.45119/ha), B:C ratio (2.96) and RWUE (5.03 kg/ha-mm) compared to farmers' variety Safari (3155 kg/ha) (Table 162).

Table 162: Performance of rice tolerant varieties under rainfed condition

Farming situation	Variety	Grain yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Midland (Maal)	MTU 1010	4957	5.03	45119	2.96
	Safari	3155	3.20	18093	1.89



Crop stand of rice var. MTU 1010



Crop stand of rice var. Safari

Drum seeding of sprouted rice seeds gave higher grain yield (3183 kg/ha), net returns (Rs. 20321/ha), B:C ratio (2.15) and RWUE (5.13 kg/ha-mm) compared to farmers' method of broadcasting (2845 kg/ha) (Table 163).

Table 163: Performance of drum seeded rice under delayed onset of monsoon

Farming situation	Intervention	Grain yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Lowland	Drum seeding with sprouted seeds	3183.54	5.13	20321.84	2.15
	Broadcasting (farmers' practice)	2845.29	4.54	15679.36	1.82



Broadcasting of sprouted seeds



Drum seeding of sprouted seeds

Performance of rice under different sowing methods

Situation: Mid season drought

At Tahkapal village, a dry spell of 9 days occurred 22-30 September coinciding with flowering stage of rice. Supplemental irrigation of 2 cm from harvested rainwater gave 12.2% higher grain yield (1609 kg/ha), net returns (Rs.9118/ha), B:C ratio (2.30) and WUE (2.48 kg/ha-mm) compared to no lifesaving irrigation (1413 kg/ha) (Table 164).

Table 164: Effect of supplemental irrigation on yield and economics of rice

Farming situation/ soil type	Intervention	Grain yield (kg/ha)	WUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Upland	Supplemental irrigation	1609	2.48	9118	2.30
	Farmers' practice (no supplemental irrigation)	1413	2.24	6769	1.81

Situation: Terminal drought

At Tahkapal village, a dry spell of 30 days occurred during 1-30 November coinciding with grain filling stage of rice. Life saving irrigation of 2 cm from harvested rainwater gave highest grain yield (2145 kg/ha), net returns (Rs.7661/ha), B:C ratio (2.10) and WUE (3.09 kg/ha-mm) compared to control (1925 kg/ha) (Table 165).

Table 165: Effect of supplemental irrigation on yield and economics of rice

Farming situation/ soil type	Intervention	Grain yield (kg/ha)	WUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Midland	Supplemental irrigation	2145	3.09	7661	2.10
	Farmers' practice (no supplemental irrigation)	1925	2.77	6877	1.60

Preparedness

Rainwater management

At Tahkapal village, row placement of FYM along with seed sowing gave higher grain yield (4039 kg/ha), net returns (Rs.39162/ha), B:C ratio (3.05) and RWUE (3.59 kg/ha-mm) compared to farmers' practice of broadcasting of farmyard manure @ 1 t/ha (3502 kg/ha) (Table 166).

Table 166: Effect of row placement of FYM along with seed sowing on yield and economics of rice

Farming situation / soil type	Intervention	Yield (kg/ha)			Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Grain	Mean grain (4 years)	Straw			
Lowland	Row placement of FYM along with seed sowing	4039	3047	8685	39162	3.05	3.59
	Farmers' practice*	3502	1487	7530	36079	2.13	2.28

*Broadcasting of FYM @ 1 t/ha

Furrow opening at 1 m interval across the slope at tillering stage of rice gave 12.2% higher grain yield (1662 kg/ha) with higher net returns (Rs.9422/ha), B:C ratio (1.66) and RWUE (2.56 kg/ha-mm) compared to farmers' practice of no furrow opening (1460 kg/ha) (Table 167).

Table 167: Effect of *in-situ* moisture conservation on yield and economics of rice

Farming situation/ soil type	Intervention	Grain yield (kg/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Midland	Furrow opening at 1 m interval	1662	9422	1.66	2.56
	Farmers' practice (no furrow opening)	1460	6994	1.45	2.31

Nutrient management

At Tahkapal village, rice + dhaincha (3:1) intercropping gave higher grain yield of rice (2904 kg/ha), net returns (Rs.19625/ha), B:C ratio (2.64) and B:C ratio (4.41 kg/ha-mm) compared to farmers' practice of sole rice (2657 kg/ha) (Table 168).

Table 168: Yield and economics of rice + dhaincha (3:1) intercropping system

Farming situation/ soil type	Intervention	Grain yield (kg/ha)		Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		2019-20	Mean (2 yrs)			
Midland	Rice + dhaincha (3:1)	2904	2719	19625	2.64	4.41
	Farmers' practice (sole rice)	2657	2526	17316	2.20	3.14

1.4.2 PHULBANI

a. Agro-ecological setting

Phulbani is located in Eastern Plateau (Chotanagpur) and Eastern Ghats, Garjat Hills, Dandakarannya and Eastern Ghats (AESR 12.1), and Eastern ghat zone in Odisha. The climate is hot, moist sub-humid. Annual normal rainfall is 1407 mm. Annual normal potential evapotranspiration is 478 mm. Length of growing period is 180-210 days.

b. On-station experiments

Experienced weather conditions during 2019-20

During 2019, the onset of monsoon was delayed by 3 days (13 June). A rainfall of 1646.0 mm was received during the year which was excess by 239.0 mm than normal (1407.0 mm). Out of total rainfall, 1503.2 mm was received during *kharif* (June-September) and was excess by 351.8 mm (30.6%) than normal (1150.5 mm). In *rabi*, 26.3 mm rainfall was received which was 98.4 mm less than the normal (124.7 mm) (Fig. 45).

Normal onset of monsoon	10 June
Onset of monsoon during 2019	13 June
Annual mean rainfall	1407.0 mm
Annual rainfall during 2019-20	1646.0 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	1150.5 and 124.7 mm, respectively
Crop seasonal rainfall during *kharif* and *rabi* (2019-20)	1365.6 and 153.2 mm, respectively

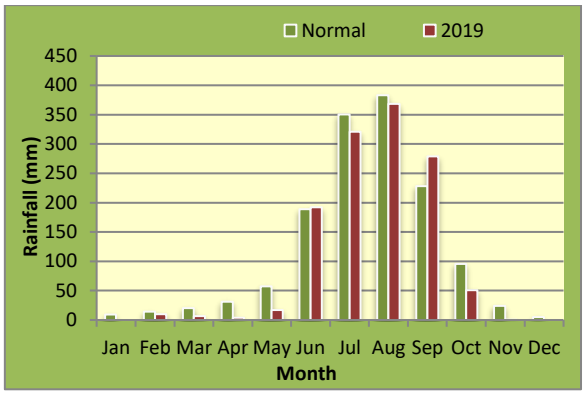


Fig. 45: Normal and actual (2019) monthly rainfall at Phulbani

Dry spells during crop growing season: Nil

Real time contingency practices (RTCP) implemented: Nil

c. On-farm demonstrations

Village profile

The program is being implemented in Budhadani village, Phulbani tehsil in Kandhamal district, Odisha. The total cultivated area is 101 ha, out of which 81.96 ha is rainfed. The mean annual rainfall is 1123 mm with seasonal rainfall of 1045 mm during *kharif* (June-September). The major soil types are red lateritic and brown forest soils. The major rainfed crops during *kharif* are rice, maize, turmeric, and greengram, blackgram and vegetables during *rabi*. The number of small, marginal, medium and large farmers is 29.26, 51.63 and 19.11%, respectively. The new village adopted during 2017-18 is Gunjidraga village, Phulbani block in Kandhamal district of Odisha.

Climate vulnerability in general

The climate is sub-humid. Out of the total annual average rainfall of 1407 mm, south-west monsoon contributes 80%, north-east monsoon contributes 10% and summer rainfall contributes 10%. The historical rainfall data (30 years) indicated that the variability in rainfall during south-west monsoon was 7.2% surplus of the average rainfall. The onset (south-west) of monsoon was during 24 SMW. For the past 15 years, the dry spells during crop season had been experienced during germination to reproductive stages in various rainfed crops. The onset of the monsoon is erratic. The extreme events like unusual and high intensity rainfall in short span are increasing during *kharif* and *rabi* seasons.

