National Innovations in Climate Resilient Agriculture

Managing Weather Aberrations

through Real Time contingency Planning

AICRPDA - NICRA

Annual Report

2016-17

All India Coordinated Research Project for Dryland Agriculture
ICAR-Central Research Institute for Dryland Agriculture
Santoshnagar, Hyderabad-500059

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Introduction

Rainfall is the key variable influencing crop productivity in rainfed agriculture. Climate change impacts on agricultural production and productivity are evident; particularly in rainfed areas of India. Rainfed crops are likely to be worst hit by climate change because of the limited options for coping with variability of rainfall and temperature. The projected impacts are likely to further aggravate yield fluctuations of many crops with impact on food security and prices. In the XI Five Year Plan, ICAR launched the National Initiative on Climate Resilient Agriculture (NICRA) in 2011 to undertake strategic research in network mode and also to demonstrate location-specific climate risk resilient technologies in farmers' fields in a participatory mode in 130 vulnerable districts spread across the country. In XII Plan, NICRA is being implemented as National Innovations in Climate Resilient Agriculture.

AICRPDA-NICRA Programme

Presently, AICRPDA network has 19 main centres, 3 sub centres, 5 voluntary centres and 8 Operational Research Projects and 3 voluntary centres at CAZRI, IGFRI and IISWC (**Fig.1**) located in 17 states representing diverse rainfed agro-ecologies (**Table.1**). The research at network centres based on natural resource management and socioeconomic status is the hallmark of the programme. Over a period of 4 decades, AICRPDA network centres generated location-specific technologies for upscaling in the respective resource domains. These technologies 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, bullock/tractor drawn farm implements for efficient tillage/seeding/ fertilizer application/ intercultural and other operations with cost effectiveness and timeliness, alternate land use systems for diversification, higher income and resource use efficiency.

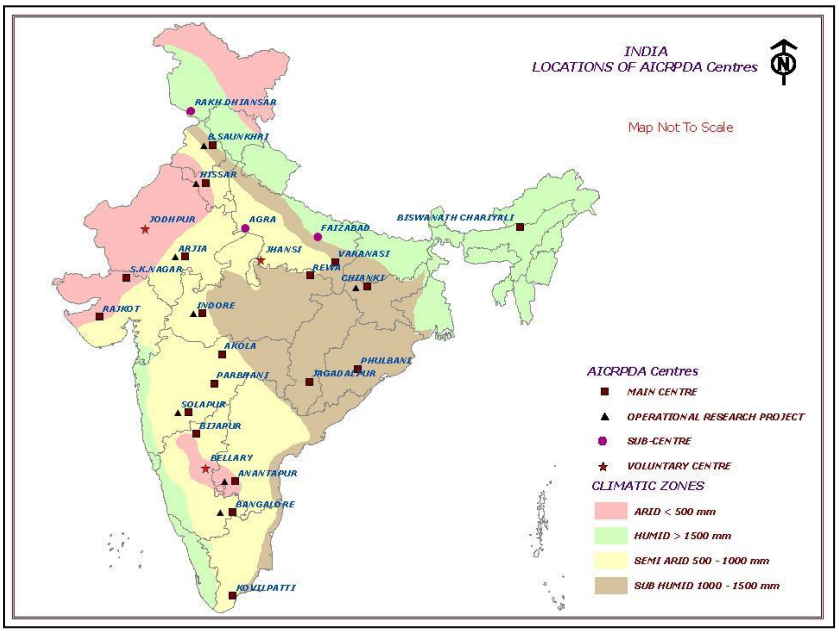

Fig 1: Location Map of AICRPDA Network Centres

Table 1: Agro-ecological setting of AICRPDA network centres

Name of the Centre	SAU/CAR institute/ their Hqrs)	Agro-Climatic Zone(NARP)/Agro– Eco sub-region (AESR)	Climate	Mean Annual	Dominant Soil Type	Major Rainfed Production
Agra (SC)	RBSC, Agra	South–western semiarid zone in Uttar Pradesh (4.1)	Semi-arid (Hot dry)	665	Inceptisols	Pearlmillet
Akola (MC)	PDKV, Akola	Western Vidarbha Zone in Maharashtra (6.3)	Semi-arid (Hot moist)	824	Vertisols	Cotton
Anantapur (MC&ORP)	ANGRAU, Hyderabad	Scarce rainfall zone (Rayalaseema) in Andhra Pradesh (3.0)	Arid (Hot)	544	Alfisols	Groundnut
Arjia (MC&ORP)	MPUAT, Udaipur	Southern zone in Rajasthan (4.2)	Semiarid (Hot dry)	656	Vertisols	Maize
Ballowal Saunkhri (MC&ORP)	PAU, Ludhiana	Kandi region in Punjab (9.1)	Sub humid (Hot dry)	1011	Inceptisols	Maize
Bengaluru (MC&ORP)	UAS_B, Bengaluru	Central, eastern and southern dry zone in Karnataka (8.2)	Semiarid (Hot moist)	926	Alfisols	Fingermillet
Bellary (VC)	CSWCRTI, Dehradun	Northern dry zone in Karnataka (3.0)	Arid (Hot)	502	Vertisols	*Rabi* Sorghum
Biswanath Chariali (MC)	AAU, Jorhat	North-west Plain zone in Assam (15.4)	Per humid (Hot)	1846	Oxisols	Rice
Chianki (MC&ORP)	BAU, Ranchi	Western plateau zone of Jharkhand (4.1)	Semi-arid (Hot dry)	1149	Inceptisols	Rice
Faizabad (SC)	NDUAT, Faizabad	Eastern plain zone in Uttar Pradesh (9.2)	Sub-humid (Hotdry)	1051	Inceptisols	Rice
Hisar (MC&ORP)	CCSHAU, Hisar	South-western dry zone in Haryana (2.3)	Arid (Hyper)	412	Inceptisols	Pearlmillet
Indore (MC&ORP)	RVSKVV, Gwalior	Malwa plateau in Madhya Pradesh (5.2)	Semi-arid (Hot moist)	958	Vertisols	Soybean
Jagdalpur (MC)	IGAU, Raipur	Basthar Plateau zone in Chattisgarh (12.1)	Sub-humid (Hot moist)	1297	Inceptisols	Rice
Jhansi (VC)	IGFRI, Jhansi	Bundhelkhand zone in Uttar Pradesh (4.4)	Semi-arid (Hot moist)	870	Inceptisols	*Kharif*
Jodhpur (VC)	CAZRI, Jodhpur	Arid Western zone of Rajasthan (2.1)	Arid (Hyper)	331	Aridisols	Pearlmillet
Kovilpatti (MC)	TNAU, Coimbatore	Southern zone of Tamil Nadu (8.1)	Semi-arid (Hot dry)	723	Vertisols	Cotton
Parbhani (MC)	MAU,Parbhani	Central Maharastra Plateau Zone in Maharashtra (6.2)	Semi-arid (Ho tmoist)	901	Vertisols	Cotton
Phulbani (MC)	OUAT, Bhubaneswar	Eastern Ghat Zone in Odisha (12.1)	Sub-humid (Hot moist)	1580	Oxisols	Rice
Rajkot (MC)	JAU, Junagarh	North Saurashtra zones in Gujarat (5.1)	Semi-arid (Hot dry)	590	Vertisols	Groundnut
Rakh Dhiansar (SC)	SKUAS_T, Jammu	Low altitude subtropical zone in Jammu and Kashmir (14.2)	Semi-arid (Moist dry)	860	Inceptisols	Maize
Rewa (MC)	JNKVV, Jabalpur	Key more plateau and Satpura Hill zone in Madhya Pradesh (10.3)	Sub-humid (Hot dry)	1088	Vertisols	Soybean
S.K. Nagar (MC)	SDAU, Dantewada	Northern Gujarat in Gujarat (2.3)	Semi-arid/Arid (Hot dry)	670	Entisols	Pearlmillet
Solapur (MC&ORP)	MPKV, Rahuri	Scarcity zone in Maharashtra (6.1)	Semi-arid (Hot dry)	732	Vertisols	*Rabi* Sorghum
Varanasi (MC)	BHU, Varanasi	Eastern Plain and Vindhyan Zone in Uttar Pradesh (4.3/9.2)	Semi-arid (Hot moist) Sub-humid (Hot dry)	1049	Inceptisols	Rice
Vijayapura (MC)	UAS_D, Dharwad	Northern dry zone in Karnataka (6.1)	Semi-arid (Hot dry)	595	Vertisols	*Rabi* Sorghum
Aklera(VC)	AU, Kota	South-eastern plain zone in Rajasthan (5.2)	Semiarid (Hot moist)	844	Vertic	Soybean
Darsi (VC)	ANGRAU, Guntur	Krishna-Godavari zone in Andhra Pradesh (7.3)	Semiarid (Hotmoist)	871	Alfisols/	Pigeonpea
Imphal	CAU, Imphal	Sub tropical zone in Manipur (17.2)	Perhumid (Warm to	1372	Alfisols/Inc	Rice
Munger (VC)	BAU, Sabour	South Bihar alluvial plain zone in Bihar (13.1)	Subhumid (Hot dry)	1143	Inceptisols	Maize
Raichur (VC)	UAS, Raichur	North-eastern dry zone in Karnataka (6.1)	Semiarid (Hot dry)	621	Vertisols/A	*Rabi*

The AICRPDA Network centres were included in the National Initiative on Climate Resilient Agriculture (NICRA) Project of ICAR for taking up demonstration and research activities at various dryland centres in a network mode. The demonstration component of NICRA has been finalized in these centres in a participatory mode. Further, the network programme envisages identifying climatic vulnerabilities of agriculture in the selected villages by each centre based on historical weather data from the nearest weather station, farmers' experiences and perceptions, preparing and implementing adaptation and mitigation strategies following a bottom-up approach. The focus of the program is 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. The location of the AICRPDA - NICRA adopted villages is shown in **Fig.2**, and the details are given in **Table-2.**

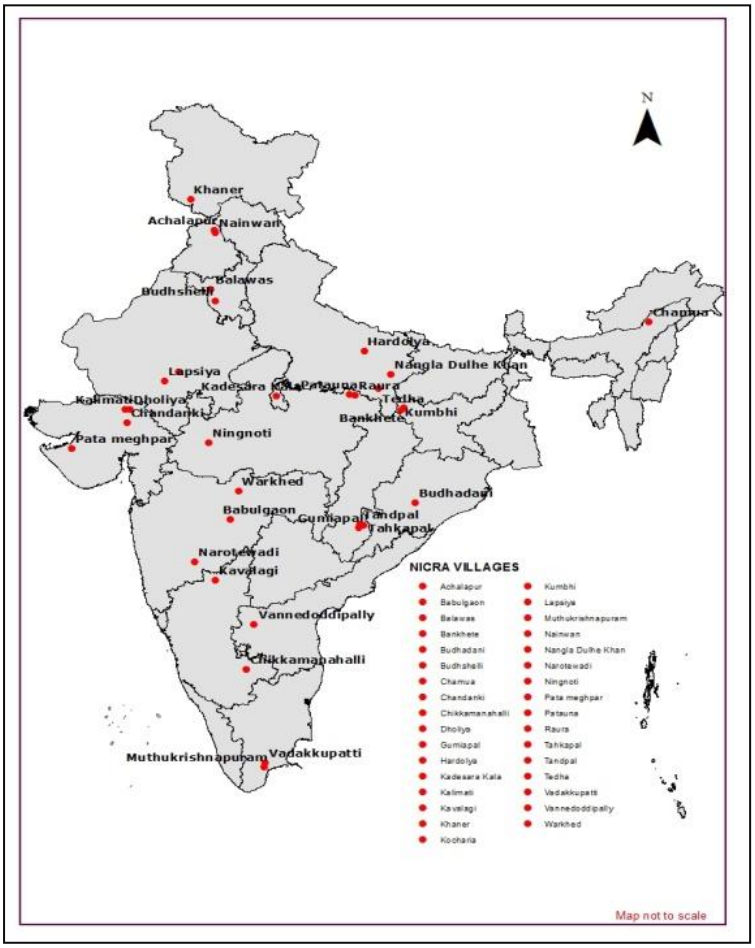

Fig 2: Location map of AICRPDA-NICRA adopted villages

Since 2011, the AICRPDA network centres initiated both on-station and on-farm research/demonstrations on real-time contingency measures. 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, inter-cropping 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.

Table 2: AICRPDA-NICRA program- Details of villages

AICRPDA centre	Name of the Villages	District	State
Agra	Nagla Duleh khan	Agra	Uttar Pradesh
Akola	Warkhed	Akola	Maharashtra
Anantapur	Vannedoddipally	Anantapur	Andhra Pradesh
Arjia	Kochariya Lapsiya	Bhilwara Rajsamand	Rajasthan
Ballowal Saunkhri	Naiwan, Achalpur	Hoshiarpur	Punjab
Bengaluru	Chikkamaranahalli	Bengaluru Rural	Karnataka
Biswanath Chariali	Chamua	Lakhimpur	Assam
Bijapur	Kavalagi	Bijapur	Karnataka
Chianki	Kumbhi & Bankheta	Garhwa	Jharkhand
Faizabad	Hardoiya	Faizabad	Uttar Pradesh
Hisar	Budhshelly Balawas	Bhiwani Hisar	Haryana
Indore	Ningnoti	Indore	Madhya Pradesh
Jagdalpur	Tahakapal, Tandapal and Gumiyapal	Bastar	Chattishgarh
Jhansi	Kadesara Kala	Lalitpur	Uttar Pradesh
Kovilpatti	Muthukrishnapuram, Vadakkupatti	Thoothukkudi	Tamil Nadu
Parbhani	Babhulgaon	Parbhani	Maharashtra
Phulbani	Budhadani	Kandhamal	Odisha
Rajkot	Pata meghapar	Jamnagar	Gujarat
Rakh Dhiansar	Khaner	Samba	Jammu & Kashmir
Rewa	Patauna, Raura	Rewa	Madhya Pradesh
SK Nagar	Kalimati/ Dholia, Chandanki	Banaskantha Mehasana	Gujarat
Solapur	Narotewadi	Solapur	Maharashtra
Varanasi	Tedha	Mizapur	Uttar Pradesh

The Programme Implementation – Process

The process of implementation of on-station experiments at the AICRPDA centers and on-farm demonstrations in the villages adopted by the centers under NICRA are presented below: The major interventions were implemented both under on-farm and on-station, broadly under four theme areas as follows:

I. Realtime contingency crop plan implementation both on station and on farm in a participatory mode: To sustain the productivity of pearlmillet, cluster bean, sesame under normal are drought conditions. To improve the productivity of mustard, chickpea and wheat under rainfed conditions.

II. Rainwater harvesting (*in-situ* and *ex-situ*) and efficient use: Demonstration on efficient in-situ moisture conservation practices to conserve more moisture (ridge and furrow planting, compartmental bundling etc.).Efficient and multiple use of harvested water or enhancing water use efficiency (life saving irrigation, sprinkler irrigation). Ground water recharging through bore well and open well, defunct well.

III. Efficient energy use and management: Introduction of modern tools / implements and to create awareness in the farming community about their use for different crops (establishing custom hiring centre and ensuring services in the village).

IV. Alternate land use for carbon sequestration and eco-system services: To develop alternate land use system / farming system for carbon sequestration and ecosystem services. The package included land configuration, crops or varieties/cropping system, rain water harvesting and recycling, timely operations through custom hiring centre and alternate land use and ecosystem services.

Real Time Contingency Plan Implementation (RTCP) - Concept

During 1972-73, large scale scarcity of rainfall was experienced all over the country, particularly in the scarcity region of Maharashtra, Karnataka and Andhra Pradesh. Roving seminars were organized by the ICAR at different locations, at the end of which *new phrases* were coined *viz. contingent crop planning and mid-season correction*. As a follow up, dryland centres collected data on these two aspects and after analysis of weather data for the past 100 years, listed the weather aberrations: *i) delayed onset of monsoon; ii) early withdrawal of monsoon; iii) intermittent dry spells of various durations; iv)prolonged dry spells causing changes in the strategy ; and v) prolonged monsoon*. *Contingency plans,* for each region, was a conceptual approach unique from AICRPDA project in developing location specific contingent crop strategies which were first published in 1977 in *Indian Farming*, and with further refinements and updation in crops and varieties, the first document was brought out by AICRPDA in 1983 on *"Contingent crop production strategy in rainfed areas under different weather condition"*. The AICRPDA network centres developed crop contingency plans for each centre's domain. Further, during 2009-10, AICRPDA centres prepared contingency measures considering the weather aberrations, seasons, and predominant *kharif* and *rabi* crops with appropriate crop management strategies. CRIDA with information available at AICRPDA centres and SAUs, prepared district level agriculture contingency plans for more than 580 districts in collaboration with Department of Agriculture and Cooperation (DAC), Ministry of Agriculture, GoI, ICAR institutes, State Agricultural/Horticultural/Animal Science/Veterinary/Fisheries Universities, Krishi Vigyan Kendras (KVKs), State line departments. These

plans essentially suggest coping strategies/measures in agriculture, horticulture and allied sectors in the event of delayed onset of monsoon, seasonal drought, unseasonal rainfall events, floods, cyclones, hail storm, heat/cold wave.

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 aim of real-time contingency measures is to 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, enhance performance, improve productivity and income; iii) to ensure minimum damage to horticultural crops and their produce and also to enhance performance; iv) to minimize physical damage to livestock, poultry and fisheries sector and ensure better performance v) to ensure food security at village level and to enhance adaptive capacity and livelihoods of the farmers.

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

RTCP Measures in Rainfed Agriculture

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 (Srinivasarao *et al*., 2010). 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 (Srinivasarao *et al*., 2012). 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 mutriate 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.

f. Floods

Crop/field management depends on nature of material (sand or silt) deposited during floods. In sand-deposited crop fields/fallows, ameliorative measures include early removal or ploughing in of sand (depending on the extent of deposit) for facilitating *rabi* crop or next *kharif*. In silt-deposited Indo-Gangetic Plains, early *rabi* crop plan is suggested in current cropped areas and current fallow lands. Other measures include draining out of stagnant water and strengthening of field bunds etc. In *diara* (flood prone) land areas, measures include alternate crop plans for receding situations. Usually rice cropped areas are flood prone causing loss of nurseries, delayed transplanting or damage to the already transplanted fields etc. Suggested measures include promotion of flood tolerant varieties, community nursery raising, re-transplanting in damaged fields and transplanting new areas or direct seeding depending on seed availability so that the season is not lost. Other steps include prevention of pre-mature germination of submerged crop at maturity or of harvested produce by spray of salt solution.

Experienced weather at AICRPDA- NICRA villages during 2015-16

During 2016-17, the onset of monsoon was delayed by two weeks in NICRA villages located in Kandhamal (Odisha) and Banaskantha (Gujarat) in districts (**Table.3**). Further, there were 3-6 dry spells at different stages of crops in NICRA adapted villages Akola, Ananthapuramu, Bengaluru, Jagdalpur, Lakhimpur, Garhwa, Kandhamal, Parbhani and Kovilpatti districts.

Table 3: Details of onset of monsoon in AICRPDA-NICRA villages (2015)

Villages & District	Agro-climatic Zone	Onset of monsoon		Delay in onset (days)
		Normal	Actual	
Nagla Dulhe Khan (Agra)	South–western semiarid zone in Uttar Pradesh	2nd July	6th July	4
Warkhed (Akola)	Western Vidarbha Zone in Maharashtra	10th June	7th June	-
Vannedoddipally (Ananthapuramu)	Scarce rainfall zone (Rayalaseema) in Andhra Pradesh	7th June	6th June	-
Kochariya (Bhilwara)	Southern zone in Rajasthan	1st July	28th June	-
Lapsiya (Rajsamand)	Southern zone in Rajasthan	2nd July	29th June	-
Achalpur & Nainwan. (Hoshiarpur)	Kandi region in Punjab	1st July	27th June	-
Chikkamaranahalli (Bangalorerural)	Central, eastern and southern dry zone in Karnataka	2nd June	1st June	-
Kavalagi (Vijayapur)	Northern dry zone in Karnataka	7th June	19th June	12
Chamua (Lakhimpur)	North Bank plain zone in Assam	1st July	1st July	-
Kumbhi & Bankheta (Garhwa)	Western plateau zone of Jharkhand	10th June	22nd June	12
Hardoiya (Faizabad)	Eastern plain zone in Uttar Pradesh	21st June	8th June	-
Balawas & Budhshelly (Bhiwani)	South-western dry zone in Haryana	1st July	3rd July	2
Nignoti (Indore)	Malwa plateau in Madhya Pradesh	12th June	11th June	-
Tahkapal (Bastar)	Basthar Plateau zone in Chattisgarh	15th June	8th June	-
Kadesara Kala(Lalitpur)	Bundhelkhand zone in Uttar Pradesh	25th June	25th June	-
Muthukrishnapuram and Thoppureddipatti (Toothukkudi)	Southern zone of Tamil Nadu	1st June 20th Oct	7th June 30th Oct	6 (SW) 10 (NE)

Babhulgaon (Parbhani)	Central Maharashtra Plateau Zone in Maharashtra	20th June	18th June	-
Budhani (Kandhamal)	Eastern Ghat Zone in Orissa	10th June	24th June	14
Patameghpar (Jamnagar)	North Saurashtra zones in Gujarat	16th June	12th June	-
Khaner (Samba)	Low altitude subtropical zone in Jammu and Kashmir	27th June	6th July	9
Patuana & Raura (Rewa)	Keymore plateau and Satpura Hill zone in Madhya Pradesh	23rd June	-	-
Kalimati (Banaskantha)	Northern Gujarat in Gujarat	25th June	12th July	17
Narotewadi (Solapur)	Scarcity zone in Maharashtra	7th June	10th June	3
Tedha Pahadi (Mirzapur)	Eastern Plain and Vindhyan Zone in Uttar Pradesh	22nd June	21st June	-

In general, the total rainfall during *kharif* season (June-September), 2016 was below normal in all NICRA villages except in Warkhed (Akola), Kochariya (Bhilwara), Kavalgi (Vijayapura), Chamuha (Lakhimpur), Kumbhi & Bankheta (Garwaha), Balawas (Bhiwani), Ningnoti(Indore), Tahakapal (Bastar),Kadesara Kalan (Lalithpur), Bhabulgoan(Parbhani),Bhudhani (Kandhamal) and Tedha (Mirzapur) (**Fig.3)**. Similarly, during *rabi* season (October-December) 2016, the rainfall was less than normal seasonal rainfall in all NICRA villages except Nagla Dulhe Khan (Agra), Warkhed (Akola), Achalpur and Naiwan (Hoshiarpur), Chamuha (Lakhimpur), Tahakapal (Bastar), Bhabulgoan(Parbhani), Petameghapar (Jamnagar) and Kalamati (Banakantha). During the period (2016), no rainfall was received in 3 NICRA villages, in khariff season at Muthukrishnapuram and Toppureddipatti(Toothukkudi) and in rabi season Kochariya(Bhilwara) and Narotewadi (Solapur) (**Fig 4)**. The rainfall was deficit by 50-100% during June 2016 in NICRA-villages of Garhwa, Bastar, Toothukkudi, Jamnagar and Mirzapur districts. In July, the deficit in rainfall was more than 60% in villages of Toothukkudi, Jamnagar and Banaskantha.Similarly, in August, villages in Kurnool, Parbhani districts recorded more than 50% deficit rainfall and in Toothukkudi districts, it is 100% deficit. In September, NICRA villages in Kurnool, Hoshiarpur, Garwha, Banaskantha and Jamnagar received 50% deficit rainfall, and in Bhilwara, Rajasmand, Bengaluru rural, Bhiwani received 50-90% deficit rainfall and Toothukkudi district received very scanty (more than 90% deficit) rainfall. Similarly, in October, 5 villages in Kurnool, Bhilwara, Jamnagar, Samba, Solapur and Mirzapur districts did not receive any rainfall (**Table 4**).