Experienced weather conditions during 2019-20

The rainfall data of Phulbani centre (being the nearest weather station) was used for on-farm rainfall analysis.

Dry spells during crop growing season (2019-20)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
14	10 - 23 October	Maize, pigeonpea	Grain filling & maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented
Terminal drought	Rice, pigeonpea	Life saving irrigation

Salient achievements of on-farm demonstrations

Real time contingency crop planning

Situation: Terminal drought

During 2019, a dry spell of 14 days occurred during 10-23 October coinciding with grain filling and maturity stage in maize and pigeonpea. Supplemental irrigation from nearby water stream given in maize gave 18.6% higher grain yield (2520 kg/ha) with higher net returns (Rs.16840/ha), B:C ratio (1.65) and WUE (1.68 kg/ha-mm) as compared to without supplemental irrigation (2125). Similarly, supplemental irrigation in pigeonpea gave 20% higher seed yield as compared to no supplemental irrigation (855 kg/ha), with higher net returns of Rs. 30168/ha and B:C ratio of 2.08 (Table 169).

Table 169: Performance of maize and pigeonpea with supplemental irrigation

Crop/ variety	Intervention	Yield (kg/ha)	WUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Maize (OMH 14-27)	Supplemental irrigation	2520	1.68	16840	1.65
	Farmers' practice (no supplemental irrigation)	2125	1.41	12125	1.51
Pigeonpea (NTL-724)	Supplemental irrigation	1025	0.68	30168	2.08
	Farmers' practice (no supplemental irrigation)	855	0.57	22521	1.87

Preparedness

Rainwater management

In-situ moisture conservation through deep summer ploughing and increase in bund height in rice gave 22.7% higher grain yield (2485 kg/ha), net returns (Rs.13600/ha), B:C ratio (1.42) and RWUE (1.65 kg/ha-mm) as compared to farmers' practice of no *in-situ* moisture conservation (2025 kg/ha). Similarly, maize recorded 18.6% higher grain yield with *in-situ* moisture conservation compared to farmers' practice (2125 kg/ha) (Table 170).

Table 170: Performance of crops under *in-situ* moisture conservation

Crop/ variety	Intervention	Yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Rice (Sahabhagi)	*In-situ* moisture conservation*	2485	22.7	1.65	13600	1.42
	Farmers' practice	2025	-	1.27	7159	1.24
Maize	*In-situ* moisture	2520	18.59	1.68	16840	1.65

(OMH 14-27)	conservation*					
	Farmers' practice	2125	-	1.41	12125	1.51

*Deep summer ploughing and raising of bund height



Field bunding



Rice (Var. Sahabhagi) with field bunding

Cropping systems

During 2019. Rice var. Sahbhagi gave 36,6% higher grain yield (2485 kg/ha) with higher net returns (Rs. 13600/ha) and B:C ratio (1.42) compared to local var. Punia (1815 kg/ha). Similarly, maize hyb. OMH 14-27 recorded 34% higher grain yield with higher net returns (Rs. 16840/ha) compared to local var. Kuji Makka (1880 kg/ha). Pigeonpea var. NTL-724 gave 33.1% higher seed yield (1025 kg/ha) with higher net returns (Rs. 30168/ha) compared to local var. Kandula (Table 171).

Table 171: performance of improved varieties of rice, maize and pigeonpea

Crop	Variety (duration)	Yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
Rice	Sahabhagi (105 days)	2485	1.65	32000	13600	1.42
	Punia (110 days)	1815	1.21	28000	5305	1.19
Maize	Hyb OMH 14-27 (100 days)	2520	1.68	26000	16840	1.65
	Kuji Makka (90 days)	1880	1.25	22000	9960	1.45
Pigeonpea	NTL-724 (160 days)	1025	0.68	28000	30168	2.08
	Kandula (220 days)	770	0.51	24000	14500	1.60



Rice var. Sahabhagi



Maize hyb. OMH 14-27

Among maize based intercropping systems, maize + cowpea (2:2) system gave higher maize equivalent yield (4295 kg/ha), net returns (Rs.43015/ha), B:C ratio (2.43) and RWUE (2.86 kg/ha-mm) followed by maize + pigeonpea (2:2) intercropping system (3679 kg/ha) while sole maize recorded lowest yield (2380 kg/ha). Similarly, pigeonpea + radish (2:2) intercropping system also

gave higher pigeonpea equivalent yield (1648 kg/ha), net returns (Rs. 53524/ha), B:C ratio (2.33) and RWUE (1.09 kg/ha-mm) as compared to sole pigeonpea (875 kg/ha) (Table 172).

Table 172: performance of maize and pigeonpea based intercropping systems

Cropping system	Yield (kg/ha)			RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Main crop	Inter crop	MEY/ PEY			
Maize (SA 701) + cowpea (Gomti) (2:2)	2030	1540 (green pods)	4295	2.86	43015	2.43
Maize (SA 701)) + pigeonpea (NTL 724) (2:2)	2110	470	3679	2.45	32543	2.08
Sole maize (Farmer's practice)	2380	-	2380	1.45	16460	1.69
Pigeonpea (NTL 724) + radish (Pusa Chetki) (2:2)	630	7220	1648	1.09	53524	2.33
Sole pigeonpea	875	-	875	0.58	29656	1.77



Maize + cowpea (2:2) intercropping system



Pigeonpea + radish (2:2) intercropping system

Demonstrations on maize-horsegram double cropping system gave higher maize equivalent yield (3750 kg/ha), net returns (Rs. 24200/ha) and B:C ratio (1.78) compared to farmers' practice of rice crop alone (2800 kg/ha) (Table 173).

Table 173: performance of maize-horsegram double cropping system

Intervention	MCEY (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Maize-horsegram	3750	31000	24200	1,78	2.5
Rice (farmers' practice)	2800	24000	17250	1.72	1.87

Alternate land use system

Mango + turmeric system gave higher mango equivalent yield (11000/ha), net returns (Rs. 160000/ha), B:C ratio (3.67) and RWUE (7.33 kg/ha-mm) compared to farmers' practice of sole mango (2000 kg/ha) (Table 174).

Table 174: performance of mango + turmeric system

Intervention	MCEY (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Mango + turmeric	11000	60000	160000	3.67	7.33
Mango (farmers' practice)	2000	5000	35000	8.0	1.33

1.5. Per-humid Zone

1.5.1 BISWANATH CHARIALI

a. Agro-ecological setting

Biswanath Chariali centre is located in middle Brahmaputra plain eco-sub region (AESR 15.2). The climate is hot humid. Annual normal rainfall is 1865 mm. The length of growing period is 240 to 270 days. Seasonal drought and flooding is common which demands special selection for normal crop husbandry.

b. On-station experiments

Experienced weather conditions during 2019-20

During the year 2019, the onset of monsoon was normal (1st week of June). An annual rainfall of 1756.9mm was received which was deficit by 107.9 mm compared to normal (1864.8 mm). During south-west monsoon (*kharif*), a rainfall of 1003.7 mm was received against a normal rainfall of 1182.2 mm. The rainfall during *rabi* was 96.4 mm which was deficit by 23.6 mm compared to normal rainfall of 120.0 mm (Fig. 46).