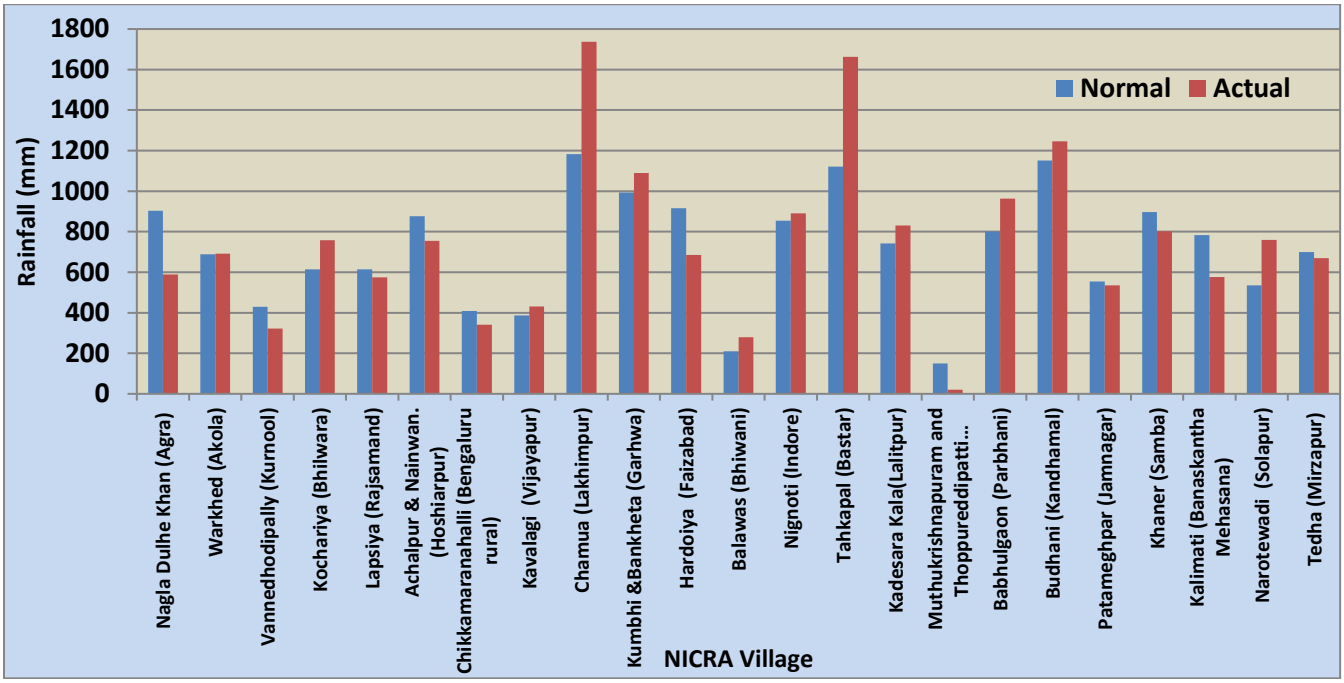

Fig 3: Normal and actual (2016) rainfall in AICRPDA-NICRA villages (June – September)

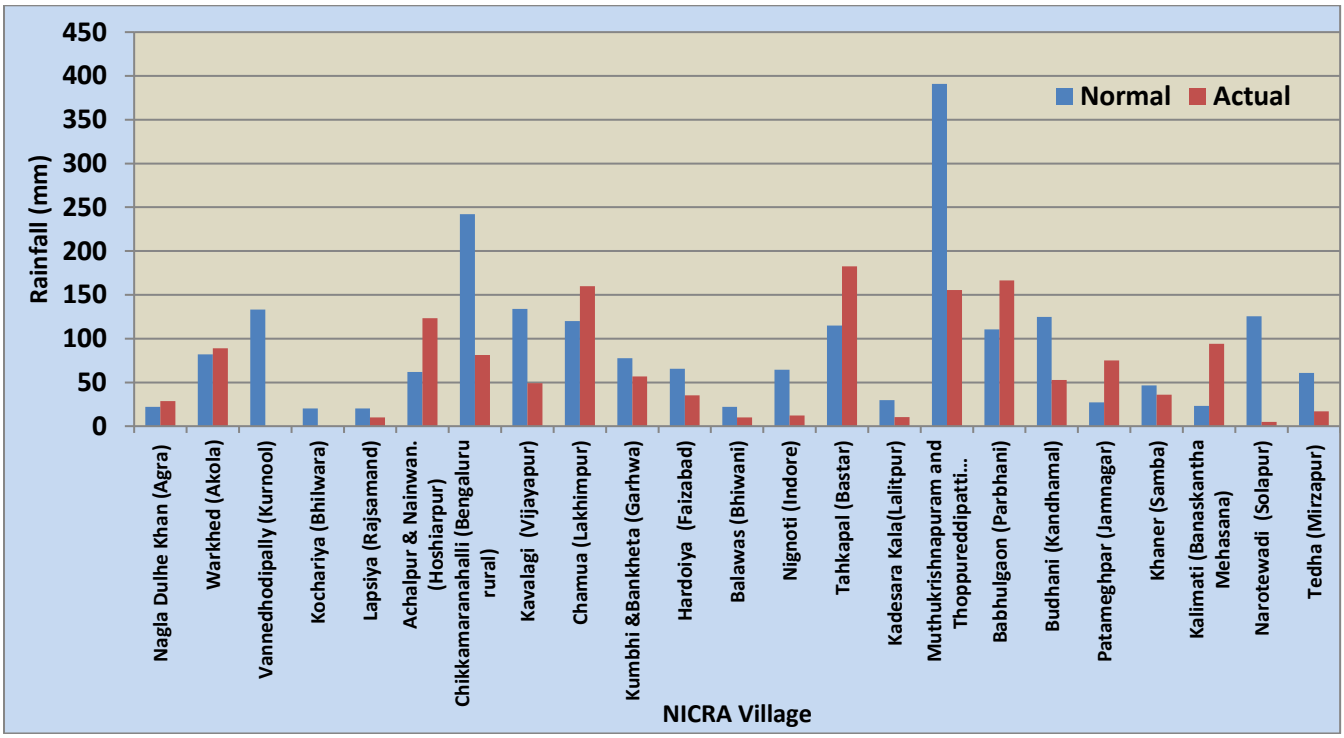

Fig 4: Normal and actual (2016) rainfall in AICRPDA-NICRA villages (October – December)

Table 3: Month-wise rainfall in AICRPDA-NICRA villages during June-December, 2016

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)	52	91	43	239	482	50	207	300	31	90	30	-205	25	22	-14	2	0	-100	2	0	-100
Warkhed (Akola)	137	199	31	225	312	28	159	98	-62	147	83	-77	35	89	61	18	0	-100	13	0	-100
Aminabad & Girigetla (Kurnool)	94	93	-2	97	122	20	97	45	-115	142	63	-126	21	0	-100	107	0	-100	5	0	-100
Kochariya (Bhilwara)	74	113	35	196	203	3	249	423	41	97	20	-385	10	0	-100	7	0	-100	4	0	-100
Lapsiya (Rajsamand)	74	68	-9	196	207	5	249	288	14	97	11	-782	10	10	0	7	0	-100	4	0	-100
Achalpur & Nainwan. (Hoshiarpur)	108	167	35	288	251	-15	304	255	-19	161	81	-98	28	110	75	7	0	-100	27	13	-103
Chikkamaranahalli (Bengaluru rural)	59	113	48	80	140	43	131	73	-79	139	14	-879	154	35	-340	61	14	-336	30	32	7
Kavalagi (Vijayapur)	85	86	1	73	130	44	78	106	27	152	108	-41	97	49	-98	30	0	-100	7	0	-100
Chamua (Lakhimpur)	360	474	24	364	638	43	316	179	-76	241	446	46	130	148	12	20	7	-186	11	5	-120
Kumbhi &Bankheta (Garhwa)	162	83	-96	320	336	5	359	234	-54	152	304	50	62	42	-48	10	0	-100	6	0	-100
Hardoiya (Faizabad)	133	93	-43	288	316	9	300	180	-66	193	95	-103	51	35	-45	4	0	-100	11	0	-100
Balawas (Bhiwani)	20	68	71	80	146	45	60	53	-13	50	12	-317	9	10	10	10	0	-100	3	-	-100
Nignoti (Indore)	147	203	28	244	333	27	326	307	-6	141	48	-196	35	12	-185	11	0	-100	3	0	-100
Tahkapal (Bastar)	236	131	-80	343	907	62	351	282	-24	193	373	48	88	189	53	20	0	-100	6	0	-100
Kadesara Kala(Lalitpur)	166	133	-25	269	330	18	180	292	38	128	77	-67	21	11	-100	3	0	-100	5	0	-100
Muthukrishnapuram and Thoppureddipatti (Toothukkudi)	11	0	-100	20	0	-100	35	0	-100	84	21	-300	199	106	-87	139	44	-216	139	5	-2680
Babhulgaon (Parbhani)	172	138	-25	225	407	45	236	94	-152	167	325	49	80	166	52	21	0	-100	9	0	-100
Budhani (Kandhamal)	189	192	2	350	321	-9	383	368	-4	228	279	18	96	51	-88	24	1	-3900	5	0	-100
Patameghpar (Jamnagar)	103	13	-692	252	27	-851	103	366	72	97	50	-94	22	81	73	5	0	-100	0	0	-100
Khaner (Samba)	95	187	49	323	543	40	337	359	6	142	82	-73	19	0	-100	6	0	-100	22	0	-100
Kalimati (Banaskantha Mehasana)	87	74	-18	278	90	-209	275	341	19	142	71	-100	20	94	79	3	0	-100	1	0	-100
Narotewadi (Solapur)	107	172	38	116	214	46	140	113	-24	173	261	34	98	5	-1860	22	0	-100	6	0	-100
Tedha Pahadi (Mirzapur)	87	31	-179	293	496	41	337	455	26	228	228	0	49	5	-807	7	0	-100	5	0	-100

N : Normal A : Actual during 2016 % Dev: % Deviation

During 2016-17, the emphasis was on 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 production-system wise and centre–wise salient achievements and other activities are presented in the following chapters.

1. Salient Achievements

Technology Demonstrations

1.0 Dry Semi Arid Zone (500-750 mm)

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 2016-17

During the year 2016, the onset of monsoon was early by 7 days (26th June). A rainfall of 997.8 mm was received which was excess by 340.1 mm compared to normal rainfall of 657.7 mm (Fig.). During South-West monsoon (June to September), 964.1 mm rainfall was received which was excess by 349.6 mm (56.89%); During October-December, there was 13.0 mm of rainfall against normal (20.2 mm). During summer (March- May), 19.0 mm of rainfall was received which was excess by 3.9 mm compared to normal (15.1 mm) (Fig 1.1.1).

Normal onset of monsoon	: 2 July
Onset of monsoon during 2016-17	: 26 June
Annual mean rainfall	: 657.7 mm
Annual rainfall during 2016-17	: 997.8 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	: 614.5 and 20.2 mm, respectively
Crop seasonal rainfall during 2016-17 (*kharif* and *rabi*)	: 964.1 and 13 mm, respectively

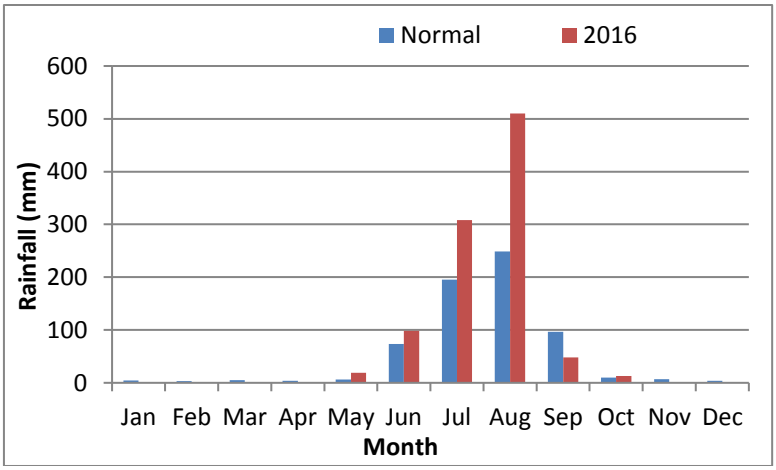

Fig. 1.1.1: Normal and actual (2016) monthly rainfall at Arjia

Dry spells during crop growing season (2016)

Dry spell		Crop	Stage of the crop
Duration (days)	**Dates & months**		
>30	4 September to till harvest	Maize	Grain filling to maturity

Salient achievements of on-station experiments

Real time contingency planning

Situation: Terminal drought

During the year 2016, there was one dry spell (4 September to till harvest) at grain filling to maturity stage of crops. To cope with the situation crop management practices like soil stirring, supplemental irrigation and foliar spray of KNO_3 + $ZnSO_4$ were carried out. Among the management practices, supplemental irrigation gave higher yield in all the crops and cropping systems tested (Table 1.1.1).

Table 1.1.1: Effect of different treatments on crop yields under terminal drought

Treatment	Control (normal practice)	Soil stirring during drought	Supplemental irrigation	Foliar spray of KNO_3 (2%) + $ZnSO_4$ (0.5%)
Sole maize	1921	2072	2419	2125
Maize + blackgram (2:2) ICS	2245	2632	3866	2667
Sole blackgram	2583	2630	2981	2685
Sole broundnut	1879	2531	3179	2623
Sole sesame	1111	1215	2049	1262
Groundnut + sesame (6:2) ICS	1879	2200	2489	2260
Sorghum (fodder)	0	0	0	0
Sole clusterbean	1719	2037	2951	2639
Sole greengram	741	903	1366	1213
Sole horsegram	829	935	1620	1032
CD at 5%	317			

Among the agronomic practices, foliar application of NPK @ 2.0% (during drought) produced significantly higher maize grain yield (2464 kg/ha) which was 32.5% higher over control (1860 kg/ha) (1738 kg/ha) (Table 1.2)

Table 1.1.2: Effect of agronomical practices and foliar spray on yield and economics of maize

Treatment	Grain yield (kg/ha)	Stover yield (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Control (normal practice)	1860	3623	16285	22530	2.38	2.26
Reduce 25% plant population	1642	3216	17005	17313	2.02	2.00
Remove lower leaves (4-5)	1952	3831	17365	23451	2.35	2.38
Soil stirring one time during drought	2161	4247	18985	26204	2.38	2.63
Thiourea spray 0.05%	2015	4023	17995	24301	2.35	2.45
Soluble NPK spray 2%	2464	4916	17905	33804	2.89	3.00
KNO_3 spary @1 % during drought	2098	4194	17105	26951	2.58	2.55
Ridging after 1st interculture	2313	4511	19225	29066	2.51	2.81
CD at 5%	326	496				

Preparedness

Cropping systems

During 2016, there was terminal drought (4th September, 2016 to till harvest) and the yields levels of maize and sesame crops were low. Blackgram (PU-31) gave highest MEGY (4213 kg/ha) followed by clusterbean (3677 kg/ha) which was 107 & 81% higher, respectively over sole maize PM-3 (2028 kg/ha) (Table 1.1.3).

Table 1.1.3: Yield and economics of different crops and cropping systems

Crop	Variety	MEY (kg/ha)		Gross returns (Rs/ha)	Net returns (Rs/ha)	B:C ratio
		Grain	Stover			
Maize	Navjot	2028	2694	37153	20308	2.21
	PM-3	2400	2878	43195	26350	2.56
	PM-5	2139	2306	37848	21003	2.25
	PEHM-2	2306	2806	41598	24753	2.47
Blackgram	T-9	3009	1710	49756	33041	2.98
	TAU-1	2744	1836	46124	29409	2.76
	Gujrat-1	2624	1746	44076	27361	2.64
	PU-19	3250	1512	52833	36118	3.16
	PU-31	4213	1500	67245	50530	4.02
Greemgram	RMG-62	1275	1110	24779	10554	1.74
	SML-668	1726	1272	32370	18145	2.28
Horsegram	AK-21	1373	1530	28391	14366	2.02
	AK-42	1667	1410	32191	18166	2.30
	AK-53	1618	1245	30614	16589	2.18
Clusterbean	RGC-936	2892	672	46810	30465	2.86
	RGC-1003	3407	726	54806	38461	3.35
	RGC-1022	3677	1020	60350	44005	3.69
Sesame	RT-46	2206	444	35355	21483	2.55
	RT-127	2451	511	39372	25500	2.84
Groundnut	Pratap Mungfali-2	2706	2478	53226	34576	2.85
	Pratap Raj Mungfali	2745	2040	51581	32931	2.77
	TG 37 A	3987	2370	71891	53241	3.85
	TAG 24	2850	2592	55965	37315	3.00
Sorghum	CSV-15	735	10500	37280	22225	2.48
	CSV-17	1348	6750	37096	22041	2.46
Maize + blackgram (2:2) ICS		2851	5208	69332	52677	3.2
Groundnut + sesame (6:2) ICS		2854	1734	51659	34169	2.0
Castor + greengram (1:2) ICS		2451	4098	57659	42809	2.9
Sorghum (fodder) MP Chari		0	9667	49301	40246	4.4
Cenchrus spp. (pasture) dry		0	2500	12750	8080	1.7

c. On-farm demonstrations

Village profile

The program is being implemented by AICRPDA centre, Arjia in Kochariya village, Suwana block, Bhilwara Tehsil, district and in Lapsiya village, Railmagra block and 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 vulnerability in general

The climate in this agro-climatic zone is semi-arid. 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 0.96^0C 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 2016-17

During 2016, in Kochariya village, onset of monsoon was normal (1st July). A rainfall of 354.1 mm was received which deficit by 303.6 mm compared to normal 657.7 mm (Fig 1.1.2). During South-West monsoon (*kharif),* 354.1 mm rainfall was received which was deficit by 260.4 mm (42.4%) than normal of 614.5 mm. During *rabi* and summer, there was no rain against normal of 20.2 and 15.1 mm, respectively.

During 2016, in Lapsiya village, onset of monsoon was normal (2nd July). A rainfall of 272 mm was received which was deficit by 385.7 mm compared to normal (657.7 mm) (Fig.). During South-West monsoon (June to September*),* 237 mm rainfall was received which was deficit by 377.5 mm than normal rainfall of 614.5 mm. During October- December, there was no rain as against normal of 20.2 mm and during summer (March - May), 14 mm rainfall was received against normal rainfall of 15.1 mm.

Normal onset of monsoon	: 2 July (Rajsamand), 1 July (Bhilwara)
Onset of monsoon during 2016-17	: 29 June (Lapsiya), 28 June (Kochariya)
Annual mean rainfall	: 657.7 mm
Annual rainfall during 2016-17	: 512.9 mm (Lapsiya), 758.0 mm (Kochariya)
Mean crop seasonal rainfall (*kharif* and *rabi*)	: 614.5 mm and 20.2 mm during *kharif* and *rabi*, respectively
Crop seasonal rainfall during 2016-17	: 584.0mm (Lapsiya) & 758.0 mm (Kochariya) during *kharif*

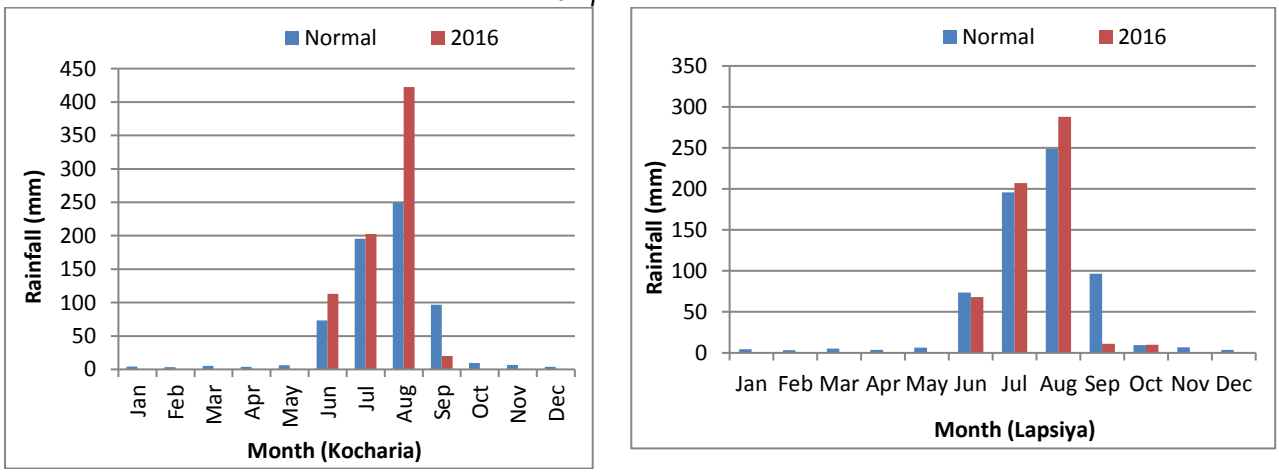

Fig. 1.1.2: Normal and actual (2016) monthly rainfall at Kocharia & Lapsiya

Dry spells during crop growing season (2016-17)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
>50	7 August till harvest	Maize	Grain filling and maturity

Real time contingency measure implemented

Weather aberration	Crop	Stage of crop	Real time contingency measure implemented
Terminal drought	Maize + blackgram (2:2) Groundnut + sesame (6:2)	Seed filling	Supplemental irrigation

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Terminal drought

A dry spell of more than 50 days occurred during 7 August till crop harvest coinciding with seed/grain filling and maturity. One supplemental irrigation given in maize + blackgram (2:2) intercropping system during mid to terminal drought gave 27.7% higher maize grain equivalent yield (3027 kg/ha) over farmers' practice (2370 kg/ha) with higher RWUE (4.69 kg/ha-mm), net returns (Rs33853/ha) and B:C ratio (2.79). Similar results were observed in Lapsiya village with the supplemental irrigation. In groundnut + sesame (6:2) intercropping system, supplemental irrigation at 65 DAS gave 32.2% higher groundnut pod equivalent yield (954 kg/ha) over farmers' practice (722 kg/ha) with higher RWUE (1.48 kg/ha-mm), net returns (Rs.30715/ha) and B:C ratio (2.50) and similar results were observed in Lapsiya village (Table 1.1.4).

Table 1.1.4: Performance of different intercropping systems under supplemental irrigation at Kochariya and Lapsiya

Intervention	Yield (kg/ha)						RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Grain/seed		Straw/stover		MEY				
	Maize	Blackgram	Maize	Blackgram	Grain	Straw			
Maize + blackgram (2:2) intercropping system									
Kochariya									
With supplemental irrigation	2625	125	3775	235	3027	4151	4.69	33853	2.79
Without supplemental irrigation	2065	95	3125	180	2370	3413	3.67	24168	2.38
Lapsiya									
With supplemental irrigation	2575	95	3650	225	2880	4010	5.58	32050	2.75
Without supplemental irrigation	2160	58	3065	165	2345	3329	4.54	23950	2.39
Groundnut + sesame (6:2) intercropping system									
	Pod/ seed		Straw/stover		GEY		RWUE (kg/ha-mm)	Net returns (Rs/ha)	BC ratio
	Groundnut	Sesame	Groundnut	Sesame	Pod	Stover			
Kochariya									
With supplemental irrigation	810	75	1575	190	954	1599	1.48	30715	2.50
Without supplemental irrigation	645	40	1310	130	722	1326	1.12	20420	2.09
Lapsiya									

With supplemental irrigation	795	63	1675	240	915	1705	1.77	30110	2.53
Without supplemental irrigation	660	38	1413	160	732	1433	1.42	22725	2.31

In Kochariya, foliar spray of 1% KNO_3 during drought resulted in 15.6% higher maize grain yield (2467 kg/ha), net returns (Rs 26492/ha) and B:C ratio (2.51) over farmers' practice (2133 kg/ha). Similar results were obtained in Lapsiya village, and improved practice gave 15.8% higher maize grain yield (2373 kg/ha), net returns (Rs.24968/ha) and B:C ratio (2.45) over farmers' practice (2050 kg/ha) (Table 1.1.5).

Table 1.1.5: Yield and economic of mid season correction in maize crop at Kochriya village

Treatment	Yield (kg /ha)		% increase in yield	RUWE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ ha)	B: C ratio
	Grain	Straw					
Kochariya							
With improved practice*	2467	3783	15.6	3.82	17500	26492	2.51
Without Improved practices	2133	3217	-	3.31	16200	21708	2.34
Lapsiya							
With improved practice	2373	3577	15.8	4.60	17200	24968	2.45
Without Improved practices	2050	3117	-	3.97	16400	20092	2.23

*Foliar spray of KNO_3 1%

Preparedness

Rainwater management

In-situ moisture conservation practices in maize at Kochariya village gave 22.8% higher grain yield (2708 kg/ha) over farmers' practice of ploughing twice (2205 kg/ha) with higher net returns (Rs.30086/ha), RWUE (4.20 kg/ha-mm) and B:C ratio (2.69). Similarly, at Lapsiya, the *in-situ* moisture conservation practices gave 26.1% higher grain yield (2595 kg/ha) over farmers' practice (2058 kg/ha). Similarly, *in-situ* moisture conservation practices demonstrated in sorghum at Kochariya gave 25.9% higher sorghum grain yield (2747 kg/ha) compared to farmers' practice of no *in-situ* moisture conservation (2180 kg/ha) with higher net returns (Rs.29718/ha), RWUE (5.02 kg/ha-mm) and B:C ratio (2.83). At Lapsiya, *in-situ* moisture conservation practices gave 27.8% higher grain yield (2817 kg/ha) with higher net returns (Rs.30567/ha), RWUE (5.46 kg/ha-mm) and B:C ratio (2.86) over farmers' practice (Table 1.1.6).

Table 1.1.6: Response of maize and sorghum to *in-situ* moisture conservation practices in Kochariya and Lapsiya villages

Crop	Intervention	Yield (kg /ha)			% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ ha)	B:C ratio
		Grain	Mean (6 yrs)	Stover				
Maize	**Kochariya**							
	With *in-situ* practices	2708	2600	4013	22.79	4.20	30086	2.69
	Without *in-situ* practices	2205	2126	3250	-	3.42	21945	2.29
	Lapsiya							

	With *in-situ* practices	2595	1766	3563	26.12	5.03	27736	2.58
	Without *in-situ* practices	2058	1451	2948	-	3.99	19474	2.17
Sorghum	**Kochariya**							
	With *in-situ* practices	2747	2747	5183	25.99	4.26	29718	2.83
	Without *in-situ* practices	2180	2180	3740	-	3.38	20360	2.34
	Lapsiya							
	With *in-situ* practices	2817	2817	5267	27.84	5.46	30567	2.86
	Without *in-situ* practices	2203	2203	3780	-	4.27	20640	2.35

Improved practice included soil & water conservation measures viz., peripheral bunding, deep ploughing, chieseling, tillage and sowing across the slope, soil mulching, and making ridges after sowing (30 DAS)

Cropping systems

Among different varieties of maize demonstrated in village Kochariya, improved variety (PEHM-2) gave 23.5% higher grain yield (2646 kg/ha) over the local cultivar (2143 kg/ha) with highest net returns (Rs.30069/ha) and B:C ratio (2.80) compared to local cultivar. Similar results were observed at Lapsiya village with PEHM-2 (Table 1.1.7).