Normal onset of monsoon	1st week of June
Onset of monsoon during 2019	1st week of June
Annual mean rainfall	1864.8 mm
Annual rainfall during 2019-20	1756.9 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	1182 and 120 mm, respectively
Crop seasonal rainfall during 2019-20 *(kharif* and *rabi)*	1003.7 and 96.4 mm respectively

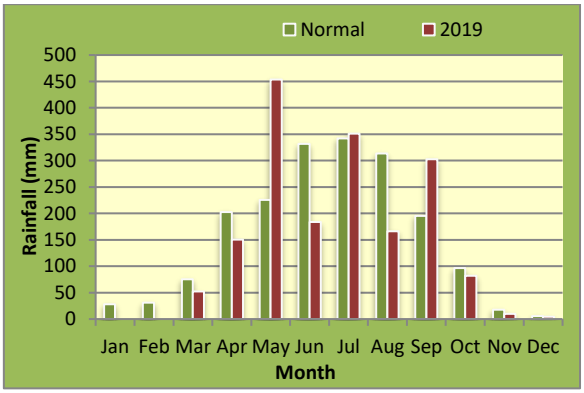


Fig. 46: Normal and actual (2019) monthly rainfall at Biswanath Chariali

Dry spells during crop growing season (2019-20)

Dry spell		Crop	Stage of the crop
Duration (days)	**Dates & months**		
10	18 - 27 August	Maize, greengram	Vegetative
19	12 - 30 November	Toria	Vegetative
23	01 - 24 December	Toria	Vegetative and flowering
24	07 - 30 January, 2020	Toria	Siliqua formation to maturity

Real time contingency practices (RTCP) implemented

Weather abbreviation	Crop	Stage of crop	RTCP implemented
Mid season drought	Maize, toria	Vegetative, flowering	Foliar spray

Salient achievements of on-station experiments

Real time contingency planning

Situation: Mid season drought

Time of foliar spray i.e. during dry spell and after relieving of dry spell had no significant effect on yields of maize and toria. Among sources of nutrients, foliar spray of water soluble complex fertilizer (19:19:19) @ 0.5% + ZnSO4 @ 0.5% + borax @ 0.5% recorded significantly higher yield of maize (3840 kg/ha), toria (1120 kg/ha), system productivity (7040 kg/ha), net returns (Rs. 68520/ha) and B:C ratio (1.51) compared to other treatments (Table 175).

Table 175: Yield and economics of maize - toria system as influenced by foliar sprays

Treatment	Grain/seed yield (kg/ha)		Stalk yield (kg/ha)		System yield (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Maize	Toria	Maize	Toria					
M_1	3350	971	5430	2417	6125	49130	51869	1.06	7.26
M_2	3450	958	5520	2385	6188	48091	54459	1.13	7.33
CD at 5%	NS	NS	NS	NS	148	-	-	-	-
S_1	3470	1001	5660	2437	6332	43895	60564	1.38	7.50
S_2	3580	1080	5760	2411	6665	44725	64850	1.45	7.90
S_3	3320	941	5400	2374	6010	44835	54524	1.22	7.12
S_4	3840	1120	5840	2496	7040	45480	68520	1.51	8.34
S_5	3510	1000	5740	2400	6369	44855	60373	1.35	7.55
S_6	3160	815	5070	2348	5490	43330	48423	1.12	6.50
S_7	3060	765	4870	2342	5245	43395	44645	1.03	6.21
CD at 5%	100	30	500	30	541	-	-	-	-

M_1: Foliar spray during dry spell; M_2: Foliar spray after relieving of dry spell; S_1: Urea @ 1%; S_2: Urea @ 2%; S_3: Water soluble complex fertilizer (19:19:19) @ 0.5%; S_4: Water soluble complex fertilizer (19:19:19) @ 0.5% + $ZnSO_4$ @ 0.5% + borax @ 0.5%; S_5: $ZnSO_4$ @ 0.5% + borax @ 0.5%; S_6: Water spray; S_7: Control (no spray)



Toria under foliar spray (S_4)



Toria under control (no spray)

c. On-farm Demonstrations

Village profile

The NICRA project is being implemented in two villages of Lakhimpur district which is situated in the North bank plain zone of Assam. Apparent drought is the major weather aberration in Chamua (cluster of four villages); on the other hand, Ganakdoloni village is affected by 3-5 flash floods of 7 to 15 days duration in almost every year.

Chamua village

The NICRA programme is being implemented in Chamua village which is situated in the Narayanpur block of Lakhimpur district, Assam. The total cultivated area of the village is 133 ha which is entirely rainfed. The mean annual rainfall is 1987 mm with seasonal rainfall of 1375.3 mm during *kharif* (June-September). The major soil types are Inceptisols (sandy loam to silty clay loamy with pH ranging from 4.65 to 6.38). The soil organic matter content of the village varies from 0.34 to 3.03%. Status of available nitrogen (275 – 540 kg/ha) and potassium (138 to 330 kg/ha) is medium; however available phosphorus (21.4 – 54.0 kg/ha) content is low to medium. High soil acidity, high phosphate fixation, micronutrients deficiency, iron toxicity, periodic soil moisture stress during winter seasons etc are some of the soil related problems of this village. Earlier, mono-cropping was practiced by the farmers and 90% of total cultivable land (118 ha) was occupied by only *Sali* rice. Presently, farmers are encouraged to take up various crops like rapeseed, potato, tomato, blackgram, greengram, turmeric, ginger, maize etc. Only 14.5% of the farmers are medium farmers and rest are either small or marginal farmers. Though depth of ground water table of the village is only 6 m, ground water is contaminated with both Arsenic (10 ppb) and iron (14.2 ppm) and not suitable for use. The weather related problems in the village are dry spells during growing season of *Sali* rice, scanty and less rainfall during *rabi* season and occurrence of occasional flash floods in a portion of the village. There is ample scope for rainwater harvesting due to presence of many natural farm ponds, and also for crop diversification due to availability of different land situations in the village.

Climate vulnerability in general

In general, the climate in this agro-climatic zone is humid. The south-west monsoon contributes 64.5%, north-east monsoon 7.7%, summer 24.8% and winter 3.1% of the total annual average rainfall of 1987 mm. The historical rainfall data (of 30 years) indicated that the variability in rainfall during south-west monsoon is 30-40% deficit of the average rainfall. The onset (south-west) of monsoon is during 23 SMW (standard meteorological week). Early season drought or normal onset of monsoon followed by 15 to 20 days dry spell and mid-season drought are recurrent. The dry spells or flood during crop season are being experienced for the past 15 years in July, August, September and October at tillering, panicle initiation and reproductive growth stages of *sali* rice. The onset of the monsoon is normal. The maximum/minimum temperature during crop season is increasing (maximum temperature by 0.0060C/year and minimum by 0.01940C/year since the past 50 years. The extreme events like unusual and high intensity rainfall in short span are increasing during *kharif* (June, July, August, September and October) and *rabi* seasons. The area is also experiencing other extreme events like flood and hail storm.

Experienced weather conditions during 20119-20

During 2019, in Chamua Narayanpur village, the onset of monsoon was delayed by 10 days (14 June). A rainfall of 2975.3 mm was received during the year which was excess by 996.7 mm compared to normal (1978.6 mm). During south-west monsoon (*kharif*), a rainfall of 1887.5 mm was received against a normal rainfall of 1280.1 mm. The rainfall during *rabi* was 255.0 mm which was excess by 93.9 mm compared to normal rainfall of 161.1 mm (Fig. 47).