Table 1.1.7: Yield and economics of maize varieties at Kochariya and Lapsiya villages

Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Grain	Straw				
Kochariya						
PEHM-2	2646	3880	23.5	4.10	30069	2.80
Local	2143	3248	-	3.32	22172	2.39
Lapsiya						
PEHM-2	2472	3826	19.1	4.79	27673	2.68
Local	2076	3058	-	4.02	20909	2.32

Among different varieties of sorghum, CSV-15 gave 28.6% higher grain yield (2884 kg/ha) over the local cultivar (2242 kg/ha) in Kochariya village. Similarly, in Lapsiya (Rajsamand), CSV-15 gave 28.9% higher sorghum grain yield (2748 kg/ha) over local cultivar (2132 kg/ha). CSV-15 also gave higher net returns (Rs. 31898/ha) and B:C ratio (3.04) than local varieties (Table 1.1.8).

Table 1.1.8: Yield and economics of sorghum varieties at Kochariya and Lapsiya villages

Variety	Yield (kg/ha)			% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Grain	Mean (6 yrs)	Straw				
Kochariya							
CSV-15	2884	2176	5156	28.6	4.47	31898	3.04
Local	2242	1668	4140		3.48	22074	2.45
Lapsiya							
CSV-15	2748	1940	5110	28.9	5.33	30501	3.00
Local	2132	1419	4180		4.13	21384	2.46

Among groundnut varieties demonstrated in Kochariya, TG 37A gave 68.5% higher pod yield (943 kg/ha) compared to local (560 kg/ha) with higher RWUE (1.46 kg/ha-mm), net returns (Rs.28920/ha) and B:C ratio (2.90). Similarly, the same variety of groundnut (TG 37A) at Lapsiya gave 50.3% higher pod yield (807 kg/ha) over local (537 kg/ha) (Table 1.1.9).

Table 1.1.9: Yield and economics of groundnut varieties at Kochariya and Lapsiya villages

Variety	Yield (kg/ha)			% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Pod	Mean (6 yrs)	Stover				
Kochariya							
TAG-24	843	1627	1883	50.6	1.31	28920	2.58
TG- 37A	943	1504	2140	68.5	1.46	34647	2.90
Local	560	820	1550	-	0.87	15020	1.86
Lapsiya							
TAG-24	730	1075	1493	36.0	1.41	22733	2.30
TG- 37A	807	1125	1707	50.3	1.56	27190	2.55
Local	537	355	1267	-	1.04	13240	1.78

Among blackgram varieties, in Kochariya, PU-31 gave 79.9% higher seed yield (747 kg/ha) compared to local (415 kg/ha) with higher RWUE (1.16 kg/ha-mm), net returns (Rs25673/ha) and B:C ratio (2.77) (Table 1.1.10). Similarly, the same variety of blackgram (PU-31) at Lapsiya gave 45.4% higher seed yield (625 kg/ha) over local (430kg/ha).

Table 1.1.10: Yield and economics of blackgram varieties at Kochariya and Lapsiya villages

Variety	Yield (kg/ha)			% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Seed	Mean (6 yrs)	Stover				
Kochariya							
T-9	668	537	1450	61.04	1.04	21375	2.47
PU-31	747	747	1643	79.92	1.16	25673	2.77
Local	415	351	1257	-	0.64	9602	1.68
Lapsiya							
T-9	553	334	1217	28.68	1.07	16087	2.18
PU-31	625	625	1460	45.35	1.21	20285	2.48
Local	430	260	952	-	0.83	10107	1.77

Among different varieties of sesame, RT-351 gave 137.1% higher seed yield (217 kg/ha) over the local cultivar (92 kg/ha) in Kochariya village. Similarly, in Lapsiya (Rajsamand), RT-351 gave 79.2% higher sesame seed yield (103 kg/ha) over local cultivar (58 kg/ha) (Table 1.1.11).

Table 1.1.11: Yield and economics of sesame varieties at Kochariya and Lapsiya villages

Variety	Yield (kg /ha)			% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Seed	Mean (3 yrs)	Stover				
Kochariya							
RT-351	217	217	627	137.1	0.34	9773	1.97
RT-127	183	119	528	98.9	0.28	6664	1.66
Local	92	74	413	-	0.14	-1393	0.86
Lapsiya							
RT-351	103	103	157	79.2	0.20	-522	0.95
RT-127	89	82	128	54.3	0.17	-1826	0.82
Local	58	58	110	-	0.11	-4255	0.55

In an on-farm demonstration, maize + blackgram (2:2) intercropping system at Kochariya, gave maximum MEY (2820 kg/ha), net returns (Rs.32338/ha), RWUE (4.37 kg/ha-mm) and B:C ratio (2.86) were recorded as compared to mixed cropping of maize and blackgram (Table 1.12). Similarly, in Lapsiya village, maximum MEY (2740kg/ha), net returns (Rs.30771/ha), RWUE (5.31 kg/ha-mm) and B:C ratio (2.78) was recorded with intercropping system of maize + blackgram (2:2) (Table 1.1.12).

Table 1.1.12: Yield and economics of maize + blackgram (2:2) intercropping system

Cropping system	Yield (kg/ha)		MEY (kg/ha)	% yield increase	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Maize	Blackgram					
Kochariya							
Maize + blackgram (2:2)	2403	130	2820	20.7	4.37	32338	2.86
Mixed cropping	2035	94	2336	-	3.62	24571	2.48
Lapsiya							
Maize + blackgram (2:2)	2323	130	2740	22.7	5.31	30771	2.78
Mixed cropping	1945	90	2234		4.33	22468	2.36

At Kochariya, groundnut + sesame (6:2) intercropping system gave maximum pod yield of groundnut (848 kg/ha) and seed yield of sesame (52 kg/ha), net returns of Rs.32958/ha, RWUE of 1.48 kg/ha-mm and B:C ratio of 2.82 compared to mixed cropping of both crops. Similarly, in Lapsiya, maximum groundnut equivalent yield (878 kg/ha), grain yield of maize (777 kg/ha) and seed yield of sesame (53 kg/ha), RWUE (1.70 kg/ha-mm), net returns (Rs.28850/ha) and B:C ratio (2.62) were recorded with groundnut + sesame (6:2) intercropping system compared to mixed cropping of both crops (Table 1.1.13).

Table 1.1.13: Yield and economics of groundnut + sesame (6:2)intercropping systems

Village	Cropping system	Yield (kg/ha)		GEY (kg/ha)	% yield increase	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Groundnut (Pod)	Sesame (Seed)					
Kochariya								
	Groundnut + sesame (6:2) intercropping	848	52	952	49.48	1.48	32958	2.82
	Groundnut and sesame mixed cropping	597	20	637	-	0.99	17422	1.99
Lapsiya								
	Groundnut + sesame (6:2) intercropping	777	53	878	43.21	1.70	28850	2.62
	Groundnut and sesame mixed cropping	562	27	613	-	1.19	16058	1.93

Similarly, sorghum + greengram (2:1) intercropping system at Kochariya gave maximum sorghum equivalent yield (3167 kg/ha) compared to farmers' practice of mixed cropping (2432 kg/ha) with higher net returns of Rs. 35688/ha and B:C ratio of 3.20 (Table). Similarly, at Lapsiya village, maximum sorghum equivalent yield (3417 kg/ha) was recorded with sorghum + greengram (2:1) intercropping system over farmers' practice of mixed cropping (Table 1.1.14).

Table 1.1.14: Performance of sorghum + greengram (2:1) intercropping system at Kochariya and Lapsiya villages

Treatment	Yield (kg/ha)		SEY (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Sorghum	Greengram	Grain	Mean (5 yrs)				
Kochariya								

Improved practice	2717	120	3167	2501	30.23	4.91	35688	3.20
Farmers' practice	2157	73	2432	1912	-	3.77	25653	2.67
Lapsiya								
Improved practice	2867	147	3417	2075	38.28	6.62	40225	3.59
Farmers' practice	2183	77	2471	1558	-	4.79	26382	2.76

In an on-farm demonstration, blackgram + sesame (2:2) intercropping system, at Kochariya, higher blackgram equivalent yield (657 kg/ha), net returns of Rs. 22595/ha and B:C ratio of 3.11 compared to farmers' practice of mixed cropping (500 kg/ha) (Table...). Similarly, at Lapsiya village, maximum blackgram equivalent yield (612 kg/ha) was recorded with blackgram + sesame (2:2) intercropping system over farmers' practice of mixed cropping (Table 1.1.15).

Table 1.1.15: Performance of blackgram + sesame (2:2) intercropping system at Kochariya and Lapsiya villages

Treatment	Yield (kg/ha)		BEY (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Blackgram	Sesame					
Kochariya							
Improved practice	410	123	657	31.3	1.02	22595	3.11
Farmers' practice	317	92	500	-	0.78	15280	2.51
Lapsiya							
Improved practice	392	110	612	43.3	1.19	20330	2.92
Farmers' practice	293	67	427	-	0.83	11737	2.17

Nutrient management

Application of zinc sulphate @ 25 kg/ha gave 18% higher maize grain yield (2445 kg/ha) over farmers' practice (2010 kg/ha) with higher net returns (Rs.26818/ha) and B:C ratio (2.59) at Kochariya. Similar results were recorded with application of 25 kg $ZnSO_4$/ha in maize in Lapsiya village (Table 1.1.16).

Table 1.1.16: Response of maize to application of zinc sulphate at Kochariya and Lapsiya villages

Treatment	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Grain	Straw				
Kochariya						
25 kg $ZnSO_4$/ha	2445	3775	21.6	3.79	26818	2.59
Control	2010	3188		3.12	18859	2.09
Lapsiya						
25 kg $ZnSO_4$/ha	2390	3683	22.2	4.63	26118	2.58
Control	1957	3017		3.79	19235	2.23

Site specific nutrient management involving application of 125% recommended nitrogen gave 17.8% higher sorghum grain yield (2693 kg/ha) over farmers' practice (2287 kg/ha) with higher net returns (Rs.29762/ha) and B:C ratio (2.94) at Kochariya (Table). Similarly, at Lapsiya, application of

125% nitrogen gave 24.3% higher sorghum grain yield (2725 kg/ha) over farmers' practice (2193 kg/ha) with higher net returns (Rs. 30019/ha) and B:C ratio (2.92) (Table 1.1.17).

Table 1.1.17: Response of maize to site-specific nutrient management at Kochariya and Lapsiya villages

Treatment	Yield (kg /ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Grain	Straw				
Kochariya						
SSNM	2693	5117	17.78	4.18	29762	2.94
Farmers' practice	2287	3983		3.55	22598	2.53
Lapsiya						
SSNM	2725	5188	24.29	5.28	30019	2.92
Farmers' practice	2193	4100		4.25	21510	2.43

Alternate land use

The major components of the silvi-pastoral system consisted of forages (*Cenchrus setgerus – CAZRI-76*) and perennial tree components in Lapsiya village. *In-situ* rainwater management (contour trenches at 8 m interval) was taken up as a critical input to stabilize the yields. Improved grasses with rainwater conservation practices performed better and gave higher mean dry grass yield (6590 kg/ha) as compared to local grass (2550 kg/ha) with higher net returns (Rs.16775/ha) and B:C ratio (3.33) compared to farmers' practice (Local grass) (Table 1.1.18).

Table 1.1.18: Yield and economics of silvipastoral system in Lapsiya village

Treatment	Gross yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	2016	Mean (5 yrs)			
Improved practice (*Cenchrus setigerus*)	6850	6590	7200	16775	3.33
Farmer practice (local grass*)	2550	2650	5000	100	1.02

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 2016-17

During 2016, the onset of monsoon was delayed by 4 days (9th June). A total rainfall of 545 mm was received which was deficit by 24.9 mm (4.4%) compared to normal (570 mm). Out of total rainfall 405.7 mm was received in *kharif* season which was 53.6 mm excess (15.2%) than normal of 352 mm. In *rabi*, it was 10 mm and was deficit by 134.0 mm (93.1%) than normal of 144 mm and in summer season, 112.0 mm rainfall was received which was excess by 40.5 mm (56.6%) than normal of 71.5 mm (Fig 1.2.1).

Normal onset of monsoon : 1-5 June
Onset of monsoon during 2016 : 9 June
Annual mean rainfall : 570 mm
Annual rainfall during 2016 : 545 mm
Mean crop seasonal rainfall during *kharif* and *rabi* : 352 & 144 mm, respectively
Crop seasonal rainfall during 2015-16 (*kharif* and *rabi*) : 405.7 & 10.0, respectively

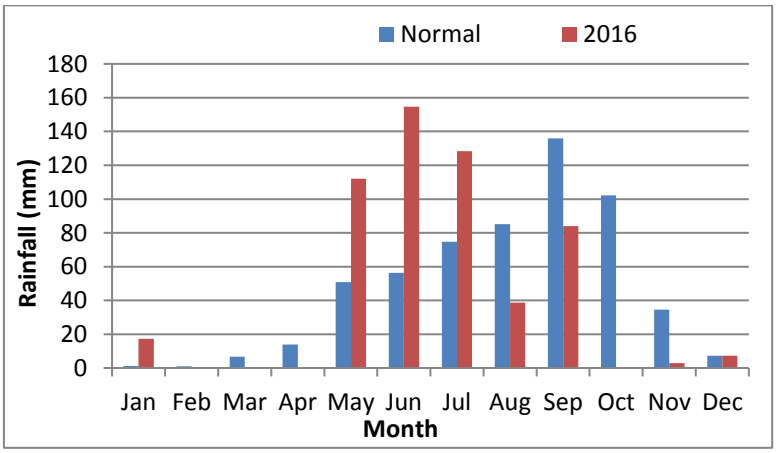

Fig. 1.2.1: Normal and actual (2016) monthly rainfall at Anantapuramu

Dry spells during crop growing season (2016)

Dry spell		Crop	Stage of the crop
Duration (days)	**Dates & months**		
22 days	30 June to 20 July	Groundnut, pigeonpea, castor, pearlmillet, foxtail millet	Vegetative
32 days	29 July to 29 August	Groundnut	Flowering to peg initiation
		Pigeonpea	Vegetative
		Castor	Flowering
		Bajra	Panicle initiation to grain formation
		Foxtail millet	Panicle initiation to grain

			formation
11 days	31 Aug to 10 Sept	Groundnut	Pegging to pod initiation
		Pigeonpea	Vegetative
		Castor	Flowering to spike initiation
		Bajra	Grain formation
		Foxtail millet	Grain filling
20 days	29 Sept to till date	Groundnut	Pod filling to maturity
		Pigeonpea	Flowering to pod initiation
		Castor	Spike development
		Bajra	Grain filling to maturity
		Foxtail millet	Grain filling to maturity

Real time contingency practices (RTCP) implemented

Weather Aberration	Crop	Real time contingency measure implemented
Early season drought	Groundnut	Sowing of drought tolerant groundnut varieties
	Pigeonpea	Sowing of high yielding pigeonpea variety PRG -176
Mid-season drought	Groundnut	Supplemental irrigation (20 mm) at pegging stage with farm pond water
	Pigeonpea	Supplemental irrigation (20 mm) through inline drip pipes at vegetative stage with farm pond water
	Castor	Supplemental irrigation (20 mm) through inline drip pipes at spike development stage with farm pond water

Salient achievements of on-station experiments

Real time contingency crop planning

Situation: Delayed onset of monsoon

Among the crops, higher groundnut equivalent yield (GEY) of 504 kg/ha was recorded with groundnut. However, the RWUE was higher with foxtail millet (2.36 kg/ha-mm) (Table 1.2.1).

Table 1.2.1: Yield of different crops sown in June

Crop	Yield (kg/ha)	GEY (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Groundnut	504	504	1.85	1146	1.05
Pigeonpea	355	369	1.25	5666	1.47
Castor	300	187	1.06	-7064	0.56
Foxtail millet	644	268	2.36	5842	1.83

Under delayed onset of monsoon, among different contingent crops, foxtail millet recorded highest yield of 529 kg/ha compared to other crops. Similarly, higher net returns of Rs.2558/ha and B:C ratio of 1.32 were also recorded with foxtail millet (Table 1.2.2).

Table 1.2.2: Yield of contingent crops sown in August

Contingent crop	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Horsegram	396	3.11	1120	1.16
Foxtail millet	529	4.16	2558	1.32
Pigeonpea	195	1.50	-2296	0.81
Castor	211	1.56	-9710	0.39
Clusterbean	142	1.15	-8298	0.25
Greengram	134	1.09	-3858	0.66
Cowpea	271	2.12	522	1.04
Groundnut (check)	154	1.20	-15654	0.32

Situation: Early season drought

During 2016, a dry spell of 22 days occurred during 30 June to 20 July coinciding with early vegetative stage of groundnut. Among drought tolerant groundnut varieties, K-9 recorded highest pod yield of 519 kg/ha, higher returns of Rs.1866/ha and B:C ratio of 1.08 compared to other varieties (Table 1.2.3).

Table 1.2.3: Yield of drought tolerant groundnut varieties

Variety	Pod yield (kg/ha)	% increase / decrease in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C Ratio
K- 9	519	3.0	1.90	1866	1.08
Harithandhra	486	-3.6	1.78	282	1.01
Dharani	458	- 9.1	1.68	-1062	0.95
K - 6 (Check)	504	-	-	-	-

Situation: Midseason drought

In 2016, there was a dry spell during 29th September onwards which coincided with pod development to maturity stages of groundnut, flowering to pod development in pigeonpea and spike development in castor. Supplemental irrigation (20 mm) was provided to crops with harvested rainwater in farm pond. Supplemental irrigation increased the yield by 58, 37 and 68% in groundnut, pigeonpea and castor, respectively. Groundnut gave higher net returns of Rs.10850/ha whereas, higher B:C ratio was recorded with pigeonpea (1.5) with supplemental irrigation (Table 1.2.4).

Table 1.2.4: Yield of dryland crops as influenced by supplemental irrigation

Crop	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With supplemental irrigation	Without supplemental irrigation				
Groundnut	727	458	58.7	2.67	10850	1.45
Pigeonpea	394	287	37.2	1.39	6554	1.50
Castor	498	300	66.0	1.76	-2300	0.87

c. On-farm demonstrations

Village profile

The program is being implemented in Vannedoddi villages 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 vulnerability 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 2016-17

During 2016, in Vannedoddi village, onset of monsoon was 4st June and total rainfall received was 442.1 mm which was deficit by 175.9 mm than normal of 618 mm. Out of the total annual rainfall received, *kharif* season recorded 332.1 mm (22.1% deficit than normal of 430 mm) and in *rabi* no rainfall was recorded against normal of 133 mm and summer rainfall was 120 mm over normal rainfall of 53 mm (Fig 1.2.2).

Normal onset of monsoon : 7-8 June
Onset of monsoon during 2016 : 4 June
Annual mean rainfall : 618 mm
Annual rainfall during 2016 : 442.1 mm
Mean crop seasonal rainfall during *kharif* and *rabi* : 430 and 133 mm, respectively
Crop seasonal rainfall during 2016 during *kharif* and *rabi* : 332.1 mm and 0 mm, respectively

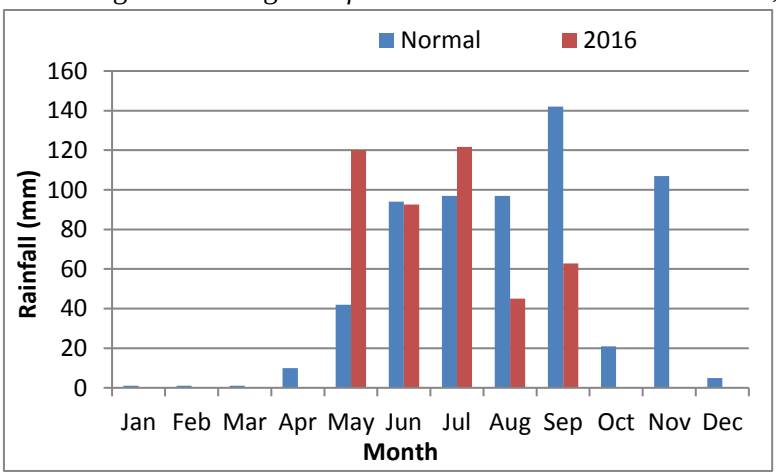

Fig. 1.2.2: Normal and actual (2016) monthly rainfall at Vannedoddi village

Dry spells during crop growing season (2016)

Dry spell		Crop	Stage of the crop
Duration (days)	**Dates & months**		
11	7-18 July	Groundnut	Vegetative
		Pigeonpea	
		Castor	
		Bajra	
		Foxtail millet	
27	2-29 August	Groundnut	Flowering to peg initiation
		Pigeonpea	Vegetative
		Castor	Flowering
		Bajra	Vegetative
		Foxtail millet	Vegetative

13	31 Aug to 14 September	Groundnut	Pegging to pod initiation
		Pigeonpea	Vegetative
		Castor	Flowering to spike initiation
		Bajra	Flowering to grain formation
		Foxtail millet	Flowering to grain formation
18	26 September to 13 October	Groundnut	Pod filling to maturity
		Pigeonpea	Flower initiation
		Castor	Capsule development

Real time contingency practices (RTCP) implemented

Weather aberration	Real Time Contingency practices (RTCP) implemented	
	Crop	**RTCP implemented**
Early season drought	Groundnut	Promotion of drought tolerant groundnut variety Dharani
	Pigeonpea	Promoting groundnut + pigeonpea intercropping system
	Groundnut + pigeonpea	Conservation furrows in groundnut + pigeonpea intercropping system
Midseason drought	Groundnut	Supplemental irrigation
		Mancozeb and carbendezim spraying against leaf spot

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Early season drought

During 2016, in Vannedoddi village, one dry spell of 11 days occurred in July, which mainly coincided with vegetative stage of different crops. Drought tolerant groundnut variety Dharani gave higher pod yield (573 Kg/ha), net returns (Rs.630/ha), B:C ratio and RWUE (2.02 kg/ha-mm) over K-6 (518 Kg/ha) (Table 1.2.5).

Table 1.2.5: Performance of drought tolerant groundnut variety

Variety	Pod yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Dharani	573	2.02	630	1.02
Farmers' variety (K-6)	518	1.83	-1986	0.93

Groundnut variety – Dharani

In-situ moisture conservation (conservation furrows) in groundnut + pigeonpea intercropping system (11:1) increased the yield by 10.8%, with higher net returns (Rs.3249/ha), B:C ratio (1.25) and RWUE (2.47 kg/ha-mm) compared to farmers' practice.

Situation: Mid-season drought

During 2016, in Vannedoddi village, the rainfed crops experienced two dry spells of duration 27 and 13 days (2-29 August and 31 August to 14 September) coinciding with flowering to peg initiation of groundnut, vegetative stage in pigeonpea, foxtail millet and cotton and flowering stage of the castor. Supplemental irrigation in groundnut from harvested rainwater in farm pond increased the yield by 15.8%, with higher net returns of Rs.5020/ha and B:C ratio of 1.18 compared to rainfed groudnut (Table 1.2.6).

Table 1.2.6: Influence of supplemental irrigation on the yield of groundnut

Crop	Yield (kg/ha)		RWUE (kg/ha-mm)		Net returns (Rs/ha)		B:C ratio	
	With irrigation	Without irrigation	IP	FP	With irrigation	Without irrigation	With irrigation	Without irrigation
Groundnut	690	596	2.44	2.10	5020	1758	1.18	1.07

Preparedness

Rainwater management

In-situ moisture conservation by deep tillage with chisel plough in groundnut recorded higher pod yield of 734 kg/ha compared to without intervention, higher net returns of Rs. 7120/ha and B:C ratio of 1.25 compared to without intervention (Table 1.2.7).

Table 1.2.7: *In-situ* moisture conservation by deep tillage with chisel plough in groundnut

Normal crop	Yield (kg/ha)		RWUE (kg/ha-mm)		Net returns (Rs/ha)		B:C ratio	
	With intervention (IP)	Without Intervention (FP)	IP	FP	IP	FP	IP	FP
Groundnut	734	638	2.59	2.25	7120	3750	1.25	1.14

Cropping systems

Groundnut and pigeonpea (11:1) intercropping system realized higher GEY of 699 kg/ha and net returns of Rs.6692/ha with the B:C ratio of 1.25 and RWUE of 2.47 kg/ha-mm compared to groundnut and pigeonpea at 20:1 ratio with GEY of 631 kg/ha, net returns of Rs.3443/ ha and B:C ratio of 1.13 (Table 1.2.8).

Table 1.2.8: Groundnut equivalent yield of groundnut + pigeonpea intercropping system

GEY (kg/ha)		% increase in yield	RWUE (kg/ha-mm)		Net returns (Rs/ha)		B:C ratio	
Groundnut + Pigeonpea (11:1) (IP)	Farmers practice (Groundnut + pigeonpea (20:1) (FP)		IP	FP	IP	FP	IP	FP
699	631	10.8	2.47	2.23	6692	3443	1.25	1.13

Energy management

Sowing of groundnut with bullock drawn seed drill resulted in 8.2% yield increase, higher net returns (Rs.5410/ha) and B:C ratio (1.22) over farmers' practice which recorded net returns of Rs.654/ha (Table 1.2.9).

Table 1.2.9: Effect of sowing of groundnut with bullock drawn groundnut seed drill

Pod yield (kg/ha)		RWUE (kg/ha-mm)		Net returns (Rs/ha)		B:C ratio	
Sowing with bullock drawn seed drill (IP)	Farmers practice	IP	FP	IP	FP	IP	FP
620	573	2.19	2.02	5410	654	1.22	1.02

Similarly, sowing of groundnut with Anantha groundnut planter resulted in 9.0% yield increase with higher net returns (Rs.4258/ha) and B:C ratio (1.17) over farmers practice (Table 1.2.10).

Table 1.2.10: Effect of sowing of groundnut with tractor drawn anantha groundnut planter

Yield (kg/ha)		RWUE (kg/ha-mm)		Net returns (Rs/ha)		B:C ratio	
With intervention (IP)	Without Intervention (FP)	IP	FP	IP	FP	IP	FP
596	545	2.10	1.92	4258	-690	1.17	0.97

Sowing of groundnut with tractor drawn Anantha groundnut planter

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 2016-17

During 2016, the onset of monsoon was delayed by 4 days (6thJuly). A rainfall of 1070.5 mm was received which was excess by 408 mm compared to normal (662.5 mm). During south-west monsoon (*kharif*), 991.2 mm rainfall was received which was excess by 404.1 mm (68.8%) as against normal of 587.1 mm. During north-east monsoon (October-December), 19.3 mm rainfall was received which was deficit by 9.2 mm compared to normal (28.5 mm). During summer (March -May), 55 mm of rainfall was received which was excess by 31.6 mm compared to normal (23.4 mm) (Fig. 1.3.1). The crop experienced dry spell of 20 days from 02-21 September at flowering stage of crops and second dry spell of 12 days at grain filling stage from 23 September to 4 October.

Normal onset of monsoon : 2 July
Onset of monsoon during 2016-17 : 6 July
Annual mean rainfall : 662.5 mm
Annual rainfall during 2016-17 : 1070.5 mm
Mean crop seasonal rainfall during : 587.1 and 28.5 mm *kharif* and *rabi*, respectively
Crop seasonal rainfall during 2016-17 : 991.2 mm and 19.3 mm *kharif* and *rabi*, respectively

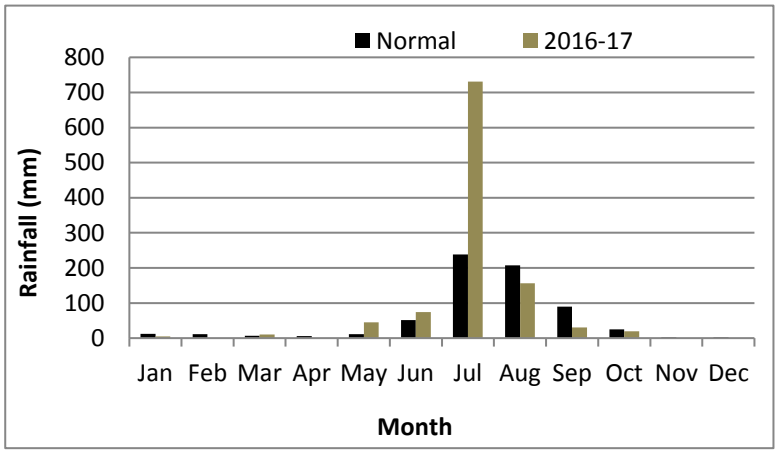

Fig. 1.3.1: Normal and actual (2016) monthly rainfall at Agra

Dry spell during crop growing season (2016)

Dry spell		Crops	Stage of the crop
Duration (days)	**Dates & months**		
20	02-21 September	Pearl millet, greengram, clusterbean, sesame	Vegetative
12	23 September to 4 October	Pearlmillet	Grain formation
		Greengram, clusterbean	Grain development
		Sesame	Capsule maturity

Real time contingency practices (RTCP) implemented: Nil

Salient achievements of on-station experiments

Real time contingency planning

Situation: Normal onset of monsoon but delay sowing

Different crops were evaluated under two sowing methods i.e. ridge and furrow and flat bed system. Pearl millet (Pro-ago-9450), sesame (Shekhar), clusterbean (RGC-1017) and greengram (Satya) were sown on 9 August as contingency crops after failure of the first sowing due to heavy rains of 552 mm in a span of 10 days from 8 to18 July (Table 1.3.1).

Table 1.3.1: Performance of various crops as influenced by sowing time and system of planting

Treatment	Yield (kg/ha)			PMEY (kg/ha)		% yield increase over PM sole	Net returns (Rs/ha)	B:C ratio
	Grain/ seed (2016)	Mean (4yrs)	Stalk (2016)	2016	Mean (4yrs)			
Flat bed sowing								
Pearlmillet	2210	2056	5570	2210	2056	---	24453	2.21
Blackgram	425	363	1003	1210	1603	(-) 45.2	3700	1.26
Greengram	495	397	1212	1375	1842	(-) 37.8	5670	1.39
Sesame	495	347	2100	2248	2791	1.7	19685	2.46
Clusterean	575	484	1860	1311	2772	(-) 40.7	5089	1.36
Pearl millet + clusterbean (4:4)	1360 + 340	1167 + 294	3500+ 1200	2135	2785	(-) 3.4	20371	2.24
Ridge & furrow system								
Pearlmillet	2504	2517	6902	2504	2516	---	28663	2.54
Blackgram	498	449	1215	1418	2029	(-)43.4	6641	1.46
Greengram	562	489	1461	1562	2328	(-)37.6	8292	1.56
Sesame	550	407	2660	2498	3275	(-) 0.2	23370	2.73
Clusterean	655	601	2290	1494	3486	(-)40.3	7781	1.54
Pearlmillet + clusterbean (4:4)	1560+ 395	1434+ 339	3904+ 1343	2461	3341	(-) 1.7	25777	2.57

PMEY- Pearlmillet equipment yield

Despite long dry spell of 20 days from 2 to 21 September at flower initiation stage, all the crops performed well due to required moisture available in soil profile. Even under delayed sowing conditions, all the six crops sown on ridge by ridger seeder, gave 13.3, 17.2, 13.6, 11.2, 14.0 and 15.3 per cent higher yield as compared to flat system of sowing. Pearlmillet cv. Pro-agro 9450 planting on ridge (45 cm + 15 cm) recorded highest grain yield of 2504 kg/ha, net returns of Rs.28663/ha with RWUE of 2.5 kg/ha-mm. Sesame gave second highest PEY (2498) followed by pearl millet + cluster bean (2461kg/ha.). The maximum B:C ratio of 2.73 was obtained with sesame followed by pearlmillet + clusterbean (4:4) strips cropping (2.57) due to lesser cost of cultivation under ridge and furrow system of sowing.


Pearlmillet sole **Pearl millet +clusterbean (4:4)**

Preparedness

Rainwater management

In-situ moisture conservation with summer ploughing by MB plough and sowing by ridger seeder in pearlmillet produced 75.8% higher grain yield of pearlmillet (3375 kg /ha) as compared to yield obtained in conventional tillage with broadcasting (1920 kg/ha. Further, summer ploughing by MB plough in combination of ridge and furrow system of planting recorded higher net returns of Rs.31645/ha, B:C ratio (2.75) and RWUE (30.30 kg/ha-mm) as compared to conventional tillage with broadcasting (Table 1.3.2).

Table 1.3.2: Effect of tillage and planting methods on yield and economics

Treatment	Grain yield (kg/ha)			% yield increase over CT+BC	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	2016	Mean (5yrs)	Stover				
Conventional tillage + broadcasting	1920	1697	5833	---	17.24	19601	2.12
Conventional tillage + ridger seeder	2299	2313	6733	19.74	20.63	25636	2.44
Summer tillage (MB plough) + broadcasting	2410	2141	6900	25.52	21.63	28219	2.60
Summer tillage (MB plough) + ridger seeder	3375	3080	9766	75.78	30.30	31645	2.75

CT – Conventional tillage, BC – Broadcasting

Cropping systems

Under delayed sowing and terminal drought situation. Pro-Agro-9450 gave higher grain yield of 2498 kg/ha over HHB-67 (2167 kg/ha) and MPMH-17(2240 kg/ha) (Table). The increase in yield was to the extent of 15.3 and 11.5% with Pro-Agro-9450 over the HHB-67and MPMH-17, respectively. Higher net returns of Rs 28525/ha and B:C ratio of 2.53 were realized with Pro-Agro-9450 followed by 86M88 (Table 1.3.3).

Table 1.3.3: Performance of pearlmillet hybrids

Hybrid	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Grain	Stover			
Pro-agro 9450	2498	6869	22.42	28525	2.53
86-M-88	2375	6650	21.31	26382	2.42
MPMH-17	2240	6361	20.10	23957	2.29
HHB-67	2167	6262	19.45	22732	2.22

Clusterbean var. RGC- 1055 produced 6% higher seed yield (655 kg/ha) than RGC-1017 (620 kg/ha), with highest net returns (Rs.7656/ha), B:C ratio (1.53) and RWUE (5.88 kg/ha-mm) (Table 1.3.4).

Table 1.3.4: Performance of clusterbean varieties

Variety	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Seed	Stover			
RGC-1055	655	2290	5.88	7656	1.53
RGC-1017	620	2207	5.56	6479	1.45

Under delayed sowing condition, highest seed yield (550 kg/ha), net returns of Rs.23239/ha and B:C ratio of 2.71 were recorded with shekher variety of sesame compared to HT-1 (Table 1.3.5).

Table 1.3.5: Performance drought tolerant variety of sesame

Variety	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Seed	Stover			
Shekhar	550	2660	4.94	23239	2.71
HT-1	498	2241	4.47	19755	2.45

Sesame var. Shekhar

Sesame var. HT- 1

Sowing of mustard in 2nd week of October produced significantly higher seed and stalk yield (2485 and 6240 kg/ha) which was 64.8, 10.3, 27.4, and 31.6% higher yield as compared to yield recorded with sowing of 4th week of September, 1st , 3rd and 4th week of October, respectively. (Table 1.3.6). Mustard sown in 1st week of October was next best planting time. Sowing of mustard in the 4th week of September produced lowest yield as compared to other planting times.

Table 1.3.6: Influence of sowing time on yield and economics of mustard

Sowing time	Yield (kg/ha)		Net returns (Rs/ha)	B:C ratio
	Seed	Stalk		
4th Week of September (D1)	1508	4129	46699	3.55
Ist week of October (D2)	2252	5624	77957	5.26
2nd week of October (D3)	2485	6240	87968	5.81
3rd week of October (D4)	1951	5254	65663	4.59
4th week ofOctober (D5)	1889	4835	62617	4.42
CD at 5%	183	909	--	--

Mustard an Giriraj (DRMRIJ-31) produced significantly higher seed and stalk yield (2203 and 5487 kg/ha) as compared to other varieties. The highest net returns (Rs.75841/ha) and B:C ratio of 5.14 was also recorded with mustard an Giriraj (Table 1.3.7).

Table 1.3.7: Performance of mustard varieties

Variety	Yield (kg/ha)		Gross returns (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Seed	Stalk			
RH-749	2150	5544	92166	73859	5.03
RH-406	1970	4884	84156	65849	4.60
NRCDR	1781	4833	76709	58402	4.19
NRCBH-101	1981	5334	84870	66563	4.64
Giriraj	2203	5487	94148	75841	5.14
CD at 5%	135	622			

In an evaluation of strip cropping of pearmillet with clusterbean and sesame, highest pearlmillet equivalent yield of 2900 kg/ha was recorded with pearmillet + sesame (4:4) sown on ridge (4:4) with higher net returns (Rs. 32742/ha) and B:C ratio (3.03). Lowest net returns (Rs.7741/ha) and B:C ratio of 1.54 was obtained with clusterbean grown as sole crop (Table 1.3.8).

Table 1.3.8: Effect of strip cropping system on yield and economics

Treatment	Yield (kg/ha)		RWUE (kg/ha-mm)	PMEY (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Grain/ seed	Stover					
Pearlmillet (sole) Pro-agro 9450	2504	6902	22.47	2504	18624	28663	2.54
Clusterbean (sole) RGC-1055	655	2290	5.88	1494	14384	7781	1.54
Sesame (sole) Shekhar	550	2660	4.94	--	13611	23370	2.73
PM + CB (4:4)	1560+395	3904+1343	---	2461	16380	25777	2.57
PM + sesame (4:4)	1560+295	4056+1357	---	2900	16117	32742	3.03

PM: Pearlmillet; CB: Clusterbean; PMEY- Pearlmillet equivalent yield

Nutrient management

Summer ploughing appreciably enhanced mustard yield by 20.4% compared to conventional ploughing (1738 kg/ha). The highest net retunrs of Rs.101353/ha was obtained with 25% more RDF applied along with summer ploughing during rainy season, which gave additional income of Rs.21093/ha over conventional tillage with 25% more RDF application (Table 1.3.9).

Table 1.3.9: Influence of summer ploughing with fertilizer application on mustard

Treatment	Yield (kg/ha)		RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Seed	Stalk				
Conventional ploughing + RDF	1738	4508	7.04	18590	55954	4.01
Conventional ploughing + 25% more RDF	2316	6331	8.77	19560	80260	5.10
Summer ploughing + RDF	2093	5841	8.48	19390	70998	4.66
Summer ploughing + 25 % more RDF	2826	7666	9.87	20360	101353	5.98
CD at 5%	431	1372				

c. On-farm demonstrations

Village profile

The programme is being implemented in village Nagla Dulhe Khan of Faziyatpura Block, tehsil Kheragarh in district Agra, Uttar Pradesh. The total cultivated area is 981 ha out of which 878 ha is rainfed. The mean annual rainfall is 665 mm with seasonal rainfall of 589 mm during *kharif* (June-September). The major soil types are sandy loam to loamy sand. The major rainfed crops during *kharif* are pearlmillet, pigeonpea, greengram, blackgram and sesame and during *rabi* are mustard, barley, chickpea, lentil and linseed. The numbers of small, medium and large farmers are 326, 256 and 37, respectively. The ground water table is 40 m which is saline in nature. The source of irrigation is bore wells covering 30% of cultivated area.

Climate vulnerability in general

In general, the climate in this agro-climatic zone is semi arid, with heat waves during summer (March to mid June). The south-west monsoon contributes 88%, winter rains 9.0% and summer 2.5% of the total annual average rainfall of 665 mm. Historical rainfall data (of 30 years) indicated that the variability in rainfall during south-west monsoon was 30.5% of the average rainfall. The onset (south-west) of monsoon is in the 1st week of July (27th SMW). The temperature reaches 48^{o}C in June and as low as up to 1.0^{o}C or below during January. Heat wave during summer and cold wave during winter are common along with frost or foggy conditions during crucial crop growth stages. The dry spells during crop season had been experienced, for the past 10 years, in July, August and September respectively at germination, vegetative and grain formation stage of the major rainfed crops. The onset of monsoon was during 20th June to 15th July in the last 38 out of 40 years. The withdrawal of monsoon was during 10th September and 25th September in 29 out of 40 years. In 8 years, withdrawal was noticed after 25th September and too early withdrawal was registered in three years i.e. 1979 (11th August), 2001 (26th August) and 2006 (16th August).

Experienced weather conditions during 2016-17

During 2016, the onset of monsoon was delayed by 2 days (4th July). A rainfall of 983.4 mm was received which was excess by 320.9 mm compared to normal (662.5 mm) (Fig. 1.3.2). During south-west monsoon (*kharif)*, 902.9 mm rainfall was received which was excess by 315.8 mm as against 587.1 mm; during *rabi* (October-December), there was 22.0 mm rainfall which was deficit by 6.5 mm as against normal of 28.5 mm. During summer (March-May), there was 54.5 mm of rainfall which was excess by 31.1 mm compared to normal (23.4 mm).

Normal onset of monsoon : 2 July
Onset of monsoon during 2016-17 : 4 July
Annual mean rainfall : 662.5 mm
Annual rainfall during 2016-17 : 983.4 mm
Mean crop seasonal rainfall during *kharif* and *rabi* : 587.1 and 28.5 mm, respectively
Crop seasonal rainfall during 2016-17 *kharif* and *rabi* : 902.9 mm and 22.0 mm, respectively

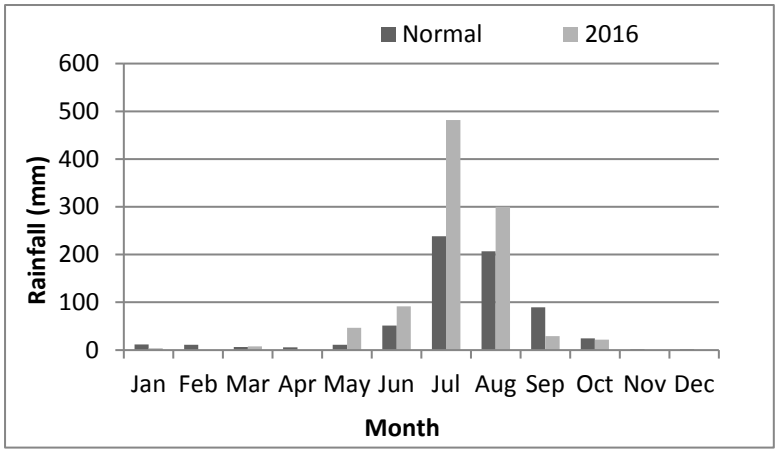

Fig.1.3.2: Normal and actual (2016) monthly rainfall in Nagla Dulhe Khan Village

Dry spell during crop growing season (2016-17)

Dry spell		Crop	Stage of the crop
Duration (days)	**Date & month**		
26	7 September to 4 October	Pearlmillet, greengram, Blackgram, sesame	Grain development and maturity

Real time contingency practices (RTCP) implemented - Nil

Salient achievements of on-farm demonstrations

Preparedness

Rainwater management

Demonstrations on sowing of pearlmillet (Pro-Agro-9450**)** on ridges at both corners by ridger seeder, revealed that highest yield was recorded under ridger seeder (2615 kg/ha) compared to yield (1795 kg/ha) under broadcasting system. The highest net returns of Rs.31865/ha, B:C ratio (2.87) and RWUE (6.59 kg/ha-mm) was also registered under ridger seeder sowing.

Ridge sowing of pearlmillet

Pearlmillet - broadcasting

Similarly, the highest pearlmillet yield of 2260 kg/ha was recorded with compartment bunding compared to farmers practices (1690 kg/ha), with higher net returns of Rs. 25162/ha, B:C ratio of 2.48 and RWUE of 5.70 kg/ha-mm (Table 1.3.10).

Table 103.10: **Effect of compartment bunding on pearlmillet yield and economics**

Treatment	Grain yield (kg/ha)		% increase in yield	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2016	Mean (2011-16)					
Compartment bunding (IP)	2260	2175	33.7	16973	25162	2.48	5.70
No compartment bunding	1690	1762	-	15994	15040	1.94	4.26

The deep ploughing in summer with mould board plough produced higher mustard seed yield of 2202 kg/ha compared to without deep ploughing (1775 kg/ha), with highest net returns of Rs. 76481/ha and B:C ratio of 5.80 (Table 1.3.11).

Table 1.3.11: Performance of mustard (Giriraj) under deep ploughing in summer on farmer's field

Treatment	Yield (kg/ha)		% increase over FP	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Seed	Stalk				
Deep summer ploughing (IP)	2202	4336	24.1	15920	76481	5.80
Conventional ploughing (FP)	1775	3468	-	15758	58669	4.72
CD at 5%	289	-	-			

Mustard with deep tillage

Mustard with conventional tillage

The increase in mustard yield (2177 kg/ha) was 21.3% with tillage after each effective rainfall over farmers' practice (1794 kg/ha) with highest net returns of Rs. 73807/ha and B:C ratio of 5.44 (Table 1.3.12).

Table 1.3.12: Effect of *in-situ* moisture conservation practices on mustard yield and economics

Treatment	Yield (kg/ha)		% increase over FP	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Seed	Stalk				
Tillage after each effective rainfall (IP)	2177	4690	31.4	16620	73807	5.44
Local practice (FP)	1794	3490		15758	59433	4.77
CD at 5%	311.9					

Cropping systems

Pearlmillet hybrid Pro-agro-9450 gave highest grain yield of 2412 kg/ha, compared to 86-M-88 (2358 kg/ha) with highest net returns of Rs.28995/ha and B:C ratio of 2.72 (Table 1.3.13).

Table 1.3.13: **Performance of pearlmillet hybrids**

Hybrid	Grain yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
Pro-agro- 9450	2412	6.08	16803	28995	2.72
86 M 88	2358	5.94	16803	26341	2.56

Sesame variety Shekhar gave higher seed yield of 413 kg/ha, compared to HT-01 (375 kg/ha), with highest net returns of Rs. 14082/ha and B:C ratio of 2.03 (Table 1.3.14).

Table 1.3.14: **Performance of sesame varieties under normal onset of monsoon**

Variety	Seed yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
Shekhar	413	10.1	1.04	13611	14082	2.03
HT-1	375		0.94	13611	11514	1.84

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Cluster bean variety, RGC 1017 gave higher seed yield of 504 kg/ha, compared to HG-220 (480 kg/ha), with maximum net returns of Rs. 2325/ha and B:C ratio (1.17) (Table 1.3.15).

Table 1.3.15: **Performance of clusterbean varieties**

Variety	Yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
HG-220	480	0.83	14384	1768	1.12
RGC-1017	504	1.27	14384	2325	1.17

Strip cropping of pearlmillet in association with clusterbean (4:4) gave maximum pearlmillet equivalent yield of 1880 kg/ha, which was 15.3% higher than pearlmillet sole (1630 kg/ha) (Table 1.3.16). The highest net returns of Rs.17883/ha and B:C ratio (2.14) was also obtained under strip cropping compared to pearl millet sole.

Table 1.3.16: Effect of strip cropping system demonstrated under normal onset of monsoon and terminal drought conditions

Cropping system	Yield (kg/ha)		PMEY (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	2016	Mean (2011-16)	2016	Mean (2011-16)			
Pearlmillet + clusterbean Strip cropping system	1328+ 242	1213+ 282	1880	2907		17883	2.14
Sole pearlmillet	1630	15492	1630	1549	4.11	14288	1.89

Pearl millet + clusterbean (4:4)

Pearlmillet sole

Similarly, pearlmillet + sesame strip cropping system (4:4) gave highest pearlmillet equivalent yield of 2542 kg/ha compared to sole pearlmillet (1630 kg/ha), with highest net returns (Rs.28516/ha) and B:C ratio (2.87) (Table 1.3.17).

Table 1.3.17: **Performance of pearlmillet under sole and strip cropping system with sesame (4:4)**

Cropping system	Yield (kg/ha)		PMEY (kg/ha.)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Grain 2016	Mean (2011-16)	2016	Mean (2011-16)			
Pearlmillet + sesame strip cropping	1465+ 237	1235+238	2542	3153	2.87	28516	2.87
Sole pearlmillet	1630	1659	1630	1659	1.89	14285	1.89

PMEY- Pearlmillet equivalent yield

Mustard cv. Giriraj gave higher seed yield 2142 kg/ha followed by RH-749 (2052 kg/ha) and NRCHB-101 (1930 kg/ha). The highest net returns of Rs.74759 and B:C ratio of 5.69 were also recorded with Giriraj followed by RH-749 with Rs. 70843/ha and B:C ratio 5.45 (Table 1.3.18).

Table 1.3.18: Performance of mustard varieties

Variety	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Seed	Stalk			
RH-749	2052	4475	15920	70843	5.45
Giriraj	2142	4748	15920	74759	5.69
RH-406	1902	3700	15920	63827	5.00
NRCHB-101	1930	3601	15920	65121	5.09
NRCDR-2	1755	3396	15920	57619	4.62
CD at 5%	323.7				

Among barley varieties, Narendra-2 gave higher grain yield (2880 kg/ha) compared to K-551(2685 kg/ha), with higher net returns of Rs.41629/ha and B:C ratio(3.16) (Table 1.3.19).

Table 1.3.19: Performance of different varieties of barley on farmer's field.

Varieties	Yield (kg/ha)		Harvest index	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Grain	Stalk				
K-551	2685	5765	31.84	19311	36153	2.87
Narendra-2	2880	6713	30.03	19311	41629	3.16
CD at 5%	NS					

Nutrient management

In demonstrations on sesbania-mustard crop sequence mustard grown after green manuring gave higher seed yield of 2287 kg/ha, net returns of Rs.78860/ha and B:C ratio (5.50) compared to fallow-mustard sequence (1862 kg/ha). The green manuring - mustard cropping system produced additional income of Rs.16603/ha over without green manuring (Table 1.3.20).

Table 1.3.20: **Performance of mustard with green manuring on farmers' fields**

Crop sequence	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Seed	Stalk			
Green manuring (sesbania)-mustard	2287	4845	17620	78860	5.50
Fallow –mustard	1862	3585	15758	62257	4.94
CD at 5%	372	-	-	-	-

In pearlmillet, highest grain yield of 2549 kg/ha was recorded with split application of nitrogen compared to farmers' practice (1852 kg/ha) (Table 1.3.21), with higher net returns of Rs.30820/ha and B:C ratio of 2.82. During dry period, one life saving irrigation was given at the time of flowering to grain formation stage.