Normal onset of monsoon	1st week of June
Onset of monsoon during 2019	14 June
Normal annual rainfall	1978.6 mm
Annual rainfall during 2019-20	2975.3 mm
Normal crop seasonal rainfall during *kharif* and *rabi*	1280.1 mm and 161.0 mm, respectively
Crop seasonal rainfall during 2019-20 (*kharif* and *rabi*)	1887.5 mm and 366.0 mm respectively

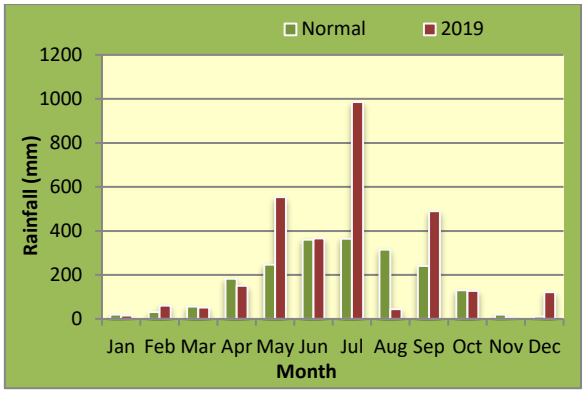


Fig. 47: Normal and actual (2019) monthly rainfall at Chamua village

Dry spells during crop growing season (2019-20)

Dry spell		Crop	Stage of the crop
Duration (days)	**Dates & months**		
17	29 July - 14 August	*Sali* rice	Transplanting, tillering
18	27 October - 13 November	*Sali* rice	Grain filling to maturity
11	20 - 30 November	Potato, toria	Seedling
29	12 December - 09 January, 2020	Potato, toria	Flowering

Real time contingency practices (RTCP) implemented

Chamua village			
Weather aberration	**Farming situation/ Soil type**	**Crop**	**RTCP implemented**
Delayed onset of monsoon	Upland	Rice	Sowing of rice in nursery using harvested rainwater
Early season drought	Upland	Rice	Supplemental irrigation with harvested rainwater
Mid-season drought	Upland	Rice, potato	Supplemental irrigation with harvested rainwater
Terminal drought	Medium/lowland	Rice	Supplemental irrigation with harvested rainwater

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Delayed onset of monsoon

During 2019, the onset monsoon was delayed by 10 days (14th June). Among high yielding rice varieties, Dishang (short duration) in upland and TTB-404 (medium duration) in medium land situation gave 63.5 and 66.2% higher grain yield (4940 and 5020 kg/ha), respectively over local var. Mahsuri (3020 kg/ha), with higher net returns and B:C ratio (Table 176).

Table 176: Performance of improved rice varieties as compared to local cultivars

Farming situation/ soil type	Variety (duration)	Grain yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Upland	Dishang (100-110 days)	4940	2.71	35340	1.82

Medium land	TTB-404 (135-140 days)	5020	2.75	36220	1.90
	Mashuri (130-135 days)	3020	1.38	18740	1.07





Performance of short (Dishang) and medium duration (TTB-404) rice varieties

Situation: Early season drought

A dry spell of 17 days from 29 July to 14 August affected early tillering stage of upland rice. One supplemental irrigation of 5 cm depth with the water lifting pump from farm pond gave 19.8% higher grain yield (4240 kg/ha) with higher net returns (Rs. 35340/ha) as compared to no irrigation (3540 kg/ha) (Table 177).

Table 177: Effect of supplemental irrigation on yield and economics of upland rice

Farming situation/ soil type	Intervention	Grain yield (kg/ha)	WUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Upland	Supplemental irrigation	4240	2.71	35340	1.82
	Farmers' practice (no supplemental irrigation)	3540	1.49	27480	1.83

Situation: Mid season drought

Potato experienced two dry spells of 11 days (20-30 November), 29 days (12 December-9 January). Two supplemental irrigations of 2 cm depth each with the water lifting pump from farm pond increased the tuber yield by 72.7% (23433 kg/ha) with higher net returns (Rs. 171830/ha) and B:C ratio (2.70) over no supplemental irrigation (13568 kg/ha) (Table 178).

Table 178: Effect of supplemental irrigation on yield and economics of potato

Farming situation/ soil type	Intervention	Tuber yield (kg/ha)	WUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Upland	Supplemental irrigation	4520	3.11	27700	1.58
	Farmers' practice (no supplemental irrigation)	3015	2.07	15150	1.01



Potato with supplemental irrigation



Potato with no supplemental irrigation

Situation: Terminal drought

A dry spell of 18 days occurred from 27 October to 18 November coinciding with grain filling and maturity stage of rice. One supplemental irrigation (2 cm) from harvested water in farm pond gave 14.8% higher grain yield (5540 kg/ha) with higher net returns (Rs. 35400/ha) and B:C ratio (1.77) compared to farmers' practice of no supplemental irrigation (4826 kg/ha) (Table 179).

Table 179: Effect of supplemental irrigation on yield and economics of upland rice

Farming situation/ soil type	Intervention	Grain yield (kg/ha)	WUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Medium/ lowland	Supplemental irrigation	5540	3.04	35400	1.77
	Farmers' practice (no supplemental irrigation)	4826	2.65	29560	1.58

Preparedness

Rainwater management

Organic mulching with rice straw/stalk of rapeseed in turmeric gave 25.1% increase in yield of turmeric (34350 kg/ha) with higher net returns (Rs.270000/ha) and B:C ratio (3.60) as compared to no mulching (27452 kg/ha) (Table 180).

Table 180: Effect of organic mulching for *in-situ* moisture conservation on yield and economics of turmeric

Farming situation/ soil type	Intervention	Yield (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Upland	Organic mulching	34350	70500	270000	3.60	17.54
	Farmers' practice (no mulching)	27452	68000	206520	3.03	14.02



Turmeric with (left) and without mulching (right)

Cropping systems

Double cropping of rice-potato gave higher net returns (Rs. 90940/ha) and B:C ratio (4.96) followed by rice-toria system (Rs 63380/ha) as compared to farmers' practice of growing only rice (Rs. 16420/ha) under uplands (Table 181).

Table 181: Yield and economics of different double cropping systems

Farming situation/ Soil type	Intervention	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
		Rice	Potato/ toria			
Upland	Rice-toria	5014	1065	29000	63380	2.10
	Rice-potato	4042	9852	48000	90940	4.96
	Farmers' practice (sole rice)	3583	-	15000	16420	1.60

At Chamua village, 7 low-cost polyhouses were established for demonstrating cultivation of high value off-season/ seasonal vegetables and raising nursery for vegetable seedlings in advance for cultivation during *rabi* season. Further, roof water harvesting structure was created along with drip irrigation system for providing irrigation in polyhouse. The farmers could realize net returns of Rs 46710/ha with cultivation of different vegetables in the polyhouse.





Cultivation of vegetables under low-cost polyhouse

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

Organic agriculture is one of the fastest growing sectors of agricultural production, and is reported to have both climate change adaptation and mitigation potential particularly in rainfed agriculture. A field experiment was conducted during *kharif* 2018 at Gunegal Research Farm (GRF) of ICAR-CRIDA to evaluate the performance of sunflower, greengram and pigeonpea under organic, inorganic and integrated crop management systems. The experiment was laid out in a strip-plot design with three production systems and three crops. In the plots under organic management, farmyard manure was applied on the N equivalent basis to all the three crops and the P requirement was supplemented through rock phosphate. In the plots under integrated management, 25% of equivalent recommended N was applied through farmyard manure. The remaining 75% N and 100% P and K was applied through chemical fertilizers. The plots under inorganic management received recommended dose of chemical fertilizers (20:50 kg N & P_2O_5/ha for pigeonpea and greengram; 60:60:30 kg N, P_2O_5 & K_20/ha for sunflower).

In general, the seed yield of pigeonpea was less across different treatments due to terminal drought (no rainfall after 25th October). The seed yield of sunflower was 17.8 and 18.9% higher in the plots under integrated management (1138 kg/ha) than that under inorganic and organic management, respectively. However, plots under organic management gave marginally higher seed yield of greengram (791 kg/ha) compared to integrated (765 kg/ha) and inorganic management (744 kg/ha). Similarly, pigeonpea seed yield was similar in the plots under three production systems (400-443 kg/ha) (Fig).

During the last 8 years, pigeonpea recorded significantly higher pigeonpea equivalent yield (PEY) in 2013 (1898 kg/ha) whereas, sunflower produced higher PEY in 2014 (641 kg/ha), 2016 (721 kg/ha), 2017 (969 kg/ha) and 2018 (948 kg/ha) and greengram in 2015 (573 kg/ha). Among the production systems, crops under integrated management produced significantly higher PEY in 2012 (1553 kg/ha) but was at par with organic production system during next 7 years. On average, integrated management being on par with organic management recorded significantly higher PEY (873 kg/ha) compared to inorganic management (825 kg/ha).



Pigeonpea under organic management

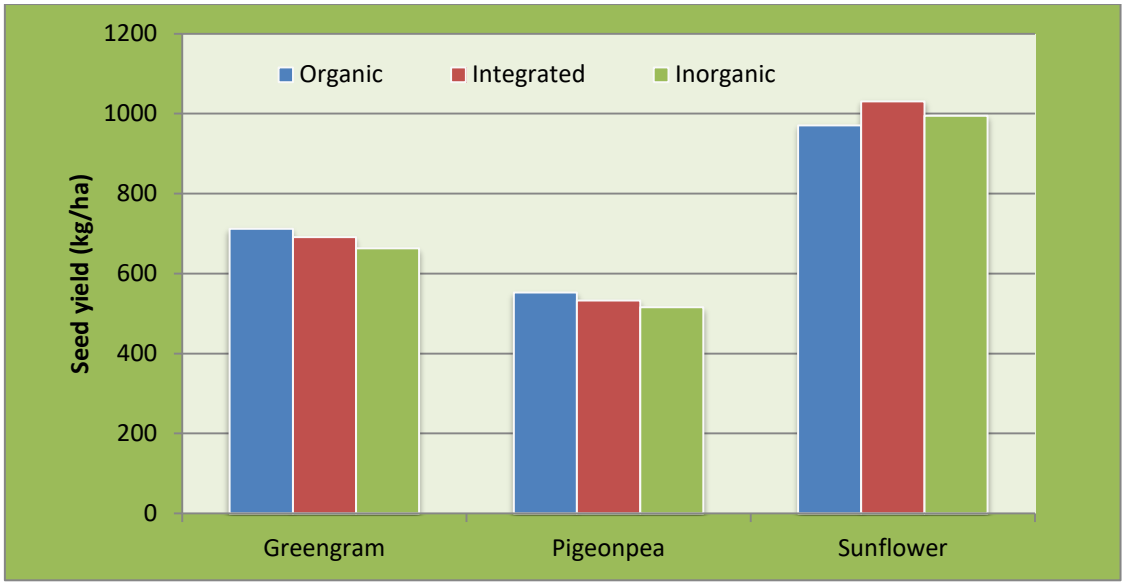


Fig . Performance of crops under different production systems

Different production systems had no significant on soil pH and available Mn. However, plots under organic management recorded significantly higher soil organic C (0.66%), compared to inorganic and integrated production systems. Plots under organic management being on par with integrated production system also recorded significantly higher available K (242.3 kg/ha), Cu (2.01 ppm), Fe (13.4 ppm) and Zn (0.69 ppm) compared to inorganic production system. However, integrated production system recorded significantly higher available P (26.9 kg/ha) compared to other production systems. The plots under organic management had higher dehydrogenase activity (5.69 µg TPF/g soil/h) and microbial biomass carbon (302 µg/g soil) compared to other production systems. The incidence of insect-pests on greengram and sunflower was below economic threshold level. The incidence of pod borer complex on pigeonpea was less in organic production system (33%) compared to inorganic (42%) and integrated production system (57%).

In general, the cost of cultivation under organic management was higher by Rs. 2610/ha in pigeonpea & greengram and by Rs. 9790/ha in sunflower compared to that under integrated production system. Therefore, a price premium of at least 5% for organic greengram, 10% for organic pigeonpea and 40% for organic sunflower may be required to offset the higher cost of cultivation and low yields under organic production system compared with integrated production system.

3.1 Village Institutions

3.1.1 Village Climate Risk Management Committee (VCRMC)

VCRMCs established in each NICRA village are actively involved in various activities of the project. During 2019-20 in NICRA villages, the VCRMCs participated in identification of beneficiaries, and implementation of various climate risk resilient interventions such as contingency crop planning, soil and crop based interventions and efficient functioning of custom hiring centers etc.

NICRA village	VCRMC meeting	Decision taken/outcome of meeting
Warkhed and Kajleshwar villages, Akola district, Maharashtra (Akola)	19.07.2019 20.07.2019	Suggested farmers to implement opening of furrows by tying a rope to hoe in soybean and cotton crop for in-situ moisture conservation
Vannedoddipally and Bachepalli villages, Anantapur district, Andhra Pradesh (Ananthapuramu)	19.06.2019	Sowing of contingent crops during delayed onset of monsoon, soil testing and soil test based fertilizer application
	24.06.2019	
	19.07.2019	
Naiwan, Achalpur and Bhawanipur villages, Hoshiarpur district, Punjab (Ballowal Saunkhri)	25.06.2019	Preparations for the forthcoming kharif season were discussed with the committee members
	18.10.2019	Discussed effect of deficit rain in September on crops and performance of contingency measures taken
	11.06.2019	Effective use of implements from the custom hiring centre
	27.06.2019	Plant protection measures in maize, field bean and cowpea
	07.07.2019	Weeding and intercultivation in fingermillet and groundnut
	15.07.2019	Opening of ridges and furrow between pigeonpea rows in pulse based cropping system
	22.08.2019	Weeding and intercultivation in fingermillet
	30.08.2019	Opening of moisture conservation furrow between paired of pigeonpea
	30.10.2019	Advised farmers to take up plant protection measures in pigeonpea
Chamua, Borkhet, Kachikata, Borbali and Nagaya villages, Lakhimpur district, Assam (Biswanath Chariali)	16.03.2019	Discussed about the interventions and beneficiaries for ensuing kharif season
	28.04.2019	Discussed about repairing of implements available at CHC and construction of low cost vermicompost unit
	04.06.2019	Discussed about women empowerment and formation of women self-help group, initiating mushroom cultivation
	10.01.2020	Discussed about ensuring supply of improved HYVs of rice and potato, replacement of existing thresher with modern threshing machine as per requirement of the farmers
Hardoiya and Pero Saraiya villages, Faizabad district, Uttar Pradesh (Faizabad)	17.07.2019	Discussed about planting of fruit plants like aonla, beal, guava, ber and suggested to farmers regarding green fodder
	27.08.2019	Control of termite in paddy crop and weed control in pulses using herbicides

	10.01.2020	Insect and disease management in mustard
	21.01.2020	Foliar spray of nutrients in rabi crops
Nignoti, Bisakhedi Village, Indore district,Madhyapradesh (Indore)	2.5.2019	Site selection for water harvest tank
	22.5.2019	Kharif planning
	9.12.2019	Efficient utilization of harvested water
	18.08.2019	Tillage operation of midland and lowlands
	12.09.2019	Dry spell management during kharif crops
	02.11.2019	Seed bank collection meeting
Gumiyapal and Tandapal villages, Bastar district, Chhattishgarh (Jagdalpur)	18.08.2019	Tillage operation of midland and lowlands
	12.09.2019	Dry spell management during kharif crop
Kadesara Kala and Hanauta, Lalitpur district, Uttar Pradesh (Jhansi)	30.06.2019	Arrange visit of farmers to MPKV, Rahuri to learn production systems of high value fruit crops
Toppureddiapatti, Muthukrishnapuram, Dharmathanpatti village, Thoothukkudi district, Tamil Nadu (Kovilpatti)	21.08.2019	To practice contingent crop management technologies under aberrant weather situations
	07.11.2019	To recommend suitable pest management technology for control of Fall army worm pest
Babhulgaon, Ujalamba villages, Parbhani district, Maharashtra (Parbhani)	26.06.2019	Timely sowing should be followed. Early and drought tolerant varieties given by the university should be sown
	25.07.2019	Dust mulching (hoeing) and first weeding operation should be carried out Opening of furrow should be undertaken after every 4 rows in soybean and 2 rows in pigeonpea and cotton (30 days after sowing)
	16.08.2019	Protective irrigation may be given if dryspell continues for more than 15 days
	10.10.2019	Soybean should be harvested for early sown crop
Budhadani and Gunjidraga villages, Kandhamal district, Odisha (Phulbani)	18.06.2019	Selection of beneficiaries and demonstrations to be taken up under NICRA programme
	12.07.2019	Discussion regarding interventions to be taken up during drought situatios
Khaner village (old village), Samba district, Jammu & Kashmir (RakhDhiansasr)	14.06.2019	Discussed about sowing of kharif crops in khaner village
Madana village (new village) Samba district, Jammu & Kashmir (RakhDhiansasr)	14.06.2019	Discussed about sowing of kharif crops in the newly adopted NICRA village
(Kalimati, Dholiya villages, Banaskantha district, Gujarat (S.K. Nagar)	12.06.2019	Planning of interventions for different crops and selection of farmers
Ganghu village, Banaskantha district, Gujarat (S.K. Nagar)	13.06.2019	Planning of interventions for different crops and selection of farmers
Pata meghapar and Dangarvala villages, Jamnagar district, Gujarat (Targhadia)	10.07.2019	Advised for moisture conservation and life saving irrigation in Bt cotton and groundnut
	22.07.2019	Surface removal of excess water from the field when continuous high rainfall occurs
Tedha, Patharaha (Hinauti), Gurkhuli and Danti villages, Mizapur district, Uttar Pradesh (Varanasi)	30.06.2019	Due to delay in onset of monsoon, short duration varieties of rice were suggested for sowing