Table 1.3.21: Effect of split application of N on pearlmillet yield and economics

Treatment	Grain yield (kg/ha)	RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
N in three equal splits (1/3rd each at sowing, tillering and jointing stage)	2549	6.43	17058	30820	2.82
Farmers practice	1842	4.67	15994	17945	2.12

Application of 50 kg/ha K in mustard along with RDF improved the yield (2555 kg/ha) by 33.4% over farmers' practice of no K application (1915 kg/ha), with highest net returns of Rs.91196/ha and B:C ratio (6.30) (Table 1.3.22).

Table 1.3.22: Effect of potassium application on mustard yield and economics

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Grain	Stalk			
RDF + 50 kg K_2O (IP)	2555	5803	17192	91196	6.30
RDF (FP)	1915	3640	15758	64387	5.10
CD at 5%	675				

RDF: 60:40 kg/ha N&P

1.4 HISAR

a. Agro-ecological setting

Hisar is located in Western Plain, Kachchh and part of Kathiawar peninsula, Rajasthan Bagar, NorthGujaratPlainandSouth-westernPunjabplain (*AESR2.3)*andSouth-westerndryzoneinHaryana. Theclimateishotarid.Annualrainfallis411mm. Annual potential evapotranspiration is 769 mm.

b. On-station experiments

Experienced weather conditions during 2016-17

During 2016, the onset of monsoon was normal (3rd July) and an annual rainfall of 422.3 mm was received which was excess by 10.3 mm (2.5%) compared to normal (412 mm) (Fig.1.4.1). During *kharif*392.3 mm rainfall was received which was excess by 56.5 mm (16.83%) than normal of (335.8 mm). In *rabi*, 30.0 mm rainfall was received which was 20.8mm excess than normal (9.2 mm).

Normal onset of monsoon	: 1st week of July
Onset of monsoon during 2016-17	: 3rdJuly
Annual mean rainfall	: 412 mm
Annual rainfall during 2016-17	: 422.3 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	:335.8 (*kharif*) and 9.2 mm (*rabi*)
Crop seasonal rainfall during 2016-17 (*kharif*&*rabi*)	:392.3 mm (*kharif*) and 30.0 mm (*rabi*)

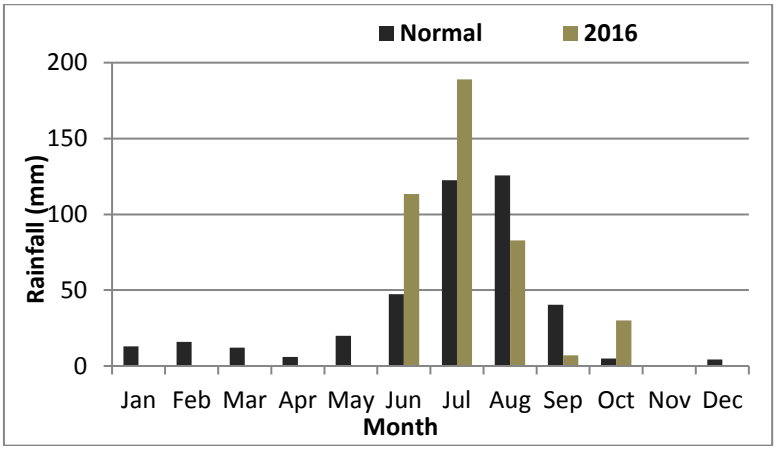


Fig.1.4.1: Normal and actual (2016) monthly rainfall at Hisar

Dry spells during crop growing season (2016)

Dry spells (days)	High intensity rainfall/floods	Stages of the crop
21 (29 July to 18 August)	-	Vegetative and reproductive
27 (30 August to 25 September)	50 mm (29 August)	Reproductive and maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	Real time contingency measure implemented
Mid season drought	Pearlmillet Cluster bean Greengram	Seed/grain filling	Mechanical weeding/ hoeing by *kasola* and wheel hand hoe. Harvest of every 3rd row of pearl millet for green fodder 30 DAS Spray water on crops to avoid white fly.

Terminal drought	Pearlmillet luster bean Greengram		Supplemental irrigation

Salient achievements of on-station experiments

Real time contingency planning

Situation: Mid season drought

During *kharif* season, there was long dry spell of 21 days (29thJuly to 18thAugust) coinciding with the flowering and grain filling stage of rainfed crops.*In-situ* moisture conservation and weeding with traditional *kasola* and wheel hand hoe has been done. Weeding/interculture increased the crop yield in pearlmiller, clusterbean and greengram (4.04, 7.5 and 13.3%, respectively). Similarly, netreturns, B:C ratio and RWUE of the crops also increased due to weeding/interculturing (Table 1.4.1).

Table 1.4.1: Effect of interculture/weeding on crop yield and economics

Crop	Hybrid/ variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With weeding/ interculture	Without weeding/ interculture				
Pearlmillet	HHB-67	1852	1780	4.04	8.7* 8.4	24632* 23674	1.4* 1.4
Clusterbean	HG-870	1280	1190	7.5	6.1* 5.2	39680* 36890	2.1* 2.2
Greengram	MH-421	680	600	13.3	3.2* 2.8	35496* 31350	2.1* 2.0

* Intervention

All high yielding varietiesneed optimum nutrition for good harvests; recommended dose of fertilizer application increased the yield of all the crops tested. The yield of the pearlmillet, clusterbean and mungbean was increased by 6.4, 4.6 and 4.2%, respectively when compared to farmers practice. Similarly, net returns, B:C ratio and RWUE of the crops also high with fertilizer application (Table 1.4.2).

Table 1.4.2: Effect of package of practices on yield and economics of crops under drought conditions

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C
		With intervention	Without intervention				
Pearl millet	HHB-67 Improved	1925	1805	6.4	9.4* 8.5	25602* 24006	1.4* 1.4
Clusterbean	HG-870	1305	1205	4.6	6.1* 5.6	40455* 37355	2.1* 2.2
Mungbean	MH-421	710	675	5.2	3.3* 3.1	37062* 35235	2.2* 2.2

* Intervention

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 vulnerability 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 south-west 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/-0.071^{0}C) 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 in Balawas during 2016-17

The onset of monsoon was normal (1st July). An annual rainfall of 289 mm was received which was deficit by11.0 mm (3.8%) mm compared to normal (300 mm) (Fig 1.4.2). During *kharif*, 279 mm rainfall was received which was excess by 68.3 mm (32.4%) than the normal (210.7 mm); *rabi* season recorded 10 mm rainfall as against normal of 22 mm.

Normal onset of monsoon	: 1st week of July
Onset of monsoon during 2016-17	: 1st July
Normal annual mean rainfall	: 300 mm
Actual annual rainfall during 2016-17	: 289 mm
Mean crop seasonal rainfall during *kharif* &*rabi*	: 210.7 and22 mm, respectively
Crop seasonal rainfall during 2016-17*(kharif*and *rabi)*	:279 and 10 mm, respectively

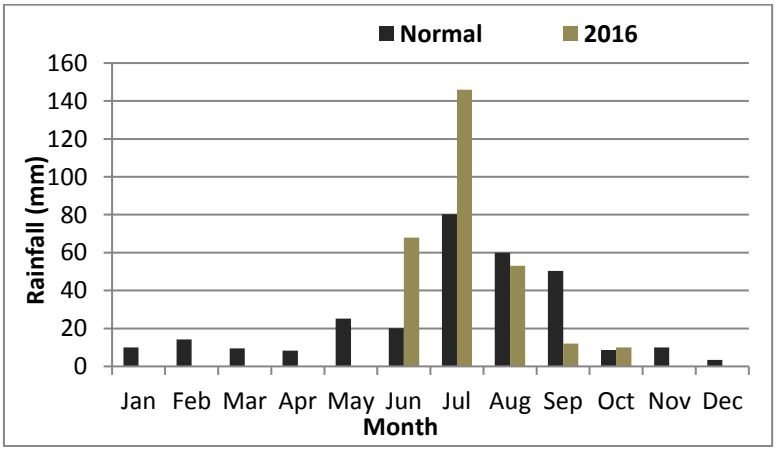


Fig.1.4.2: Normal and actual monthly rainfall (2016) at Balawas

Dry spells during crop growing season (2016)

Dry spell		Crop	Stage of the crop
Duration	**Dates & Months**		
24 days	31 July to 23August	Pearl millet, clusterbean, greengram	Flowering, branching, grain filling, pod formation and maturity
27 days	30 August to 25 September		

Real time contingency practices (RTCP) implemented

Weather aberration	Real Time Contingency practices (RTCP) implemented	
	Crop	**RTCP implemented**
Mid season drought	Pearlmillet Cluster bean Greengram	Mechanical weeding/ hoeing by kasola and wheel hand hoe to keep crops weed free and to conserve soil moisture.
Terminal drought	Pearlmillet Cluster bean Greengram	Supplemental irrigation

Situation: Mid season drought

A dry spell of 24 days (31stJuly to 23rdAugust) was coincidedwith the flowering, branching, grain filling, pod formation and maturity stage of rainfed crops. *In-situ* moisture conservation and harvest of every third row after 30 days after sowing as intervention in pearlmillet was implemented resulting in pearlmillet yield of 1900 kg/ha with net returns of Rs.25270, B:C ratio of 1.3 and RWUE of 13.9 kg/ha-mm.Similarly, strip cropping (pearlmillet + clusterbean(8:4) gave pearlmillet equivalent yield (PEY) of 2600 kg/ha, net returns of Rs.34580, B:C ratio of 1.8 and RWUE of 19.1 kg/ha-mm (Table 1.4.3).

Table 1.4.3: Effect of *in-situ* moisture conservation&strip cropping system on the yield and economics of the crops during drought stress

Crop/intervention	Variety	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C
Pearlmillet/harvest every 3rd row	HHB-67(I)	1900	13.9	25270	1.3
Pearlmillet + clusterbean (8:4)/strip cropping	HHB-67(I) and HG-870	Pearlmillet equivalent yield 2600	19.1	34580	1.8

Demonstrations were conducted on interculture with kasola or and wheel hand hoe (WHH)in pearlmillet, clusterbean and mungbean. The weeding with wheel hand hoe (WHH) gave higher grain/seed yield (1420, 1280 and 620 kg/ha) compared to kasola (1390, 1250 and 600 kg/ha) in pearlmillet, clusterbean and greengrma, respectively (Table 1.4.4).

Table 1.4.4: Effect of weeding/interculture on crop yield and economics

Crop	Variety	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C
		With weeding/ interculture	Without weeding/ interculture			
Clusterbean	HG-870	1420	1390	10.4*	44020*	2.3*

				10.2	43090	2.2
Pearlmillet	HHB-67 (I)	1280	1150	9.4* 8.4	17024* 15295	0.9* 0.9
Greengram	Satya	620	600	4.5* 4.4	32364* 31350	1.9* 2.0

* Intervention

High yielding varieties need optimum nutrition for good harvests; adoption of recommended package of practice increased the yield of pearlmillet and clusterbean crops (9.95 and 8.89%, respectively). Similarly, higher net returns (Rs.17622 and Rs.43245/ha) and RWUE (9.7 and 10.2 kg/ha-mm) was obtained in pearlmillet and clusterbean, respectively with recommended package of practice (Table 1.4.5).

Table 1.4.5: Effect of package of practices on yield and economics of crops under drought conditions

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C
		With intervention	Without intervention				
Pearl millet	HHB 67 (I)	1325	1205	9.95	9.7* 8.8	17622* 16026	0.9 0.9
Clusterbean	HG-870	1395	1280	8.89	10.2* 9.4	43245* 39680	2.2* 2.4

* Intervention

Improved variety of mungbean (MH-421) recorded higher seed yield (640 kg/ha) with higher net returns (Rs.33440/ha), B:C ratio (2.0) and RWUE (4.7 kg/ha-mm) compared to Satya (Table 1.4.6).

Table 1.4.6: Performance of mungbean varieties under midseason drought

Variety	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C
Satya	620	4.5	32395	1.9
MH-421	640	4.7	33440	2.0

1.5 KOVILPATTI : Nil

1.6 RAJKOT

a. Agro-ecological setting

Rajkot is located in Western plain, South Kachchh and north Kathiawar peninsula (AESR2.4). The climate is hot arid. Average annual rainfall is 590 mm.

b. On-station experiments

Experienced weather conditions during 2016-17

During 2016, the onset of monsoon was delayed by 12 days (28th June). A rainfall of 425.1 mm was received which was deficit by 165.3 mm compared to normal of 590.4 mm (Fig.1.6.1). During south-west monsoon (*kharif*), 387.9 mm rainfall was received which was deficit by 170 mm (30.5%) than normal of 557.9 mm. During *rabi*, it was 37.2 mm and was excess by 12.7 mm compared to normal 24.5 mm and during summer there was no rainfall compared to normal of 6.0 mm.

Normal onset of monsoon : 16 June (24th SMW)
Onset of monsoon during 2016-17 : 28 June (26th SWM)
Annual mean rainfall : 590.4 mm
Annual rainfall during 2016-17 : 425.1 mm
Mean crop seasonal rainfall : 557.9 and 24.5 mm, during *kharif* and *rabi* respectively
Crop seasonal rainfall during 2016-17 : 387.9 mm and 37.2 mm *kharif* & *rabi* respectively

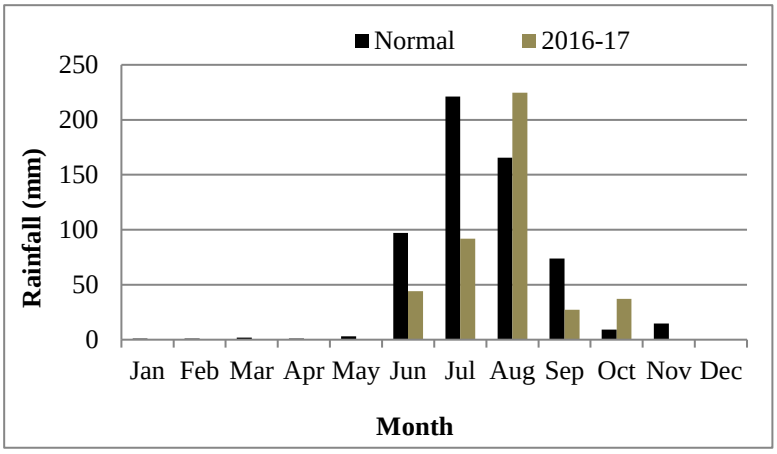


Fig 1.6.1: Normal and actual (2016) monthly rainfall at Rajkot

Dry spells during crop growing season (2016-17)

Dry spell		Crop	Stage of the crop
Duration (days)	**Dates & Months**		
12	12 to 23 August	Groundnut	Flowering & pegging
		Cotton, sesame, green gram, black gram, castor, pigeon pea	Vegetative
16	3 to 18 September	Groundnut	Pod formation
		Cotton	Square and boll formation
		Sesame, green gram, black gram	Pod development
		Castor, pigeon pea	Vegetative
13	20 September to 2 October	Groundnut	Pod development
		Cotton	Boll formation/ development
		Sesame, greengram	Maturity
		Castor	Flowering
		Pigeon pea	Vegetative

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Mid season drought	Groundnut	Flowering& pegging	Interculture and weeding, supplemental irrigation
	Cotton	Square initiation	
	Sesame	Vegetative	Interculture and weeding
	Green gram	Flowering	
	Black gram	Flowering	
	Castor	Vegetative	
	Pigeon pea	Vegetative	
Terminal drought	Groundnut	Pod development	Supplemental irrigation
	Cotton	Boll formation/ development	
	Green gram	Maturity	Picking of mature pods
	Black gram		
	Castor	Capsule formation	Interculture and weeding
	Pigeon pea	Flowering	

Salient achievements of on-station experiments

Real time contingency planning

Situation: Delayed onset of monsoon

During 2016, the onset of monsoon was delayed by 12 days and the improved varieties of different crops were evaluated under delayed onset of monsoon. Though the crop yields varied widely, higher net return of Rs. 92750/ha and B:C ratio of 6.30 was recorded with sesame followed by soybean var. G. soybean-4 (Table 1.6.1).

Table 1.6.1: Performance of improved crop varieties under delayed onset of monsoon

Crop	Variety	Seed/kapas yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Cotton	G.cot-8BGII	1240	2.92	38700	2.31
Groundnut	TG-37A	1360	3.20	43980	2.63
	G.G.20	1050	2.47	24975	1.93
Sesame	G.til-2	1750	4.12	92750	6.30
Greengram	G.M-4	770	1.81	25700	3.01
Blackgram	G.Blackgram-1	950	2.23	39450	4.08
Soybean	G.Soybean-4	1570	3.69	48000	4.24

Situation: Early season drought

One dry spell of 12 days occurred during 12-23 August coinciding with early vegetative stage of crops. The seed cotton yield (1430 kg/ha) was increased by 15.3% due to furrow opening for *in-situ* moisture conservation (45 cm wide) in cotton at vegetative stage as compared to without furrow. It also recorded higher net returns (Rs.48150/ha), B:C ratio (2.58) and RWUE (3.36 kg/ha-mm) (Table 1.6.2).

Table 1.6.2: Effect of furrow opening on cotton yield and economics

Variety	Seed cotton yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Furrow opening	Normal practice			
G.cotton-8 BGII	1430	-	3.36	48150	2.58
	-	1240	2.92	38700	2.31

In-situ moisture conservation through mulching in cotton increased seed cotton yield by 12.9 and 21.8% with plastic mulching and groundnut shell mulching, respectively compared to control. Higher net returns (Rs. 51550/ha) and B:C ratio (2.64) was recorded with groundnut shell mulching (Table 1.6.3).

Table 1.6.3: Effect of mulching on yield and economics of cotton

Treatment	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Plastic mulching	1400	3.29	45500	2.44
G.nut shell 5 t/ha	1510	3.55	51550	2.64
Control	1240	2.92	38700	2.31

Situation: Midseason drought

A dry spell of 16 days occurred during 3 to 18 September affecting flowering and pod formation in groundnut and square/boll formation in cotton. Pod yield of groundnut was increased by 12.4% and that of seed cotton yield by 17.3% due to pre-emergence weedicide, one weeding and two interculture operations as compared to normal practice with one weeding and two interculture operations (Table 1.6.4).

Table 1.6.4: Effect of interculture and weeding on yield of groundnut and cotton

Crop/ variety	yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Interculture/ weeding	No interculture/ weeding			
Groundnut (GG20)	1180 (2130)	1050 (1575)	2.78	31687	2.11
			2.47	24975	1.93
Cotton (G.cotton-8 BGII)	1455	1240	3.42	49025	2.58
			2.92	38700	2.31

Foliar application of sea weed extract @ 4% solution at pegging and pod formation stage in groundnut gave 10% higher pod yield (1150 kg/ha) with higher net returns (Rs.30650/ha) compared to control (Table 1.6.5).

Table 1.6.5: Effect of foliar application of sea weed extract on yield of groundnut (GG20)

Treatment	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Sea weed extract @ 4%	1150 (2070)*	2.71	30650	2.09
Control	1050 (1575)*	2.47	24975	1.93

*Haulm yield

Situation: Terminal drought

A Dry spell occurred from 20 September -2 October (13 days) affecting pod development in groundnut, and boll formation and boll development in cotton. Pod yield of groundnut was increased by 25.7 and 29.0% due to supplemental irrigation through rain gun and mini sprinkler over without irrigation, respectively. Higher net returns, B:C ratio and RWUE was also recorded with supplemental irrigation either through rain gun and mini sprinkler (Table 1.6.6).

Table 1.6.6: Effect of supplemental irrigation and method of irrigation on yield of groundnut

Supplemental irrigation	Yield (kg/ha)	Net returns (Rs/ha)	B:C ratio
Rain gun (30 mm)	1320 (2390)*	38387	2.32
Mini sprinkler (25 mm)	1355 (2470)	40105	2.38
Control	1050 (1575)	24975	1.93

*Figures in parentheses are haulm yield

In cotton, total 50 mm (five splits) water was applied through drip at boll formation and boll development stages. Seed cotton yield was increased by 21.8% due to supplemental irrigation through drip system over no irrigation. Similarly, higher net returns, B:C ratio and RWUE was also recorded with supplemental irrigation through drip (Table 1.6.7).

Table 1.6.7: Effect of supplemental irrigation on yield of Bt cotton

Treatment	Yield (kg/ha)	WUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Drip irrigation	1510	3.55	51550	2.64
Control	1240	2.92	38700	2.31

Preparedness

Rainwater management

The pod yield of groundnut was increased by 40.8% due to application of *murrum* @ 20 t/ha compared to normal practice. Similarly, higher net returns (Rs.43450/ha), B:C ratio (2.42) and RWUE (3.41 kg/ha-mm) was also recorded with application of *murrum* @ 20 t/ha (Table 1.6.8).

Table 1.6.8: Effect of *murrum* application on yield of groundnut

Crop/variety (duration)	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Murrum @ 20 t/ha	Normal practice			
Groundnut-GG20 (110 days)	1450 (2610)*	-	3.41	43450	2.42
	-	1030 (1545)	2.42	22985	1.82

*Figures in parentheses are haulm yield

Cropping system

Among different cotton based intercropping systems, maximum seed cotton equivalent yield (2240 kg/ha), net returns (Rs.91650/ha), B: C ratio (3.86) and LER (1.81) was recorded with sesame + cotton (1:1) followed by cotton + greengram (1:1) intercropping system and the lowest yield (1240 kg/ha), net returns (Rs.38700/ha) and B:C ratio (2.31) was recorded with sole cotton (Table 1.6.9).

Table 1.6.9: Seed cotton equivalent yield and economics with cotton based intercropping systems

Intercropping system	Seed cotton equivalent yield (kg/ha)	LER	Net returns (Rs/ha)	B:C ratio
Cotton + soybean (1:1)	1680*(770)	1.35	60400	2.89
Cotton +blackgram (1:1)	1670*(600)	1.35	59850	2.87
Cotton + greengram (1:1)	1770*(670)	1.43	65250	3.04
Cotton + groundnut (1:1)	1660*(880)	1.34	59410	2.86
Cotton + cowpea (1:1)	1660*(640)	1.34	59230	2.85
Cotton + sesame (1:1)	2240*(950)	1.81	91650	3.86
Sole cotton	1240	-	38700	2.31

Figures in parentheses are intercrop yields

Cotton + soybean (1:1)

Cotton + blackgram (1:1)

Cotton + greengram (1:1)

Nutrient management

Green manure crops were sown in between two rows of cotton and incorporated 35-45 DAS. The increase in seed cotton yield varied from 16.1 and 12.9% due to green manuring as compared to control. Maximum seed cotton yield (1440 kg/ha), net returns (Rs.48200/ha), B:C ratio (2.55) and RWUE (3.39kg/ha-mm) was recorded with sunhemp as green manure in cotton (Table 1.6.10).

Table 1.6.10: Effect of green manuring on yield of cotton

Green manure crop	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Sunhemp	1440(7200)	3.39	48200	2.55
Cowpea	1400(11200)	3.29	46000	2.48
Control	1240	2.92	38700	2.31

Figures in parentheses are fresh weight of green manure

Green manuring in cotton

Foliar spray of micronutrients in groundnut at pegging and pod formation stage increased pod yield by 9.5 and11.9% due to foliar spray of Zinc sulphate and Ferrous sulphate @ 1%, respectively over control. The higher pod yield 1175 kg/ha, net returns (Rs.31912/ha), RWUE (2.76 kg /ha-mm) and B: C ratio (2.14) was obtained with the application of Ferrous sulphate @ 1% (Table 1.6.11).

Table 1.6.11: Effect of foliar nutrition on yield of groundnut

Treatment	Yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Zinc sulphate @ 1%	1150 (2060)	9.5	2.71	30603	2.09
Ferrous sulphate @ 1%	1175 (2110)	11.9	2.76	31912	2.14
Control	1050 (1575)	-	2.47	24975	1.93

Figure in parentheses are haulm yield

c. On - farm demonstrations

Village profile

The program is being implemented in Pata Meghpar village, Kalavad taluk, Jamnagar district, Gujarat. The total cultivated area is 2793 ha out of which 1675 ha is rainfed. The mean annual rainfall is 541 mm with seasonal rainfall of 541 mm during *kharif* (June-September). The major soils types are medium black soils. The major rainfed crops during *kharif* are groundnut, cotton, sesame and during *rabi* are wheat, cumin, fenugreek and chickpea. The number of small, marginal, medium and large farmers are 28.7, 27.3, 27.8 and 16.1%, respectively. The ground water table is 19.5 m below the surface. The source of irrigation is open wells and bore wells covering 40.5% of cultivated area.

Climate vulnerability in general

The climate in this agro-climatic zone is semi-arid. Out of the total annual average rainfall of 585 mm, the south-west monsoon contributes 70-80%. The historical rainfall data (of 30 years) indicated that the variability in rainfall during south-west monsoon is 62.5% of the average rainfall. The normal

onset of monsoon is during 26th SMW and withdrawal is during 39th SWM. However, for the past 10 years, the onset (south-west) of monsoon is during 27th SMW. The dry spells are experienced during peg formation and pod development stages in groundnut, square and boll formation stages in cotton, and flowering and pod development stages in pulses. The extreme events like unusual and high intensity rainfall in short spans are increasing during 32nd and 35th SMW (August) during *kharif* season. Based on 53 years data, the probable extreme events like cold wave occur during 3rd SMW (January) and heat wave during 21st SMW (May) in the area. There has been a considerable shift in the rainfall pattern, in the past 10 years, with a rainfall of 895 mm which was excess by 67.5% as compared to normal of 585 mm in the area and crops experienced dry spells during 33-34th SWM of August (mid-season) and 37-38th SMW of September (later season). The start of monsoon during 2001-10 was 27th SMW instead of 28th SMW during 1991-00. Similarly, the withdrawal of monsoon has also followed same trend.