VCRMC meeting at Chikkaputtayanapalya village (Begaluru centre)



VCRMC meeting at Tedha village (Varanasi centre)

3.1.1 Custom Hiring Centre (CHC)

Custom Hiring Centre (CHC) was established in each NICRA village and need based implements were made available to farmers for hiring as per the rates approved by custom hiring management committee (CHMC). The money earned through hiring was incurred for CHC maintenance and for repair of the implements. Implements availability for various agricultural operations on custom hiring during 2019-20 in adopted NICRA villages, are given below:

Improved implements used for various agricultural operations on custom hiring

NICRA Village	Implement used	Farm operation	Area covered (ha)	Cost saving (Rs/ha)
Warkhed and Kajleshwar villages, Akola district, Maharashtra (Akola)	Multipurpose thresher	Threshing	26.8	1170
	Rotavator	Land preparation	6.2	900
Vannedoddipally and Bachepalli villages, Anantapur district, Andhra Pradesh (Ananthapuramu)	Chisel plough	Preparatory cultivation	-	-
	Tractor drawn Ananta Planter	Sowing	75-80%	2400
Bengaluru	Seed drill	Sowing	12.0	600
Chamua, Borkhet, Kachikata, Borbali and Nagaya villages, Lakhimpur district, Assam (Biswanath Chariali)	Power tiller	Tillage, threshing	4.0	4500
	Water lifting pump	Lifting of harvested rainwater from farm pond	10.0	1125
	Sprayer	Spraying of chemicals	10.0	-
Gumiyapal and Tandapal villages, Bastar district, Chhattishgarh (Jagdalpur)	Cultivator	Ploughing	25.0	11295
	Seed cum fertilizer drill	Sowing	52.0	5020
	Rotavator	Fining soil	21.0	4518
	Trolley	Transport	8.0	2510
Kadesara Kala and Hanauta, Lalitpur district, Uttar Pradesh (Jhansi)	Leveler	Leveling	3.0	10000
	Rotavator	Ploughing and pulverization	1.5	2400
	Bullock drawn seed drill	sowing	1.2	-
	Sprayer	spraying	6.5	-
	Wheel hoe	weeding	2.2	15200
Toppureddiapatti, Muthukrishnapuram, Dharmathanpatti village, Thoothukkudi district, Tamil	Rotavator	In-situ soil mulching	3.0	3000

Nadu (Kovilpatti)				
Babhulgaon, Ujalamba villages, Parbhani district, Maharashtra (Parbhani)	Seed cum ferti drill	Sowing and fertilizer application	2.0	400
	Stubble collector	Stubbles collection	4.0	600
Budhadani and Gunjidraga villages, Kandhamal district, Odisha (Phulbani)	Power tiller	Land preparation	3.0	15%
	Reaper	Harvesting	2.5	35%
	Winnower	Threshing	2.5	40%
	Water pump	Irrigation	1.5	30%
	Sprayer	Plant protection	1.5	40%
Patauna, Raura and Khira villages, Rewa district, Madhya Pradesh	Raised bed planter	Sowing	38.0	-
	Harrow	Field preparation	70.0	875
	Rotavator	Field preparation	65.0	565
	Seed drill	Sowing	132.0	945
	Cultivator	Land preparation	45.0	985
Khaner village (old village) and Madana village (new village), Samba district, Jammu & Kashmir (Rakh Dhiansasr)	Disc harrow	Ploughing	12.0	-
	Rotavator	Seed bed preparation	30.0	600
	Roto till drill	Sowing	9.0	1500
	Multi crop seed cum fertilizer drill	Sowing	26.0	1200
	Power weeder	Weeding / interculturing	17.0	1200
	Improved sickle	Harvesting	24.0	250
	Castor decorticator	Seed decorting	18.0	750
	Maize sheller	Threshing	04.0	400
	Winnowing fan	Seed cleaning	19.0	800
Narotewadi and Banegoan villages, Solapur district, Maharashtra (Solapur)	Tractor operated four blade baliram plough	Ploughing	60.0	14000
	Cultivator 9 teeth and 5 teeth	Clod Crushing		
	Cycle hoe	Hoeing		
	Laxmi sickle	Cutting		
	Crida-9 row tractor drawn seed cum ferti planter along with four sets of meeting plates	Sowing		
Pata meghapar and Dangarvala villages, Jamnagar district, Gujarat (Targhadia)	Cultivator	Cultivation	35.0	1320
	Reversible M.B. plough	Primary and deep tillage	25.0	1000
	Rotavator	Tillage and pulverization	46.0	1650
	Mobile chopper	Chopping of cotton stalk	28.0	1400



Tying a rope across the hoe for opening of furrows in each row in soybean (Akola)



Multipurpose thresher Warkhed and Kajleshwar (Akola)



Water lifting pump



Sprayer



Wheel hoe

Chamua village, Lakhimpur District, Assam (Biswanath Chariali)

3.1.3 Village Seed Bank

Participatory village level seed production of short duration, drought and flood tolerant varieties of different field crops was demonstrated in several villages. Efforts were made to provide the sources of alternative crop seed and varieties to address the problem of seed unavailability. The farmers of Babhulgaon village, Parbhani district produced and maintained seed of improved varieties of soybean (3200 kg) and pigeonpea (850 kg). In Hardoiya village, Faizabad district, farmers produced seed of pigeonpea, maize, chickpea, lentil, mustard, linseed and rice. Similarly, farmers produced seed of recent varieties of greengram, blackgram, clusterbean and fodder sorghum in Khalimati/Dholiya villages, Banaskantha district; naiper, wheat, blackgram and sesame in Kadesarakalan village, Lalitpur district; blackgram in Toppureddiapatti village, Thoothukkudi district; maize, greengram, blackgram, clusterbean and fodder sorghum in ghanghu village, Banaskantha district; rice, blackgram, pigeonpea, sorghum and horsegram in Tahakapal village, Bastar district; rice, rapeseed and potato in Chamua village, Lakhimpur district; and fingermillet, groundnut, pigeonpea, field bean and paddy in Chickkaputtayanapalya village, Bengaluru Rural district. The total seed of different crops produced/maintained in AICRPDA-NICRA villages was 31908 kg and 1500000 Nos Napier slips.