Experienced weather conditions during 2016-17

During the year 2016, at Pata meghapar village, the onset of monsoon was delayed by 27 days. A rainfall of 611 mm was received which was excess by 7 mm compared to normal of 604 mm (Fig.1.6.2). During south-west monsoon (June to September), 536 mm rainfall was received which was excess by 19 mm (3.4%) over the normal of 555 mm, during *rabi*, 75 mm rainfall was received which was excess by 47.7 mm against the normal of 27.3 mm and in summer there was no rainfall against the normal of 17.7 mm.

Normal onset of monsoon : 16 June (24th SMW)
Onset of monsoon during 2016-17 : 12 July (28th SMW)
Annual mean rainfall : 541 mm
Annual rainfall during 2016-17 : 611 mm
Mean crop seasonal rainfall during *Kharif* and *rabi* : 555 and 27.3 mm, respectively
Crop seasonal rainfall during 2016-17 *kharif* and *rabi* : 536 and 75 mm, respectively

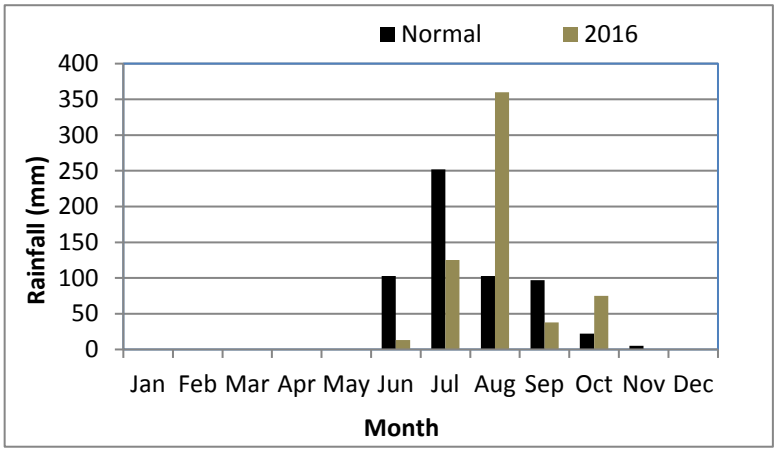


Fig 1.6.2: Normal and actual (2016) monthly rainfall at pata Meghapar

Dry spells during crop growing season (2016-17)

Dry spell		Crop	Stage of the crop
Duration (days)	**Dates & Months**		
18	13 to 30 July	Groundnut, cotton, sesame, green/black gram, castor	Germination
13	10 to 23 August	Groundnut, cotton, sesame, green gram, black gram, castor	Vegetative and flowering stage
18	1 to 18 September	Groundnut, sesame, green gram,	Pod development

		black gram	
		Cotton	Square formation
		Castor	Vegetative
14	20 September to 3 October	Groundnut	Maturity
		Cotton	Boll development
		Sesame	Maturity
		Castor	Flowering

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented
Delayed onset of monsoon	Cotton, castor, pigeonpea	Improved varieties
Early season drought	Cotton, castor	Improved varieties/hybrids
	Groundnut	Interculture and weeding
	Cotton	*In-situ* moisture conservation
Mid season drought	Groundnut	Supplemental irrigation/ interculture and weeding
	Cotton	Interculture and weeding
Terminal drought	Cotton	Supplemental irrigation/ foliar spray

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Delayed onset of monsoon

During 2016, the onset of monsoon was delayed by 27 days (12th July). Short duration improved varieties of different crops were demonstrated on farmers' fields to cope with the situation. The seed cotton yield was increased by 3.6, 1.8 and 10.9% with hybrids GTHH-49BGII, G.cotton-6BGII and G.cotton-8BGII respectively, compared to research varieties grown by the farmer. Castor var. GCH-7 produced 8.3% higher seed yield as compared to research varieties. In pigeonpea, BDN-2 and Vaishali varieties recorded 17.5 and 13.6% increase in seed yield, respectively compared to research varieties (Table 1.6.12).

Table 1.6.12: Performance of improved hybrids/hybrids

Crop	Variety/hybrid	Seed/kapas yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Bt cotton	GTHH-49 BGII	1140	3.6	1.87	31200	1.99
	G.cotton-6BGII	1120	1.8	1.83	30100	1.96
	G.cotton-8BGII	1220	10.9	2.00	35600	2.13
	Research variety	1100	-	1.80	29000	1.92
Castor	G. Castor Hy.-7	1040	8.3	1.70	14900	1.69
	Research variety	960	-	1.57	12100	1.56
Pigeon pea	BDN-2	1645	17.5	2.69	42025	2.31
	Vaishali	1590	13.6	2.60	39550	2.24
	Research variety	1400	-	2.29	31000	1.97

Pod and haulm yield of groundnut increased by 40 and 19.5% with narrow spacing as compared to farmers' practice (45 cm), respectively with higher net returns, B:C ratio and RWUE (Table 1.6.13).

Table 1.6.13: **Effect of plant geometry on yield of groundnut**

Spacing	Yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Narrow spacing of 30 cm	1470 (2350)	40.0	2.41	45000	2.58
Normal spacing of 45 cm	1050 (1890)	-	1.72	24450	1.91

*Figures in parentheses are haulm yield

Groundnut + castor intercropping system (3:1) recorded higher pod equivalent yield of groundnut (1446 kg/ha) compared to sole groundnut (Table), with higher net returns (Rs. 40640/ha), B:C ratio (2.38) and RWUE (2.37 kg/ha-mm) (Table 1.6.14).

Table 1.6.14: Performance of groundnut + castor intercropping system

Intercropping	GPEY (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Groundnut (bunch) + castor (3:1)	1446	2.37	40640	2.38
Sole groundnut (bunch)	994	1.63	21206	1.77

GPEY: Groundnut pod equivalent yield

Groundnut + castor intercropping system (3:1)

Similarly, higher pod equivalent yield of groundnut (1855 kg/ha) was recorded under pigeonpea + groundnut intercropping system compared to sole groundnut, with higher net returns (Rs. 59540/ha), B:C ratio (3.02) and RWUE (3.04 kg/ha-mm) (Table 1.6.15).

Table 1.6.15: Performance of groundnut + pigeonpea intercropping system

Intercropping system	GPEY (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Groundnut + pigeonpea (3:1)	1855	3.04	59540	3.02
Sole groundnut	1095	1.80	26351	1.96

Groundnut + pigeonpea intercropping system (3:1)

Situation: Midseason drought

During 2016, a dry spell of 13 days from 10-23 August, and 18 days from 1-18 September occurred coinciding with flowering and pegging stage in groundnut and square and boll formation stage in cotton. Supplemental irrigation of 100 mm with harvested rainwater was given on 18 August and 5 September at flowering and pod development stage in groundnut and flowering and boll development in cotton. The yield of groundnut and cotton was increased by 62.1 and 52.6% due to supplemental irrigation over normal practice, respectively (Table 1.6.16).

Table 1.6.16: Effect of supplemental irrigation on yield of groundnut and cotton

Crop	Variety	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With irrigation	Without irrigation			
Groundnut	GG 20	1570 (2820)*	-	2.57	50550	2.71
		-	1000 (1450)	1.58	18980	1.70
Cotton	Research variety	1625	-	4.09	51948	2.60
		-	1065	3.07	25328	1.84

*Figures in parentheses are haulm yield

The pod yield of groundnut increased by 12.9% and that of seed cotton yield by 10.1% due to weeding and interculture compared to normal practice, with higher net returns, B:C ratio and RWUE (Table 1.6.17).

Table 1.6.17: Effect of interculture and weeding on yield of groundnut and Bt. cotton

Crop	Variety	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Weeding/ interculture	Without weeding/ interculture			
Groundnut	GG 20	1530 (2600)	-	2.50	47565	2.60
		-	1355 (2168)	2.22	34372	2.21
Bt Cotton	Res. variety	1640	-	2.68	56200	2.65
		-	1490	2.44	44980	2.38

*Figures in parentheses are haulm yield

Foliar spray of potassium nitrate @ 1% during dry spells (16 August, 10 and 25 September) coinciding square formation, flowering and boll formation. Seed cotton yield (1410 kg/ha) was increased by 24.9 per cent due to foliar spray of potassium nitrate @ 1% as compared to normal practice (Table 1.6.18). It also recorded higher net return (Rs. 47380/ha), B: C ratio (2.55) and RWUE (2.32 kg/ha-mm).

Table 1.6.18: Effect of foliar spray of KNO_3 on yield of cotton

Crop	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With foliar spray	Without foliar spray			
Bt cotton	1410	-	2.32	47380	2.55
	-	1130	1.86	32370	2.08

Situation: Terminal drought

A dry spell of 14 days occurred during 20 September to 3 October. Supplemental irrigation, 50 mm from harvested rainwater was given on 18 August, 5 and 30 September coinciding with vegetative, boll formation and boll development stage in cotton. Seed cotton yield was increased by 57.4% due to 3 supplemental irrigations over 2 supplemental irrigations. Similarly, higher net returns, B:C ratio and RWUE were also recorded with 3 supplemental irrigations (Table 1.6.19).

Table 1.6.19: Effect of supplemental irrigation on yield of Bt. cotton

Variety	Seed cotton yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Three irrigations	Two irrigations			
Research variety	1810	-	4.56	61620	2.90
	-	1150	3.31	29800	1.99

Preparedness

Rainwater management

Application of m*urrum* @ 20 t/ha resulted in improved pod and haulm yield of groundnut by 32.1 and 39.8%, respectively over farmers' practice with higher net returns of Rs.43848/ha, B:C ratio (2.46) and RWUE (2.37 kg/ha-mm) (Table 1.6.20).

Table 1.6.20: **Effect of *murrum* application on yield of groundnut (GG20)**

Treatment	Yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
***Murrum* @ 20 t/ha**	1445 (2605)	32.1	2.37	43848	2.46
Control	1100 (1860)	-	1.79	26156	1.97

Figures in parentheses are haulm yield

Seed cotton yield was increased by 15.6% due to furrow opening between rows over control. The beneficial effect of this practice was also observed on net returns, B:C ratio and RWUE (Table1.6.21).

Table 1.6.21: Effect of *in-situ* moisture conservation through furrow opening on yield of Bt. cotton

Variety	Yield (kg/ha)		% yield increase	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	IP	FP				
Research variety	1220	-	15.56	2.00	36183	2.17
	-	1055	-	1.73	22850	1.76

Furrow opening in cotton

Cropping systems

The chickpea yield was increased by 17.2%t with chickpea var. G.gram-3 compared to research variety grown by the farmers, with higher net returns, RWUE and B:C ratio. Cumin gave 16.2% higher seed yield with G. Cumin-4 as compared to research variety (Table 1.6.22).

Table 1.6.22: Performance of improved varieties of chickpea and cumin

Crop	Variety	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Chickpea	G.Gram-3	2145	3.51	55575	2.85
	Research variety	1830	3.00	44550	2.28
Cumin	G.Cumin-4	895	1.46	68500	3.26
	Research variety	770	1.26	56000	2.67

Among various intercrops demonstrated in farmers fields, cotton + sesame intercropping (1:1) system performed better and recorded higher seed cotton equivalent yield (1920 kg/ha) with higher net returns (Rs.68200/ha) and LER of 1.54 followed by cotton + forage maize intercropping system (Table 1.6.23).

Table 1.6.23: Performance of cotton based intercropping systems

Intercropping system	SCEY (kg/ha)	LER	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Cotton + soybean (1:1)	1675	1.34	2.74	55385	2.70
Cotton + blackgram (1:1)	1545	1.24	2.53	48717	2.50
Cotton + greengram (1:1)	1465	1.17	2.40	44395	2.37
Cotton + groundnut (1:1)	1510	1.21	2.48	54186	2.67
Cotton + forage maize (1:1)	1860	1.49	3.05	65255	3.01
Cotton + sesame (1:1)	1920	1.54	3.14	68200	3.10
Sole cotton	1250		2.06	39080	2.30

SCEY: Seed cotton equivalent yield; LER: Land equivalent ratio

Cotton based intercropping systems

Nutrient management

Pod and haulm yields of groundnut were increased by 11.5 and 14.9%, respectively due to application of castor cake @ 500 kg/ha over normal practice. Similarly, 8.4% higher seed cotton yield with higher net returns of Rs.44280/ha, B: C ratio (2.36) and RWUE (2.28 kg/ha-mm) was recorded with application of castor cake (Table 1.6.24).

Table 1.6.24: Effect of INM on yield of groundnut and cotton

Crop	INM	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Groundnut	Castor cake	1240 (2110)	2.03	33620	2.16
	Control	1110 (1835)	1.82	28878	2.07
Cotton	Castor cake	1395	2.28	44280	2.36
	Control	1290	2.11	33900	2.11

Figures in parentheses are haulm yield of groundnut

1.7 SK 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). Annual rainfall is 638 mm.

b. On-station experiments

Experienced weather conditions during 2016-17

During 2016, the onset of monsoon was delayed by 17 days (12th July). A rainfall of 585.4 mm was received which was deficit by 52.6 mm compared to normal (638 mm) (Fig.1.7.1). During south-west monsoon (*kharif*), 495.0 mm rainfall was received which was deficit by 103.1 mm than normal rainfall of 598.1 mm; during October- December 90.4 mm rainfall was received which was excess by 63.3 mm compared to normal rainfall of 27.1 and in summer (March-May), no rainfall was received. Terminal drought in different crops occurred due to early withdrawal of monsoon.

Normal onset of monsoon : 25 June
Onset of monsoon during 2016-17 :12 July
Annual mean rainfall : 638 mm
Annual rainfall during 2016-17 : 585.4 mm
Mean crop seasonal rainfall during : 598.1 and 27.1 mm, respectively *kharif* & *rabi*
Crop seasonal rainfall during 2016-17 : 495 and 90.4 mm, respectively (*kharif* & *rabi*)

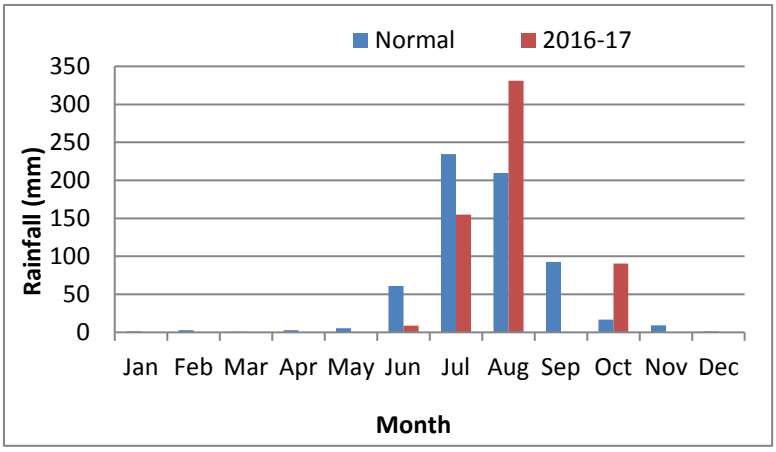


Fig.1.7.1: Normal and actual (2016) monthly rainfall at SK Nagar

Dry spells during crop growing season (2016-17)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
24	26 August to 1 September	Pearlmillet, pulses	Seedling
	1 October to maturity of crops	Pearlmillet	Grain filling to maturity
		Pulses	At maturity
		Castor	Seed filling to maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP measures implemented
Delayed onset of monsoon	Pearlmillet	-	Improved varieties
	Greengram	-	
	Blackgram	-	
	Clusterbean	-	
	Sorghum (fodder)	-	
	Castor	-	Crop management
Mid season drought	Pearlmillet	Tillering & earhead initiation	Soil and foliar application of nutrients
Terminal drought	Castor	Flowering & capsule formation	Life saving irrigation

Salient achievements of on-station experiments

Real time contingency planning

Situation: Delayed onset of monsoon

During 2016, the onset of monsoon was delayed by 17 days (12th July). The rainfall was deficit by 103.1 mm during south-west monsoon (*kharif*). Among different hybrids of castor, GCH7 (drought tolerant) recorded 23% higher seed and stalk yields of 1280 and 2432 kg/ha, respectively over local variety (GCH5). The highest net returns of Rs.34586/ha, B:C ratio (3.41) and RWUE (2.19 kg/ha-mm) were also recorded with GCH 7 (Table 1.7.1).

Table 1.7.1: Performance of castor hybrids under delayed onset of monsoon

Hybrid	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B-C ratio
	Seed	Stalk			
GCH 5	1040	2288	1.78	26354	2.19
GCH 7	1280	2432	2.19	34586	3.41

GCH 5

GCH 7

Among pearlmillet hybrids, GHB 558 recorded 11.2% higher grain and fodder yield (1145 kg and 3350 kg/ha) with highest net returns (Rs.18975/ha), B:C ratio (2.30) and RWUE (1.96 kg/ha-mm) compared to GHB 538 (Table 1.7.2).

Table 1.7.2: Performance of pearlmillet hybrids under delayed onset of monsoon

Hybrid	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Grain	Fodder			
GHB 538	1030	3210	1.76	16830	2.04
GHB 558	1145	3350	1.96	18975	2.30

Under delayed onset of monsoon, greengram cv. GM 4 recorded highest seed and stover yields of 410 and 1350 kg/ha, respectively compared to GM3 with highest net returns of Rs.25900/ha, B:C ratio of 3.78 and RWUE of 0.70 kg/ha-mm (Table 1.7.3).

Table 1.7.3: Performance of greengram varieties under delayed onset of monsoon

Variety	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Seed	Stover			
GM 3	270	1110	0.46	15430	2.27
GM 4	410	1350	0.70	25900	3.78

GM 3 **GM 4**

Clusterbean cv. GG 2 recorded higher seed and stalk yields of 475 and 1460 kg/ha, respectively over GG 1 with higher net returns of Rs. 14795/ha, B:C ratio (2.81) and RWUE (0.81 kg/ha-mm) (Table 1.7.4).

Table 1.7.4: Performance of clusterbean varieties under delayed onset of monsoon

Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Seed	Stalk				
GG 1	380	1130	-	0.65	10780	2.09
GG 2	475	1460	25.0	0.81	14795	2.81

Improved varieties of fodder sorghum (CSV 21) recorded higher fodder yield (6520 kg/ha) with higher net returns (Rs.12710/ha), B:C ratio (1.86) and RWUE (11.14 kg/ha-mm) compared to local variety (Sundhiya) (Table 1.7.5).

Table 1.7.5: Performance of fodder sorghum varieties under delayed onset of monsoon

Variety	Fodder yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
CSV 21	6520	53.4	11.14	12710	1.86
Local variety (Sundhiya)	4250	-	7.26	6400	1.01

Situation: Midseason drought

During south-west monsoon (*kharif*), 495.0 mm rainfall was received which was deficit by 103.1 mm than normal rainfall of 598.1 mm. A dry spell of 24 days occurred from 26 August to 1 September and 1 October to maturity. Soil application of N was done on 6 August and 2 September and foliar sprays on 16 August and 14 September, 2016 coinciding with critical growth stages (tillering /ear head initiation & grain filling) in pearlmillet. Among soil and foliar application of N, soil application of N @ 20 kg/ha (at 40-45 DAS) recorded significantly highest grain (1287 kg/ha) and fodder (2740 kg/ha) yields than all the other treatments, but it was found at par with application of N @ 20 kg/ha (at 20-25 DAS) and foliar spray of urea (2%) for grain and fodder yields. The highest net returns (Rs. 20307/ha), B: C ratio (2.81) and RWUE (2.20 kg/ha-mm) were recorded with application of N @ 20 kg/ha (at 40-45 DAS) (Table 1.7.6).

Table 1.7.6: Effect of different soil and foliar application of N on yield and economics of pearl millet

Treatment	Yield (kg/ha)		RWUE (kg/ha-mm)	Net return (`/ha)	B:C ratio
	Grain	Fodder			
Urea spray (1%)	1012	2110	1.73	14424	2.03
Urea spray (2%)	1149	2433	1.96	17443	2.46
Thiourea 1000 ppm	1022	2274	1.75	14980	2.09
N @ 20 kg/ha (at 20-25 DAS)	1197	2492	2.04	18213	2.52
N @ 20 kg/ha (at 40-45 DAS)	1287	2740	2.20	20307	2.81
$ZnSO_4$ spray 0.5%	906	2011	1.55	12674	1.82
CD at 5%	228	406			

Situation: Terminal drought

During 2016, due to early withdrawal of monsoon, no rainfall was received from 1st October till maturity of crop. Supplemental irrigation of 50 mm from flowering to capsule development stage to overcome the terminal drought in castor recorded higher seed and stalk yields of 1350 and 2876 kg/ha, respectively over no irrigation. The highest net returns (Rs 34288/ha), B:C ratio (2.63) and RWUE (1.97 kg/ha-mm) were also recorded with supplemental irrigation in castor (Table 1.7.7).

Table 1.7.7: Effect of supplemental irrigation in castor (GCH 7) on yield and economics

Treatment	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B-C ratio
	Seed	Stalk			
Supplemental irrigation	1350	2876	1.97	34288	2.63
Without irrigation	910	1866	1.55	21723	2.14

Two life saving irrigations were given from harvested water in farm pond through MIS

Supplemental irrigation

Check

Preparedness

Rainwater management

Compartment bunding in pearlmillet recorded highest grain and fodder yields of 1310 kg and 4050 kg/ha, respectively over no compartment bunding. The highest net returns (Rs. 22950/ha), B:C ratio (2.59) and RWUE (2.24 kg/ha-mm) were also recorded with compartmental bunding (Table 1.7.8).

Table 1.7.8: Effect of compartmental bunding in pearlmillet on yield and economics

Crop & variety	Intervention	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Grain	Fodder			
Pearl millet (GBH 558)	Compartment bunding	1310	4050	2.24	22950	2.59
	No compartment bunding	1180	3490	2.02	19920	2.41

Compartment bunding

(No compartment bunding)

Similarly, the ridge and furrow method of sowing in castor as *in-situ* moisture conservation practice recorded highest seed and stalk yields of 1060 kg and 2226 kg/ha, respectively over local practice. The highest net returns (Rs 25423/ha), B:C ratio (2.17) and RWUE (1.81 kg/ha-mm) were also recorded with ridge and furrow method (Table 1.7.9).

Table 1.7.9: Effect of ridge and furrow method on castor yield and economics

Intervention	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Seed	Stalk			
Ridge & furrow system	1060	2226	1.81	25423	2.17
Flat bed system	875	1750	1.49	20475	2.02

Castor + ridge & furrow system

Castor in flat bed system

Cropping systems

Castor being a long duration and wide-spaced crop offers a great scope for growing of short duration intercrops. Intercropping system of castor + greengram (1:1) recorded higher castor equivalent yield (CEY) (1486 kg/ha) over sole castor (1074 kg/ha) with higher net returns (Rs 37167/ha), B:C ratio (2.78) and RWUE (2.54 kg/ha-mm) (Table 1.7.10).

Table 1.7.10: Performance of castor + greengram (1:1) intercropping system

Cropping system	Yields (kg/ha)					RWUE (kg/ha-mm)	Net returns (Rs/ha)	B-C ratio
	Castor		Greengram		CEY			
	Seed	Stalk	Seed	Stover				
Castor (GCH 7) + greengram (GM 4)	750	1575	310	843	1486	2.54	37167	2.78
Castor sole	1045	1996	--	--	1074	1.84	26378	2.60

Castor + greengram (1:1)

Castor sole

c. On-farm demonstrations

Village profile

The program is being implemented in Kalimati/Dholiya village, taluka Amirgadh, Banaskantha district, Gujarat. The total cultivated area is 652.91 ha out of which 322.91 ha is rainfed. The mean annual rainfall is 873 mm with seasonal rainfall of 782.8 mm during *kharif* (July-September). 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.

Climate vulnerability 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, clusterbean, maize, castor, cotton etc.

Experienced weather conditions during 2016-17

During 2016, in Kalimati village, onset of monsoon was delayed by 17days (12th July). A total rainfall of 670 mm was received which was deficit by 203mm compared to normal (873 mm). Out of total rainfall, *kharif* season received 576 mm, deficit by 207 mm (26.4%) than normal of 783 mm. In *rabi* 94mm was received which was excess by 70.9 mm compared to normal of 23.1mm and in summer season there was no rain (Fig 1.7.2).

Normal onset of monsoon : 25 June
Onset of monsoon during 2016-17 : 12 July
Annual mean rainfall : 873 mm
Annual rainfall during 2016-17 : 670.0 mm
Mean crop seasonal rainfall : 783 &23.1 mm during *kharif* and *rabi*, respectively
Crop seasonal rainfall during 2016-17 : 670 & 94 mm during *kharif* and *rabi*, respectively

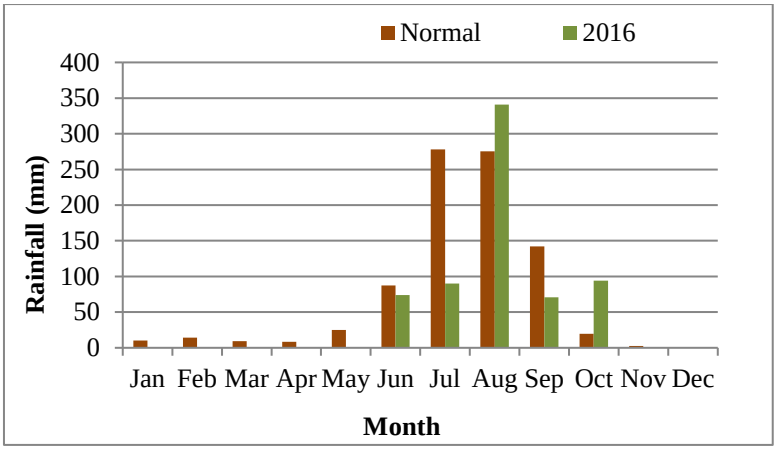


Fig.1.7.2: Normal and actual (2016) monthly rainfall in Kalimati village

Dry spells during crop growing season of year 2016-17

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
5	23 to 27 July	Pearlmillet, maize, greengram, blackgram, clusterbean	Seedling
12	27 August to 7 September	Greengram, blackgram, clusterbean	Maturity
-	1 October to maturity	Castor	Seed filling to maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTC measures implemented
Delayed onset of monsoon	Pearlmillet, maize, blackgram, greengram, clusterbean, sorghum (fodder)	-	Improved varieties of short duration
Mid season drought	Pearlmillet	Tillering & earhead initiation	Soil and foliar application of nutrients
Terminal drought	Castor	Flowering & capsule formation	Life saving irrigation

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Delayed onset of monsoon

During 2016, the onset of monsoon in Kalimati/Dholiya village was delayed by 17 days. Among different hybrids of castor, GCH7 (drought tolerant) recorded higher seed and stalk yields of 1151 and 2303 kg/ha, respectively over local variety (GCH4). The highest net returns of Rs 28538/ha, B:C ratio (2.43) and RWUE (1.72 kg/ha-mm) were recorded with GCH 7 (Table 1.7.11).

Table 1.7.11: Performance of castor hybrids under delayed onset of monsoon

Variety/hybrid	Yields (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Seed	Stalk			
GCH 5	953	2097	1.42	21702	1.85
GCH 7	1151	2303	1.72	28538	2.43

Local variety	780	1793	1.16	15950	1.39
CD at 5%	88	191			

GCH 7

Local variety (GCH 4)

Pearlmillet hybrid, GHB 558 recorded significantly highest grain (1201 kg/ha) and fodder (3191 kg/ha) yields over local variety (MH 179) with highest net returns of Rs.15648/ha, B:C ratio (1.79) and RWUE (1.24 kg/ha-mm) (Table 1.7.12).

Table 1.7.12: Performance of pearlmillet hybrids under delayed onset of monsoon

Variety/Hybrid	Yields (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio	% yield increase
	Grain	Fodder				
GHB 558	1201	3191	1.79	15648	1.71	36.9
GHB 538	1005	2922	1.50	12228	1.34	14.6
Local variety (MH 179)	877	2296	1.31	9172	1.04	-
CD at 5%	75	229	-	-	-	-

GHB 558

Local check (MH 179)

Maize variety, HQPM 1 recorded significantly highest grain (3057 kg/ha) and fodder (5029 kg/ha) yields over other varieties with highest net returns of Rs. 49854/ha, benefit cost ratio (4.94) and RWUE (4.56 kg/ha-mm) (Table 1.7.13).

Table 1.7.13: Effect of different treatments on yield and economics of maize

Variety	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio	% yield increase
	Grain	Fodder				
GM 2	1845	3708	2.75	29514	3.53	44.0
HQPM 1	3057	5029	4.56	49854	4.94	138.6
Local variety	1281	2483	1.91	18008	2.24	-
CD at 5%	204	325	-	-	-	-

HQPM 1

Local check (Land race/*Desi* maize)

Blackgram variety Guj. Urad 1 (90-110 days) recorded significantly highest seed and stover yields of 644 and 1635 kg/ha, respectively over local check (T 59) with highest net returns of Rs.59680/ha, B:C ratio (6.18) and RWUE (0.96 kg/ha-mm). Further, Gujarat Mung 4 variety of greengram recorded significantly highest seed (591 kg/ha) and stover (1215 kg/ha) yields over local variety (K 851) with highest net returns of Rs. 37347/ha, B:C ratio (4.88) and RWUE (0.88 kg/ha-mm). The Gujarat Guar 2 variety of clusterbean recorded significantly highest seed (575 kg/ha) and stalk (1175 kg/ha) yields over local variety (HG 75) with highest net returns of Rs. 16262/ha, B:C ratio (2.60) and RWUE (0.86 kg/ha-mm) (Table 1.7.14).

Table 1.7.14: Performance of different crop varieties under delayed onset of mansoon

Crop	Variety	Yields (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Seed	Stover			
Blackgram	GU 1	644	1635	0.96	59680	6.18
	Local variety (T 59)	480	1272	0.72	42955	4.86
	CD at 5%	51	134	-	-	-
Greengram	GM 4	591	1215	0.88	37347	4.88
	Local variety (K 851)	431	945	0.64	25660	3.49
	CD at 5%	42	97	-	-	-
Clusterbean	GG 2	575	1175	0.86	16262	2.60
	Local variety (HG 75)	390	840	0.58	9705	1.71
	CD at 5%	22	66			

Sorghum variety, CSV 21 recorded higher fodder (10250 kg/ha) yield over local variety with highest net returns (Rs. 22401/ha), B:C ratio (2.68) and RWUE (15.30 kg/ha-mm) compared to local variety (Table 1.7.15).

Table 1.7.15: Performance of fodder sorghum varieties

Variety	Fodder yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (`/ha)	B:C ratio	% yield increase
CSV 21	10250	15.30	22401	2.68	34.25
Local variety	7635	11.40	14346	1.68	-
CD at 5%	668	-	-	-	-

CSV 21

Local variety (Sundhiya)

Situation: Mid season drought

A dry spell of 12 days occurred during 27 August to 7 September. Among different soil and foliar application methods of N, soil application of N @ 20 kg/ha (at 40-45 DAS) recorded significantly highest grain (1531 kg/ha) and fodder (3422 kg/ha) yields was found at par with soil application of N @ 20 kg/ha (at 40-45 DAS) and 2% urea spray both for grain and fodder yields. The highest net returns of Rs. 24512/ha, B:C ratio (2.81) and RWUE (2.28 kg/ha-mm) were recorded with soil application of N @ 20 kg/ha (at 40-45 DAS) (Table 1.7.16).

Table 1.7.16: Effect of soil and foliar application treatments on pearlmillet yield and economics

Treatment	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Grain	Fodder			
Urea spray (1%)	1204	2635	1.80	17372	2.02
Urea spray (2%)	1367	3038	2.04	21025	2.45
Thiourea 1000 ppm	1216	2840	1.81	18079	2.08
N @ 20 kg/ha (at 20-25 DAS)	1424	3112	2.13	21975	2.52
N @ 20 kg/ha (at 40-45 DAS)	1531	3422	2.28	24512	2.81
$ZnSO_4$ spray 0.5%	1077	2511	1.61	15244	1.80
CD at 5%	291	564			

Situation: Terminal drought

During 2016, due to early withdrawal of monsoon, no rainfall was received from 6th October to maturity of crop. Two supplemental irrigations of 60 mm at flowering and capsule development stage to overcome the terminal drought in castor recorded higher seed and stalk yields of 1520 and 3010 kg/ha, respectively over no irrigation. The highest net returns (Rs. 38735/ha), B:C ratio (2.68) and WUE (2.24 kg/ha-mm) were also recorded with supplemental irrigation (Table 1.7.17).

Table 1.7.17: Effect of supplemental irrigation on yield and economics of castor

Intervention	Yields (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Seed	Stalk			
Supplemental irrigation	1520	3010	2.27	38735	2.68
No supplemental irrigations	1035	2174	1.54	24827	2.17

Two life saving irrigations were given from the harvested rain water in farm pond/ open well through micro irrigation system

Castor - Supplemental irrigation through drip system

Castor – no supplemental irrigation

Preparedness

Rainwater management

The *in-situ* moisture conservation practice (compartment bunding) in pearlmillet recorded significantly highest grain (1633 kg/ha) and fodder (4478 kg/ha) yields over no compartment bunding with highest net returns of Rs. 24304/ha, B:C ratio (2.49) and RWUE (2.44 kg/ha-mm) (Table 1.7.18).

Table 1.7.18: Effect of *in-situ* moisture conservation on yield and economics of pearlmillet

Intervention	Yields (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio	% yield increase
	Grain	Fodder				
Compartment bunding	1633	4478	2.44	24304	2.49	60.1
No bunding	1020	2786	1.52	12190	1.35	-
CD at 5%	162	344	-	-	-	-

Compartmental bunding

Local practice (no bunding)

Ridge and furrow method for *in-situ* moisture conservation in castor recorded highest seed (1179 kg/ha) and stalk yield (2290 kg/ha) over local practice of flat method of sowing (975 kg/ha). The highest net returns (Rs. 28606//ha), B: C ratio (2.26) and RWUE (1.76 kg/ha-mm) were also recorded with ridge and furrow method of sowing (Table 1.7.19).

Table 1.7.19: Effect of *in-situ* moisture conservation on yield and economics of castor

Intervention	Yields (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Seed	Stalk			
Ridge & furrow & system	1179	2290	1.76	28606	2.26
Flat bed system	975	1846	1.46	22632	1.98
CD at 5%	119	263			

Cropping systems

Castor + greengram (1:1) intercropping system recorded significantly higher castor equivalent yield (1801 kg/ha) with higher net returns (Rs 45704/ha), B:C ratio (2.94) and RWUE (2.69 kg/ha-mm) over sole castor (Table 1.7.20).

Table 1.7.20: Performance of castor + greengram (1:1) intercropping system

Intervention	Castor equivalent yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Castor (GCH 7) + greengram (GM 4)	1801	2.69	45704	2.94
Castor sole	1138	1.70	25414	1.91
CD at 5%	159			

Castor + greengram (1:1)

Castor sole

Energy management

Demonstrations were undertaken on different conservation equipments for sowing of greengram (GM 4) in farmers' fields. Greengram sown with roto till drill recorded significantly the highest seed (695 kg/ha) and stover (1655 kg/ha) yield, over rest of sowing implements, but was statistically similar with strip till drill. The highest net returns (Rs. 45787/ha), B:C ratio (5.83) and RWUE (1.04 kg/ha-mm) were recorded with roto till drill (Table 1.7.21).

Table 1.7.21: Effect of different sowing implements on yield and economics of greengram

Sowing implement	Yields (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio	% yield increase
	Seed	Stover				
Roto till drill	695	1655	1.04	45787	5.83	56.2
Strip till drill	610	1430	0.91	39145	4.99	37.1
Zero till drill	530	1215	0.79	32906	4.19	19.1
Local practice	445	1025	0.66	26786	3.60	-
CD at 5%	66	139	-	-	-	-

1.8 SOLAPUR

a. Agro-ecological setting

Solapur is in Deccan Plateau of South Western Maharashtra and North Karnataka Plateau (AESR 6.1). The climate is hot semi-arid. The mean Annual rainfall is 721.4 mm. Annual average potential evapo-transpiration is 589 mm. The length of growing period is 90-120 days. Solapur is a rain shadow area and has drought occurring once in ten years.

b. On-station experiments

Experienced weather conditions during 2016-17

During 2016, a rainfall of 804.1 mm was received which was excess by 82.7 mm compared to normal of 721.4 mm. During *kharif*, 684.5 mm rainfall was recorded, which was excess by 149.3 mm than normal of 535.2 mm; *rabi* recorded 67.4 mm which was deficit by 58.1 mm than normal rainfall (125.5 mm) and in summer, 52.2 mm rainfall was received against normal (52.6 mm) (Fig 1.8.1).

Normal onset of monsoon : 7 June
Onset of monsoon during 2016-17 : 12 June
Normal annual rainfall : 721.4 mm
Annual rainfall during 2016-17 : 804.1 mm
Mean crop seasonal rainfall : 535.2 and 125.5 mm during *kharif* and *rabi*, respectively
Crop seasonal rainfall during 2016-17 : 684.5 and 67.4 mm during *kharif* and *rabi*, respectively

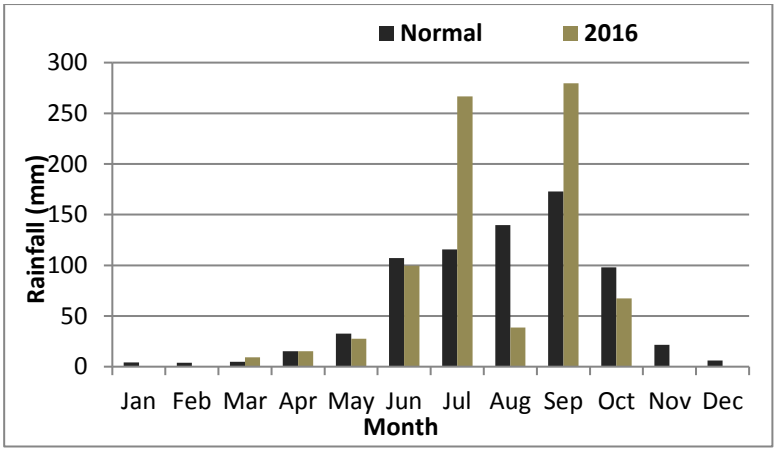


Fig.1.8.1: Normal and actual (2016) monthly rainfall at Solapur

Dry spells during crop growing season (2016-17)

Dry spell		Crop	Stage of the crop
Duration (days)	**Dates & months**		
17 days	22nd June to 9th July	Pigeonpea	Early growth stage
		Pearl millet	Vegetative stage
11 days	7th August to 18th August	Sunflower	Button stage
		Blackgram	Flowering stage
More than 30 days	13th October onwards	Sorghum and chickpea	From flowering stage onwards

Salient achievements of on-station experiments

Preparedness

Crops and cropping systems

Improved varieties of pearlmillet, sunflower and blackgram were evaluated under normal season conditions. Improved varieties gave increased yield (24.3 to 54%), higher net returns, B:C ratio and RWUE compared to local variation of respective crops. Sunflower cv. Phule Bhaskar gave higher net returns of Rs.22160/ha and B:C ratio of 2.52 (Table 1.8.1).

Table 1.8.1: Performance of improved varieties of different crops

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With improved variety	Local variety				
Pearlmillet	Dhanshakti	1033	831	24.30	2.60	9849	2.01
Sunflower	Phule Bhaskar	900	655	38.46	2.49	22160	2.52
Blackgram	TAU-1	750	487	54	2.14	21702	2.49

Pearlmillet – Dhanshakti

Sunflower - Phule Bhaskar

Blackgram - TAU-1

Pigeonpea (Vipula) + sunflower (Phule Bhaskar) intercropping system recorded higher crop yield (1050kg/ha and 780kg/ha), net returns (Rs.47990/ha), B:C ratio (3.50) and RWUE (1.74) when compared to farmers practice. Similarly, pigeonpea (Vipula) + pearlmillet (Dhanshakti) recorded higher yield (1010 and 750kg/ha), net returns (Rs.38910/ha), B:C ratio (3.49) and RWUE (1.67) when compared to farmer practice (Table 1.8.2).

Table 1.8.2: Performance of varieties under different cropping systems during *kharif* season

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Main crop	Intercrop				
Improved Practice Pigeonpea (Vipula)+ Sunflower (Phule Bhaskar)	1050	780	19100	47990	3.50	1.74
Farmers' practice* Mixed cropping of pigeon + sunflower	817	705	18350	35680	2.94	1.35

*Local variety

c. On-farm demonstrations

Village profile

The program is being implemented in Narotiwadi village, North Solapur Tehsil in Solapur district Maharashtra. The total cultivated area is 560.7 ha out of which 450 ha is rainfed. The mean annual rainfall is 554.75 mm with seasonal rainfall of 535.1 mm during *kharif* (June-September) which was deficit by 25.45 mm as compared to normal rainfall (535.1 mm). The major soil types are

sandy loam, loam and clay loam. The major rainfed crops in *kharif* are sunflower, pigeonpea and blackgram, and 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 vulnerability in general

The climate of this agro-climatic zone is semi-arid. Out of the total annual average rainfall of 554.75 mm, the south-west monsoon contributes 80% and winter rainfall 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 (south-west) of monsoon was during 21 SMW and north- east monsoon was during 40 SMW (October). 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 the monsoon is normal. The extreme events like unusual and high intensity rainfall in short span are increasing during 28 SMW (July).

Experienced weather conditions during 2016-17

During 2016, in Narotiwadi village, a rainfall of 765 mm was received which was excess by 43.6 mm compared to normal (721.4 mm). During *kharif* season, 760 mm rainfall was recorded which was excess by 224.8 mm than normal of 535.1 mm, *rabi* recorded 5 mm rainfall which was deficit by 120.5 mm than normal of 125.5 mm. During summer, there was no rainfall (Fig 1.8.2).

Normal onset of monsoon : 7th June
Onset of monsoon during 2016-17 : 10th June
Normal annual rainfall : 721.4 mm
Annual rainfall during 2016-17 : 765 mm
Mean crop seasonal rainfall : 535.1 and 125.5 mm during *kharif* and *rabi*, respectively
Crop seasonal rainfall during 2016-17 : 760 and 5 mm during *kharif* and *rabi*, respectively

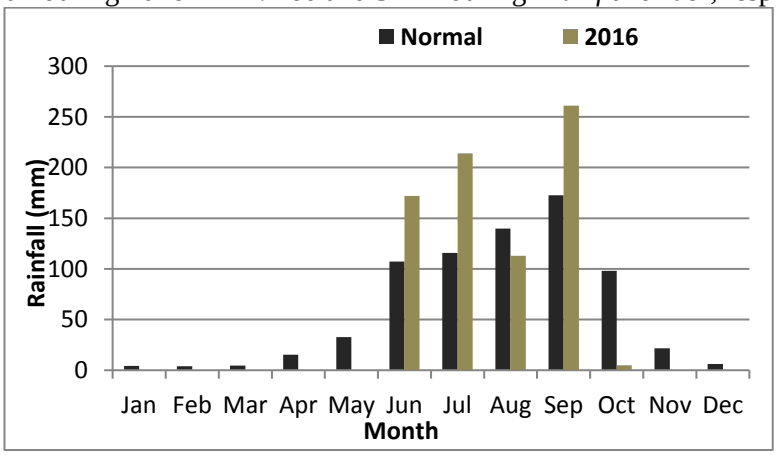


Fig.1.8.2: Normal and actual (2016) monthly rainfall at Narotiwadi

Dry spells during crop growing season (2016)

Dry spell		Crop & Stage
Duration (days)	**Dates & months**	
17	7th August to 24th August	Pigeonpea- early growth stage Pearlmillet- vegetative growth stage Sunflower- button growth stage Blackgram- flowering stage
14	31st August to 13th September	
120	28th October onwards	Sorghum and chickpea- moisture stress at flowering till maturity

Real time contingency practices (RTCP) implemented

Terminal drought	Sorghum	Improved variety *viz* Phule Vasudha, Phule Suchitra and Phule Anuradha
		One weeding within 30 days after sowing Hoeing at 3rd, 5th, 8th week after sowing Protective irrigation at 42nd day Removal of 1/3rd plant population.
	Gram	Improved variety
		1) One weeding within 30 days after sowing. 2) Hoeing at 3rd week after sowing. 3)Protective irrigation at 42nd days

Salient achievements

Real time contingency planning implemented

Situation: Terminal drought

During 2016, no rainfall was received after 28th October in Narotiwadi village. One weeding at 21 days stage, and two hoeings at 15 to 20 DAS and 30 DAS with peg tooth hoe was done to create dust mulch. The pigeonpea seed yield was higher by 18% (1180 kg/ha) with weeding/interculture and gave higher net returns (Rs 29440/ha), B:C ratio (2.68) and RWUE (1.96 kg/ha-mm) compared to no weeding/interculture (1000 kg/ha) (Table 1.8.3).

Table 1.8.3: Effect of *in-situ* moisture conservation on pigeonpea yield and economics

Crop	Seed yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With improved practice*	Farmers practice				
Pigeonpea	1180	1000	18	1.96	29440	2.68

*Two hoeings at 15 to 20 DAS and 30 DAS & 5 % neem extract spray

Preparedness

Cropping systems

Improved varieties of pigeonpea, pearlmillet, sunflower and blackgram were demonstrated under normal onset of monsoon condition. Improved varieties gave increased yield (14.68 to 40.04%), higher net returns, B:C ratio and RWUE with respect to their farmers local. Among the tested crops, blackgram variety *Dhanshakti* gave higher net returns of Rs.22509/ha and B:C ratio of 3.11 (Table 1.8.4).

Table 1.8.4: Performance of improved varieties under normal season conditions

Crop	Variety	Seed/grain yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Improved variety	Local variety				
Pigeon pea	Vipula	1100	940	17.02	1.82	26584	2.54
Pearl millet	Dhanshakti	953	831	14.68	2.46	8180	1.81
Sunflower	Phule Bhaskar	810	655	23.66	2.09	18416	2.25
Blackgram	Dhanshakti	682	487	40.04	1.76	22509	3.11

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 2016

During 2016, the onset of monsoon was delayed by 12 days (19th June), a rainfall of 481.3 mm was received which was deficit by 113.1 mm (19.02%) compared to normal (594.4 mm). Out of total rainfall, *kharif* season (June- September) recorded 402.9 mm which was excess by 15.4 mm (3.97%) than seasonal normal of 387.5 mm. During *rabi*, it was 12.0 mm which was deficit by 122.0 mm (91.04%) than normal (134.2 mm) and in summer 66.2 mm was recorded than normal (66.1 mm) (Fig 1.9.1)

Normal onset of monsoon : 7th June
Onset of monsoon during 2016 : 19th June
Annual mean rainfall : 594.4 mm
Annual rainfall during 2016 : 481.3 mm
Mean crop seasonal rainfall during *kharif* and *rabi* : *kharif* 388.6 mm and *rabi* 134.2 mm
Crop seasonal rainfall during 2016 (*kharif* & *rabi*) : *kharif* 402.9 mm and *rabi* 12.0 mm

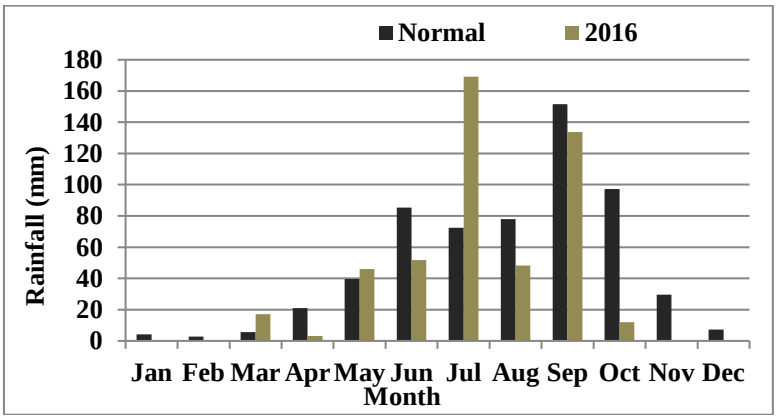


Fig 1.9.1: Normal and actual (2016) monthly rainfall at Vijayapura

Dry spells during crop growing season (2016)

Dry spell		Crops	Stage of the crop
Duration	**Dates & Months**		
16 Days	13th August 28th August	Pearlmillet	Ear head emerging stage
		Pigeonpea	Vegetative growth stage
		Groundnut	Peg initiation stage
		Greengram	Physiological maturity stage
There was no rainfall since 9th October			

Real time contingency practices (RTCPs) implemented

Weather aberration	Crop	RTCP
Delayed onset of monsoon	Pigeonpea Pearlmillet	Change in the crop varieties

Salient achievements of on-station experiments

Real time contingency planning

Situation: Delayed onset of monsoon

During 2016, the onset of monsoon was delayed by 12 days (17th June). Pigeonpea and pearlmillet crop varieties were evaluated under late sown condition. The wilt resistant, high yielding and short duration variety of pigeonpea (TS 3R) was compared with Gulyal local. The pigeonpea cv. TS 3R gave increased yield (10.26%), higher net returns (Rs.30692/ha), B:C ratio (4.41) and RWUE (2.72 kg/ha-mm) compared to local variety (Gulyal). Similarly, pearlmillet cv. ICTP 8203 gave higher yield (11.83%), net returns (Rs.11827/ha), B:C ratio (2.31) and RWUE (1.80 kg/ha-mm) compared with local variety (Table 1.9.1).

Table 1.9.1: Yield and economics of improved varieties under delayed onset of monsoon

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With improved variety/hybrid	Local variety				
Pigeonpea	TS 3R	827	750	10.26	2.72	30692	4.41
Pearlmillet	ICTP 8203	548	490	11.83	1.80	11827	2.31

Preparedness

Rainwater management

In-situ rainwater management practice with set furrow, pearlmillet + groundnut intercropping system gave significantly higher peralmillet equivalent yield (2430 kg/ha), however the yield was on par with the flat bed system (2355 kg/ha). The significantly higher gross returns and net returns of pearlmillet + groundnut system was recorded in the set furrow (43745Rs/ha, 29245 Rs/ha respectively) (Table 1.9.2).