Seed availability in NICRA villages

NICRA village	Crop	Variety/hybrid	Quantity (kg)
Chikkaputtayanapalya village, Bengaluru Rural (Bengaluru)	Fingermillet	MR-1	2500
		GPU-28	50
		GPU-48	60
		KMR-340 (White ragi)	500

	Pigeonpea	BRG-5	400
		BRG-1	200
	Field bean	HA-4	50
	Groundnut	ICGV -9114	100
	Paddy	Poustic-9	100
Chamua village, Lakimpur (Biswanath Chariali)	Rice	Disang	350
		TTB-404	700
		Ranjit	650
		Mahsuri	550
		Swarna sub-1	150
		Ranjit sub-1	450
		Nania	45
		Sokuwa	75
		Bora	75
		Joha	80
	Rapeseed	TS-38	850
		TS-36	450
	Potato	Local	750
		Kufri Pokhraj	3500
Hardoiya village, Faizabad (Faizabad)	Pigeonpea	NDA-2	75
	Pigeonpea	NDA-1	70
	Maize	Naveen	50
	Chickpea	PUSA-362	90
	Chickpea	Udai	30
	Lentil	HUL-57	80
	Mustard	NDA1	45
	Mustard	Varuna	25
	Linseed	Garima	35
	Rice	NDR 97	125
Tahakapal village, Bastar (Jagdalpur)	Rice	-	1760
	Blackgram	-	590
	Pigeonpea	-	287
	Sorghum	-	259
	Finger millet	-	467
	Kodo millet	-	532
	Horsegram	-	314
	Little millet	-	371
	Niger	-	138
Kadesarakalan village, Lalitpur (Jhansi)	Naiper	BN Hybrid rooted slips	1500000 Nos
	Wheat	-	1500
	Gram	-	200
	Blackgram	-	500
	Sesame	-	100
Toppureddiapatti village, Thoothukkudi (Kovilpatti)	Blackgram	-	2400
Babhulgaon village, Parbhani (Parbhani)	Soybean	(MAUS 71 and MAUS 158)	3200
	Pigeonpea	(BDN 711 and BSMR 736)	850
Khalimati/Dholiya village, Banaskantha (SK Nagar)	Maize	GM 2	315
	Green gram	GM 4	290
	Black gram	GU 1	165

	Cluster bean	GG 2	120
	Sorghum (fodder)	CSV 21	2000
Ghanghu village, Banaskantha (SK Nagar)	Maize	GM 2	285
	Green gram	GM 4	250
	Black gram	GU 1	145
	Cluster bean	GG 2	110
	Sorghum (fodder)	CSV 21	1500



Rice var. Poustic-9



White ragi var.KMR-340



Pigeonpea var.BRG-5

Participatory seed production in Bengaluru Rural district, Karnataka

3.1.4 Fodder Bank

To strengthen the availability of the green fodder in the NICRA villages of Naiwan and Achalpur, Hoshiarpur district seed of improved variety of pearlmillet (FBC 16) was provided and hybrid Napier cuttings were planted on the field bunds of the farmers. At Chikkamaranahalli village, Bengaluru Rural district, farmers were supplied with seeds of *Stylosanthes hamata* for sowing on the bunds to establish perennial fodder source and to stabilize bunds. The fodder was used for feeding small ruminants. Sub sequently, fodder maize (South African Tall) was grown in an area of 4 ha (38708 kg/ha) in 20 farmers' fields produced for realizing better fodder supply to milch animals in the cluster, 47064 kg/ha of fodder bajra and 2717 kg/ha of dry fodder of finger millet was produced during the year. At Tahakpal village, Bastar district farmers produced seed of *Stylosanthes* (64 kg), hybrid Napier bajra (10 kg), berseem (44 kg), perennial sorghum (17 kg) and fodder sorghum (52 kg). At Babhulgaon village Parbhani district, about 1200 kg of *kharif* sorghum and 4200 kg of *rabi* sorghum was produced. At Chamua village Lakhimpur district, in collaboration with AICRP on Forage Crops, Jorhat Centre, AAU, three species of perennial fodder varieties viz. Hydrid Napier (Variety: CO-2 and CO-4), Congo signal and Setaria are being grown in the fodder bank. Cultivation of mixed fodder (sorghum + pearlmillet + cowpea) was demonstrated in 5 ha in Khaner and Madana villages, Samba district. In Kadesara kala village, Lalitpur district, about 10 tons of hybrid napier slips were sold to farmers of different villages. Further about 150 tons of BN hybrid green fodder, 1.0 ton of silage and 8.0 q urea treated straw was produced during the year.

3.2 Trainings/Field days etc. organized

3.2.1 Trainings

AICRPDA centre	Training programme	Beneficiaries (No.)	Date
Agra	One day pre-seasonal training on *Kharif* crop production participated	62	16.06.2019
	Contingency crop/cultivars planning	64	07.08.2019

	Climate resilient agriculture	58	28.01.2020
Ananthapuramu	Farm mechanization and allied farm engineering technologies" under RKVY Project	18	13.05.2019
	Farm mechanization and allied farm engineering technologies in dryland agriculture	20	04.06.2019
Arjia	Pre seasonal training on *kharif* crop production Lapsiya, Rajasamand	63	20.06.2019
	Pre seasonal training on *kharif* crop production at Kochariya, Bhilwara	18	21.06.2019
	Pre seasonal training *rabi* crop production at Kochariya, Bhilwara	40	15.10.2019
	Rain water management	65	14.02.2020
Bengaluru	*Kharif* crop planning	35	21.05.2019
Biswanath Chariali	Agricultural farm machinery	50	24.07.2019
	Scientific crop management	100	07.11.2019
Chianki	Pre-monsoon training on *kharif* crops	55	11.06.2019
	Kharif crop production	126	02.07.2019
	Rabi crop production	75	11.10.2019
Hisar	Improving the productivity of *kharif* crops by improved practices	42	27.06.2019
	Importance of agro-techniques for increasing the productivity of *kharif* crops	37	29.06.2019
	Weed management in *kharif* crops	29	17.08.2019
	Agro-techniques in *rabi* crops	38	03.10.2019
	Agropractices of mustard and chickpea	42	05.10.2019
Indore	Summer ploughing and residues management	25	01.04.2019
	Improved practices of *rabi* crops	30	25.09.2019
	Nutrient management in rainfed crops	25	27.09.2019
	Irrigation scheduling	15	09.12.2019
Jagdalpur	Rainfed rice technologies	85	17.07.2019
	Badi based vegetable cultivation	35	13.08.2019
	Stem borer management	45	19.08.2019
	Blast diseases management	46	12.09.2019
	Tillage operation for *rabi* crops	56	05.10.2019
	Cucurbits production technology	49	08.11.2019
	Post-harvest management of crops	35	15.12.2019
Jhansi	NB Hybrid production techniques in different framers	18	15.01.2019
	Farmers-Scientists interface meting	33	15.06.2019
	Production technology of *rabi* crops	45	14.11.2019
Kovilpatti	Training on field crop production	45	21.08.2019
	Improved production technologies for black gram	43	31.10.2019
	Improved production technologies for green gram	40	22.11.2019
	Improved production technologies for Maize	40	03.12.2019
Parbhani	BBF technology for soybean	54	19.06.2019
	High density cotton planting using inclined plate planter	27	27.06.2019
	Foliar sprays for dryspell management	54	25.08.2019
	Rabi crop production	120	24.09.2019

	Scientist-farmers interaction meeting	35	10.10.2019
Rajkot	*Kharif* crop planning	48	06.06.2019
	Contingency crop measures in major *kharif* crops including IPDM	28	22.07.2019
	Integrated farming system and risk minimization in agriculture	39	21.08.2019
	Rabi crop planning	26	24.10.2019
	Rabi crop planning	32	02.11.2019
	IPDM in *rabi* crops	38	05.12.2019
	IPDM in *rabi* crops	24	10.12.2019
Rewa	Plant protection and water management in *kharif* crops	32	01.08.2019
	Moisture conservation practices in *kharif* crops	26	12.09.2019
	Rabi crops and cropping system suitable for the region	34	27.09.2019
	Post-harvest operation in *kharif* crops crops	28	06.11.2019
	Plant protection measures in *rabi* crops	22	19.12.2019
Solapur	*Kharif* pre-seasonal trainings	80	01.07.2019
	Rabi pre-seasonal trainings	120	25.09.2019
SK Nagar	Method of sowing of different crops	210	04.06.2019
	Interculture and weeding operation in *kharif* crops	152	17.07.2019
	Compartmental bunding in pearlmillet	102	04.06.2018
	Irrigation scheduling in castor	168	25.08.2019
SK Nagar	Method of sowing of different crops	90	04.06.2019
	Interculture and weeding operation in *kharif* crops	52	17.07.2019
	Compartmental bunding in pearlmillet	95	04.06.2018
	Irrigation scheduling in castor	60	25.08.2019
Varanasi	Contingency crop planning	45	24.06.2019
	Total	**3588**	



Training on *Kharif* crop planning at Chikkaputtayanapalya village, Bengaluru Rural district, Karnataka



Training on *Kharif* crop production at kumbhi village, Gathwa district, Jharkhand





Training on crop management at Chamua village, Lakshmipur district, Assam

3.2.2 Field Days

AICRPDA centre	Intervention	NICRA village	Date	Beneficiaries (No.)
Akola	Furrow opening for in-situ moisture conservation	Warkhed, Ta-Barshitakli	21.06.2019	37
Ananthapuramu	Importance of farm pond for lining work to store harvested rainwater	Vannedoddi	18.06.2019	20
	Agricultural engineering interventions	Vannedoddi & Bachupally	29.11.2019	30
Ballowal Saunkhri	Cultivation practices of *Kharif* crops	Achalpur	25.06.2019	63
	Management of *kharif* crops and stem borer in maize	Achalpur	17.07.2019	60
	Disease management of *kharif* crops and Army worm in maize	Achalpur	25.07.2019	20
	livestock management	Achalpur	21.08.2019	39
	Cultivation of *rabi* crops	Bhawanipur	05.11.2019	44
	Yellow rust management and insect-pests of *rabi* crops	Nainwan	15.01.2020	50
Bengaluru	Climate smart finger millet based cropping system	Chikkamaranahalli,	31.10.2019	60
Parbhani	Field day for crop stage advisory	Babhulgaon, Ujalamba	16.08.2019	54
Rajkot	Field day on management of cotton and groundnut pests	Patameghpar	10.07.2019	28
	Field day on management of groundnut diseases	Dangarvada	21.08.2019	47
	Excess water removal and surface drainage	Patameghpar	08.09.2019	48
			Total	**600**



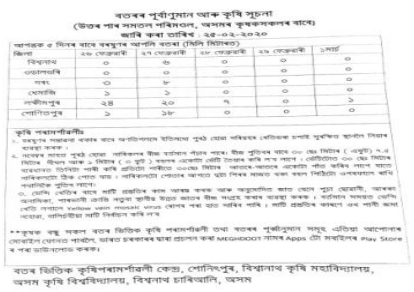

Field day on furrow opening in soybean and cotton at warkhed and kajleshwar villages, Akola district, Maharshtra



Field day on Climate smart finger millet based cropping system at chikkamaranahalli village, Bengaluru Rural district, Karnataka

3.3 Agro-Advisories

Centre	Agro-advisories	Frequency
Agra	SMS	As required
Akola	Weekly bulletins	Weekly
Ananthapuramu	Black board and SMS	Twice in a week
Ballowal Saunkhri	Weekly bulletins	Weekly
Bengaluru	Bulletin, Black board in NICRA village	Twice in a week
Biswanath Chariali	SMS through farmers portal, black board	As required
Faizabad	Newspaper, Radio	Daily
Hisar	Weekly bulletins	Weekly
Jagdalpur	Meeting in NICRA village	As required
Kovilpatti	SMS, Weekly bulletins	As required
Parbhani	Weekly bulletins	Weekly
Phulbani	SMS	As required
Rajkot	SMS	As required
Rakh Dhiansar	Weekly bulletins	Weekly
Rewa	Meeting in NICRA village	As required
SK Nagar	Meeting in NICRA village	As required
Solapur	Weekly bulletins	Weekly
Vijayapura	Meeting in NICRA village	Weekly

Agro-advisories through black board in chamua village, Lakshmipur district, Assam

3.4 Soil Health Cards

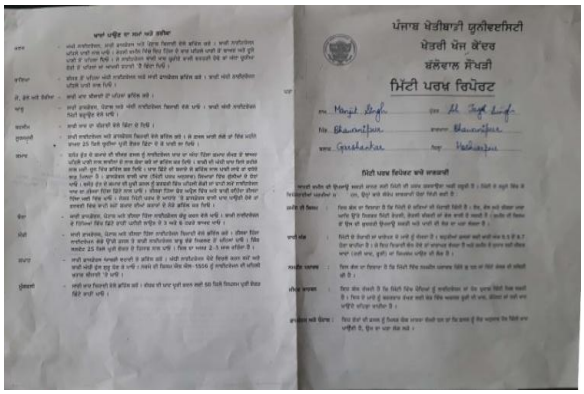
Distribution of soil health cards in NICRA villages during 2019-20

Centre	NICRA Village	Soil health cards issued (No. of farmers)
Anantapuramu	Vannedoddi	65
Ballowal Saunkhri	Achalpur and Naiswan	155
Bengaluru	Chikkamaranahalli	124
Chianki	Kumbhi and bankheta	50
Jhansi	Kadesara Kalan	04
Rajkot	Pata Meghpar	12
Rakh Dhiansar	Khaner and Madana	73
Rewa	Patauna	41
	Raura	11
SK Nagar	Kalimati, Dholiya and Ghanghu	590
Solapur	Narotewadi	10
	Total	**1135**

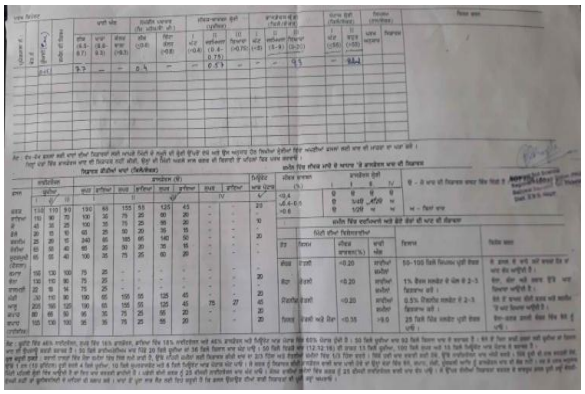




Soil profile1 in Vannedoddi village, Ananthapuramu district, Andhra Pradesh



ਪੰਜਾਬ ਖੇਤੀਬਾੜੀ ਯੂਨੀਵਰਸਿਟੀ
ਖੇਤਰੀ ਖੋਜ ਕੇਂਦਰ
ਬੱਲੋਵਾਲ ਸੌਂਖੜੀ
ਮਿੱਟੀ ਪਰਖ ਰਿਪੋਰਟ



3.5 Linkages developed

The AICRPDA centres have developed linkages with ICAR institutes, Central government schemes/ State Government programmes for implementation of NICRA programmes, and with state line department, KVKs, ATMA, KSDA, and NGOs for capacity building of various stakeholders. During 2019-20, the scientists of the centres were actively involved in updating the district level crop contingency plans, involving scientists and officials from KVKs and line departments in respective states. Further, the scientists from centres also participated in state level meetings organized in 5 states (Maharashtra, Odisha, Karnataka, Gujarat and Andhra Pradesh) for operationalization of district agriculture contingency plans and contributed in developing action plans.

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Best farmers from NICRA villages felicitated during the XXVI Biennial Workshop of AICRPDA

USAB, Bengaluru, Karnataka, 16-19 January, 2019



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Shri Sachin Digambar Kondankar
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Shri Rupram Saikia
from Chamua village, Lakhimpur district, Assam



Shri Manjit Singh
from Bhawanipur village, Hoshiarpur district, Punjab



Shri S. Ramamoorthi
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Shri Thimmappa Gowda
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