Table 1.9.2: Effect of set furrow cultivation on yield of pearlmillet and groundnut

Treatment	Seed (kg/ha)		PEY (kg/ha)	RWUE (kg/ha-mm)		Gross return (Rs/ha)	Net returns (Rs/ha)
	Pearlmillet	Groundnut		Pearl millet	Ground nut	Pearlmillet + groundnut	Pearlmillet + groundnut
Set furrow + residue + Glyricidia incorporation	675	367	1859	2.11	1.15	33455	18955
Set furrow + silt + residue + glyricidia incorporation	481	319	1509	1.50	1.0	27168	12668
Set furrow without any GLM and crop residue incorporation	848	491	2430	2.65	1.54	43745	29245
Flatbed system	933	441	2355	2.92	1.38	42390	27890
CD @ 0.05	132	69	253			4570	4570

GLM- green leaf manuring

Cropping systems

Pigeonpea cv TS 3R recorded higher grain yield (856 kg/ha), net returns (Rs.32077/ha), B:C ratio (4.56) and RWUE (2.82 kg/ha-mm) compared with Gulyal local. Similarly, pearlmillet cv ICTP 8203 recorded higher grain yield (663 kg/ha), net returns (Rs.16212/ha), B:C ratio (2.80) and RWUE (2.18 kg/ha-mm) compared with local variety (Table 1.9.3).

Table 1.9.3: Performance of improved varieties of pigeonpea and pearlmillet

Crop/cultivar	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain/ seed in 2016	Stover/ talk				
Pigeonpea (TS 3R)	856	1806	9000	32077	4.56	2.82
Pearl millet (ICTP 8203)	663	1418	6000	16212	2.80	2.18

Among different intercropping systems, safflower + chickpea (2:4) recorded higher seed yield (941 kg/ha), net returns (Rs.38841/ha) and RWUE (19.17 kg/ha-mm) compared to other intercropping systems (Table 1.9.4).

Table 1.9.4: Performance of different intercropping systems

Intercropping system	Yield (kg/ha)		Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Main crop	Intercrop			
Pigeonpea + pearl millet (2:1)	423	510	13827	1.84	1.39
Pigeonpea + ground nut (2:4)	760	577	54942	4.33	2.50
Sorghum + chickpea (2:4)	500	565	37206	4.38	10.18
Safflower + chickpea (2:4)	941	182	38841	4.38	19.17

Nutrient management

Seed treatment with $CaCl_2$ gave higher yield in all the crops tried when compared to without seed treatment. Among the crops, chickpea (Jaki-9218) and sorghum (M 35-1) showed higher percentage of yield increase (14.75 & 14.19%, respectively). B:C ratio was also high in all the treatments (Table 1.9.5).

Table 1.9.5: Effect of seed treatment on crop yield and economics

Crop/variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Improved variety	Local variety				
Sorghum (M 35-1)	941	824	14.19	19.17	14627	3.08
Sorghum (BJV-44)	1059	1029	2.91	21.56	17333	3.47
Chickpea (Jaki-9218)	941	820	14.75	16.77	48431	7.02
Chickpea (JG-11)	971	882	9.16	19.77	50195	7.24
Chickpea (GBM-2)	824	765	7.71	16.77	41372	6.15

On-farm demonstrations

Village profile

The program is being implemented by AICRPDA Centre, Vijayapura in Kavalagi village, Vijayapur tehsil, Vijayapur 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.

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 2016-17

During 2016, the onset of monsoon was delayed by 12 days (19th June) in Kaulagi village. An annual rainfall of 490.6 mm was received which was deficit by 103.8 mm (17.46%) than normal (594.4 mm). During *kharif*, there was a rainfall of 430.4 mm, excess by 42.9 mm (11.07%) than normal (387.5 mm) and in *rabi* season 49.1 mm rainfall was recorded which was deficit by 84.9 mm (63.36%) against normal of 134 mm and during summer it was 11.1 mm, deficit by 55.0 mm (83.2%) than normal of 66.1 mm (1.9.2).

Normal onset of monsoon	: 7 June
Onset of monsoon during 2016-17	: 19 June
Annual mean rainfall	: 594.4 mm
Annual rainfall during 2016-17	: 490.6 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	: *kharif* 387.5 mm and *rabi* 134.0 mm
Crop seasonal rainfall during 2015-16	: *kharif* 430.4 mm and *rabi* 49.1 mm

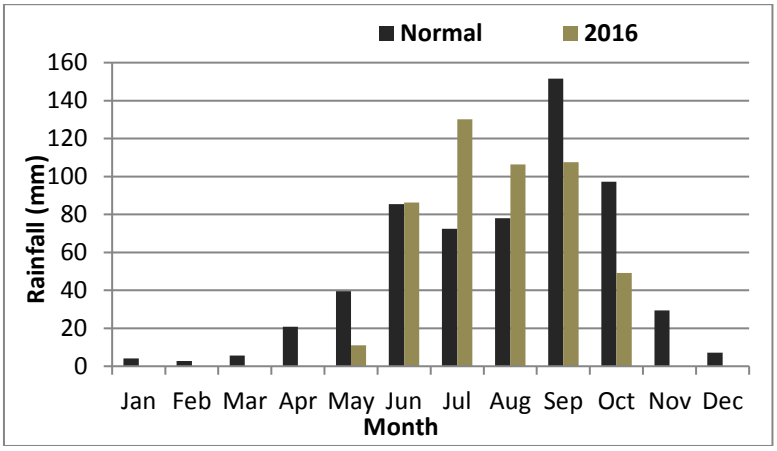


Fig.1.9.2: Normal and actual (2016) monthly rainfall at Kavalagi

Dry spells during crop growing season (2016-17)

Dry spell		Crop	Stage of the crop
Duration	**Dates & Months**		
16 days	13-08-2016 to 28-08-2016	Pigeonpea, pearlmillet	Vegetative growth stage
		Greengram	Pod development stage
13 days	30-08-2016 to 12-09-2016	Pigeonpea, pearlmillet	vegetative growth stage
		Greengram	Grain filling stage
There was no rainfall since 9th October			

Salient achievements

Real time contingency plan implementation

Situation: Delayed onset of monsoon

During 2016, the onset of monsoon was delayed by 12 days (19th June). Improved varieties of pigeonpea, greengram and pearlmillet crop were demonstrated in five farmer's fields. The improved varieties recorded higher percentage of increase in yield with their respective local varieties. The improved variety TS 3R of pigeonpea recorded higher yield (975 kg/ha), net returns (Rs.39750/ha), B:C ratio (5.42) and RWUE (2.46 kg/ha-mm) as compared to farmer's practices (Gulyal) (Table 1.9.6).

Table 1.9.6: Effect of improved variety on crop yield and economics

Crop	Variety (duration)	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Improved variety	Local variety				
Pigeonpea	TS 3R (135-145days)	975	700	39.28	2.46	39750	5.42
Greengram	GBS-9	128	98	30.61	0.53	3945	1.66
Pearlmillet	(ICTP 8203)	425	571	34.35	1.75	4275	1.71

Situation: Early season drought

During *rabi* 2016, there was a dry spell during September and October. Repeated interculturing operation at seedling stage, vegetative growth stage and grand growth stage were done in chickpea for in-situ moisture conservation and weed management. Improved practice recorded 57.9% increase in yield, higher net returns (Rs.45125/ha), B;C ratio (6.64) and RWUE (14.92 kg/ha-mm) compared to without interculturing (1.9.7).

Table 1.9.7: Effect of interculturing operation on yield and economics

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With interculture	Without interculture				
Chickpea	Jaki 9218	782	499	57.9	14.92	45125	6.64

Situation: Mid season drought

To cope with dry spell during November, foliar spray of KNO_3 @ 0.5% was done on sorghum and chickpea crops. The yield of chickpea was increased by 41.4% and chickpea gave higher yield (750 kg/ha), net returns (Rs.43000/ha), B:C ratio (6.38) and RWUE (15.27 kg/ha-mm) compared to without foliar spray treatment. Similarly, sorghum yield increased by 34.3% and sorghum gave higher yield (1583 kg/ha), net returns (Rs.25250/ha), B:C ratio (4.16) and RWUE (32.25 kg/ha-mm) compared to without foliar spray treatment (Table 1.9.8).

Table 1.9.8: Effect of Foliar spray on yield and economics of the crops

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With foliar spray	Without foliar spray				
Chickpea	Jaki 9218	750	532	41.4	15.27	43000	6.38
Sorghum	BJV-44	1583	1042	34.3	32.25	25250	4.16

Preparedness

Rainwater management

In-situ moisture conservation practice with compartmental bunding in chickpea recorded significantly highest seed yield (691 kg/ha), higher net returns of Rs.38963/ha, B:C ratio (5.87) and RWUE (14.07 kg/ha-mm) over no compartmental bunding (Table 1.9.9).

Table 1.9.9: Effect of *in-situ* moisture conservation on yield and economics of chickpea

Intervention	Yield (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	RWUE (kg/ha-mm)
Compartment bunding	691	8500	38963	14.07
Without compartment bunding	444	8000	22184	9.04

Cropping systems

Pigeonpea + roundnut (2:4) intercropping system gave maximum CEY (2265 kg/ha), net returns (Rs.967258/ha), and RWUE (6.86 kg/ha-mm) compared to other cropping systems (Table 1.9.10).

Table 1.9.10: Yield and economics of maize + blackgram (2:2) intercropping system

Intecropping system	Yield (kg/ha)		CEY	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Main crop	Intercrop					
Pigeonpea + ground nut (2:4)	1000	800	1928	16500	79900	5.84	2.52
Pigeonpea + ground nut (2:4)	1163	950	2265	16500	96725	6.86	2.93
Sorghum + chickpea (2:4)	500	565	2096	11000	37206	4.38	11.50
Safflower + chickpea (2:4)	941	182	2014	11500	38841	4.38	19.17

Energy management

The energy input for chickpea production was 4924 and 4876 MJ/ha in the field with compartment bunds and without compartment bunds respectively. The energy ratio (Output energy/ input energy) was in the ratio of 6.09 to 7.74 in crops with compartment bunds while it was 3.67 to 5.07 in the crops without compartment bunds (Table 1.9.11).

Table 1.9.11: Effect of treatments on energy use efficiency

Treatment	Yield (kg/ha)	Energy (MJ/ha)		Energy use efficiency
		Input	Output	
Compartment bunding				
Chickpea	675	4924	33750	6.85
Chickpea	600	4924	30000	6.09
Chickpea	763	4924	38150	7.74
Chickpea	725	4924	36250	7.36
Without compartment bunding				
Chickpea	358	4876	17900	3.67
Chickpea	473	4876	23650	4.85
Chickpea	450	4876	22500	4.61
Chickpea	495	4876	24750	5.07

**During the crop production different tillage operations have been carried out, so we cannot give as the single field efficiency*

Land management units

On the bases of soil conservation unit (SCU) and soil quality units (SQU) the land management units (LMU) have been derived. There are totally 14 LMUs. However, for the present study on three LMU (I, II and III) have been considered. The higher pigeonpea and chickpea yields was recorded in LMU-I followed by LMU-II and LMU-III. Further, net returns and benefit cost ratio were also high in LMU-I followed by LMU-II and LMU-III (1.9.12).

Table 1.9.12: Effect of Different land management units on different crops yield and economics

Treatment	Crop	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
		Seed/ grain	Stover/stalk				
LMU-I	Pigeonpea	1175	2502	9000	47400	6.27	2.96
	Chickpea	775	1627	8000	44700	6.59	15.78
	Sorghum*	1688	3544	8000	27438	4.43	34.57
LMU-II	Pigeonpea	950	2033	9000	36600	5.07	2.40
	Chickpea	588	1186	8000	31950	4.99	11.97
	Sorghum*	1250	2875	8000	18250	3.28	25.46
LMU-III	Pigeonpea	675	1437	9000	24250	3.55	1.70
	Chickpea	295	568	8000	12060	2.51	6.01
	Sorghum*	1100	2420	8000	15100	2.89	22.40

2.0 Moist Semi Arid Zone (750-1000 mm)

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 2016-17

During 2016, the onset of monsoon was early by 4 days (7th June) and a rainfall of 852.8 mm was received which was excess by 78.0 mm (10.1%) compared to normal (774.8 mm) (Fig 2.1.1). Out of total rainfall received, 741.8 mm was received during *kharif* season which was excess by 75.5 mm compared to normal of 666.3 mm. During *rabi* (October-December), 90.5 mm of rainfall was received compared to normal of 66.8 mm. During summer (March-May), 20.5 mm of rainfall was received which was deficit by 2.8 mm compared to normal (23.3 mm).

Normal onset of monsoon	: 11-17 June (24th SMW)
Onset of monsoon during 2016-17	: 7 June
Annual mean rainfall	: 774.8 mm
Annual mean rainfall during 2016-17	: 852.8 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	: 666.3and 66.8 mm respectively
Crop seasonal rainfall during 2016-17	: 741.8 in *kharif* and 90.5 mm in *rabi*

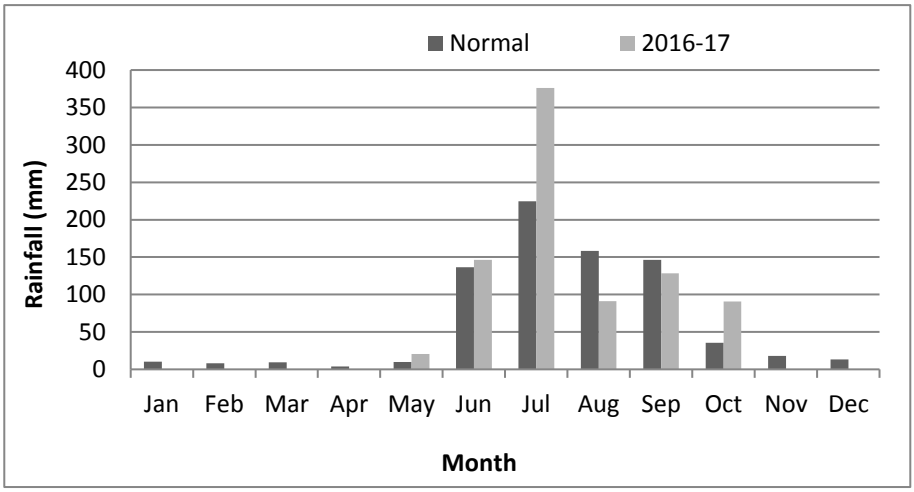


Fig.2.1.1: Normal and actual (2016) monthly rainfall at Akola

Dry spells during crop growing season (2016)

Dry spells		Crop	Stage of the crop
Duration (days)	**Dates & Months**		
12	13 -24 July	Cotton, soybean, pigeonpea, sorghum and greengram	Vegetative
16	8 -23 August	Soybean, sorghum, greengram	Flowering, flag leaf pod development
		Cotton	Square formation
		Pigeonpea	Vegetative
19	25 August -13 September	Cotton	Flowering and boll initiation
		Pigeonpea	Vegetative

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	Real time contingency measure implemented
Early season drought	Cotton, soybean, pigeonpea, sorghum and greengram	Vegetative	Opening of furrows after each row at 30-35 DAS and mulching
Mid Season drought	Cotton	Vegetative	
	Soybean	Flowering	
	Sorghum	Flag leaf	
	Pigeonpea	Vegetative	
	Greengram	Pod initiation	
Terminal drought	Cotton	Boll development	Spraying of 2% urea at flowering and 2% DAP at boll development stage
	Pigeonpea	Vegetative	Mulching

Salient achievements of on-station experiments

Real time contingency crop planning

Situation: Early season drought

During 2016, there was one dry spell of 12 days (13-24 July) coinciding with vegetative stage of crops. During early season drought, furrow opening at 30-35 DAS in between crop rows and mulching was implemented in soybean. *In-situ* moisture conservation (furrow opening at 30-35 DAS in between crop rows) & mulching in soybean variety (JS-335**)**, resulted in mitigating the dry spells and gave higher seed yield (2220 kg/ha) with higher net returns (Rs.28062/ha), B:C ratio (1.77), RWUE (10.39 kg/ha-mm) compared to farmers' practice (2000 kg/ha) (Table 2.1.1).

Table 2.1.1: Effect of *in-situ* moisture conservation in different varieties of soybean

Treatment/ variety	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)	% yield increase
	Seed	Stover					
JS-335							
Furrow opening	2084	2606	33400	27179	1.81	3.01	3.7
Mulching	2220	2775	36457	28062	1.77	3.21	10.4
Control	2011	2514	33305	25143	1.75	2.91	-
JS-9560							
Furrow opening	2107	2633	33429	27796	1.83	3.05	5.3
Mulching	2200	2750	36431	27507	1.76	3.18	10.0
Control	2000	2500	33291	24835	1.75	2.89	-

Situation: Midseason drought

During 2016, there was one dry spell of 16 days (8-23 August) coinciding with flowering, vegetative and pod initiation in soybean, pigeonpea and greengram, respectively. To overcome dry spell in soybean (JS-335), one protective irrigation (50 mm depth) from stored farm pond water with sprinkler system at pod initiation resulted in 12.2% increase in yield whereas two protective irrigations at pod initiation and pod development resulted in 48.2% increase in yield over the control. The net returns (Rs.12113 and 24214/ha), B: C ratio (1.44 and 1.87) and RWUE (1.69 and 2.24 kg/ha-

mm) were also higher with one and two protective irrigations, respectively compared to control (Table 2.1.2).

Table 2.1.2: Effect of protective irrigation on yield of soybean (JS-335)

Treatment	Yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
One protective irrigation (at pod initiation)	1399	12.2	1.69	12113	1.44
Two protective irrigations (at pod initiation and pod development)	1848	48.2	2.24	24214	1.87
Without irrigation (Control)	1247	-	1.51	8017	1.29

Preparedness

Rainwater management

During 2016, mulching in different varieties of cotton AKH-9916, AKH-081under high density planting system (HDPS) and *Bt.* cotton (Balwan), resulted in higher seed cotton yield of 2033, 2433 and 2664 kg/ha, respectively over control (1818, 2222 and 2444 kg/ha). Opening of furrows (1922, 2351 and 2589 kg/ha) in each row after 30-35 DAS and spraying of 2% urea and 2% DAP at flowering and boll development stage recorded similar seed cotton yields in all three varieties, respectively. However, furrow opening recorded higher B: C ratio (2.33, 2.60 and 2.29) in all cotton varieties compared to other treatments due to low cost of furrow opening (Table 2.1.3).

Table 2.1.3: Effect of *in-situ* moisture conservation under timely sowing in cotton

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)	% yield increase
	Seed cotton	Stalk					
AKH-9916							
Control	1818	2272	34953	43325	2.24	2.63	0.00
Furrow opening	1922	2403	35475	47301	2.33	2.78	5.75
Mulching	2033	2542	38911	48650	2.25	2.94	11.86
Spray*	1911	2389	36480	45818	2.26	2.76	5.13
AKH-081 under HDPS							
Control	2222	2778	38371	57324	2.49	3.21	0.00
Furrow opening	2351	2939	39015	62229	2.60	3.40	5.80
Mulching	2433	3042	42306	62479	2.48	3.52	9.50
Spray	2362	2953	40131	61592	2.53	3.42	6.30
***Bt.* cotton (Balwan)**							
Control	2444	3056	47882	57382	2.20	3.54	0.00
Furrow opening	2589	3236	48604	62880	2.29	3.74	5.91
Mulching	2664	3331	51862	62876	2.21	3.85	9.00
Spray	2600	3250	49720	62243	2.25	3.76	6.36

*Foliar spraying of 2% urea at flowering and 2% DAP at boll development stage of cotton

Among different *in-situ* moisture conservation practices, mulching in pigeonpea (PKV Tara) recorded higher seed yield (1592 kg/ha) followed by foliar spray (1542 kg/ha) and opening of furrows (1520 Kg/ha). Mulching, spraying and opening of furrows recorded 6.5, 11.5 and 8.0% increase in seed yield over control. However, B:C ratio (2.61) was higher with opening of furrow in each row after 30-35 DAS (2.61) followed by spraying of 2% urea at flowering and 2% DAP at pod development stage (2.55) (Table 2.1.4).

Table 2.1.4: Effect of *in-situ* moisture conservation under timely sowing in pigeonpea (PKV Tara)

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)	% yield increase
	Seed	Stalk					
Control	1427	2240	28409	41380	2.46	2.06	0.00
Furrow opening	1520	2386	28530	45825	2.61	2.20	6.54
Mulching	1592	2499	31503	46357	2.47	2.30	11.57
Spray*	1542	2420	29618	45796	2.55	2.23	8.06

*Foliar spraying of 2% urea at flowering and 2% DAP at pod development stage

Mulching in sweet corn recorded higher yield (126222 cobs/ha), net returns (Rs.249441/ha) and RWUE of 182.56 kg/ha-mm. Further, opening of furrow after 25-30 DAS recorded higher B:C ratio (4.92) due to low cost of furrow making (Table 2.1.5).

Table 2.1.5: Effect of *in-situ* moisture conservation in sweet corn (US-103)

Treatment	Number of cobs/ha	Cost of cultivation (Rs/ ha)	Net return (Rs/ ha)	B:C ratio	RWUE (kg /ha-mm)	% yield increase
Control	115556	63234	225654	4.57	167.13	-
Furrow opening	124444	63234	247877	4.92	179.99	7.7
Mulching	126222	66114	249441	4.77	182.56	9.2

Under late sown condition, higher seed cotton yield 1382 kg/ha was recorded ewith spraying of 2% urea and 2% DAP at flowering and boll development stage followed by mulching (1362 kg/ha) and furrow opening (1336 kg/ha). However, due to low cost of cultivation furrow opening recorded higher B:C ratio (1.77) followed by spraying of 2% urea at flowering and 2% DAP at boll development stage of cotton (Table 2.1.6).

Table 2.1.6: Effect of *in-situ* moisture conservation techniques under late sown condition in cotton (AKH-9916)

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)	% yield increase
	Seed cotton	Stalk					
Control	1211	1514	31920	20234	1.63	2.88	0.00
Furrow opening	1336	1669	32542	24971	1.77	3.18	10.28
Mulching	1362	1703	35555	23106	1.65	3.24	12.48
Spray	1382	1728	33835	25687	1.76	3.29	14.13

*Foliar spraying of 2% urea at flowering and 2% DAP at boll development stage of cotton

Risk resilient intercropping system of cotton + sorghum + pigeonpea + sorghum in row proportion of 3:1:1:1 with a spacing of 45 cm was demonstrated under timely sown condition during *kharif* 2016. In this system, the higher cotton equivalent yield (1784) was recorded with spraying of 2% urea at flowering and 2% DAP in cotton and pigeonpea followed by mulching and furrow opening in each row at 30-35 DAS (1761 and 1720 kg/ha, respectively) (Table 2.1.7).

Table 2.1.7: Effect of *in-situ* moisture conservation in intercropping system of cotton + sorghum + pigeonpea + sorghum (3:1:1:1)

Treatment	Yield (kg/ha)			CEY (kg/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Cotton	Intercrop					
		Sorghum	Pigeonpea				
Control	985	1237	212	1659	40725	2.26	1.42
Furrow opening	1015	1262	212	1720	43208	2.33	1.47
Mulching	1032	1294	212	1761	41994	2.18	1.49
Spray	1050	1267	212	1784	44745	2.33	1.52

Risk resilient intercropping system of cotton: soybean: pigeonpea: soybean in row proportion of 3:2:2:2 with a spacing of 45 cm was demonstrated under timely sown condition during *kharif* 2016. In this system, the higher cotton equivalent yield (1656 kg/ha) was recorded with foliar spray (2% urea and 2% DAP at boll and pod development stage of cotton and pigeonpea, respectively followed by mulching and furrow opening (1654 and 1613 kg/ha, respectively). However, B:C ratio was higher with furrow opening in each row after 30-35 DAS (2.13) (Table 2.1.8).

Table 2.1.8: Effect of *in-situ* moisture conservation techniques in intercropping systems (Cotton + + soybean + pigeon pea + soybean (3:2:2:2)

Treatment	Yield (kg/ha)			CEY (kg/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Cotton	Intercrop					
		Soybean	Pigeonpea				
Control	844	611	306	1581	36059	2.09	1.22
Furrow opening	861	626	311	1613	37368	2.13	1.25
Mulching	887	654	307	1654	36025	2.00	1.28
Spray	900	617	319	1656	37970	2.11	1.30

*Foliar spra of 2% urea at flowering and 2% DAP at bolls and pod development stage of cotton and pigeonpea

c. On-farm demonstrations

Village profile

The program is being implemented in Varkhed (Bk) village, Barshi Takali Taluka, Akola district, Maharashtra. The total cultivated area is 275 ha out of which 252 ha is rainfed. The mean annual rainfall is 796.0 mm with seasonal rainfall of 743 mm 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 vulnerability 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 upto 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 2016-17

The onset of monsoon was on 7th June. A rainfall of 781 mm was received which was deficit by 11.8 mm compared to normal (792.8 mm) (Fig..). During *kharif* season (June to September), 692 mm of rainfall was received which was excess by 4.0 mm as compared to normal (688 mm). During *rabi* season (October - December), 89 mm rainfall was received which was excess by 7 mm compared to

normal (82 mm). During summer, there was no rainfall compared to normal (22.8 mm) (Fig 2.1.2).

Normal onset of monsoon : 11-17 June
Onset of monsoon during 2016 -17 : 7 June
Annual mean rainfall : 792.8 mm
Annual rainfall during 2016-17 : 781 mm
Mean crop seasonal rainfall during *kharif* and *rabi* : 688 mm and 82 mm, respectively
Crop seasonal rainfall during 2016-17 : 692mm and 89 mm, respectively
Kharif and *rabi*

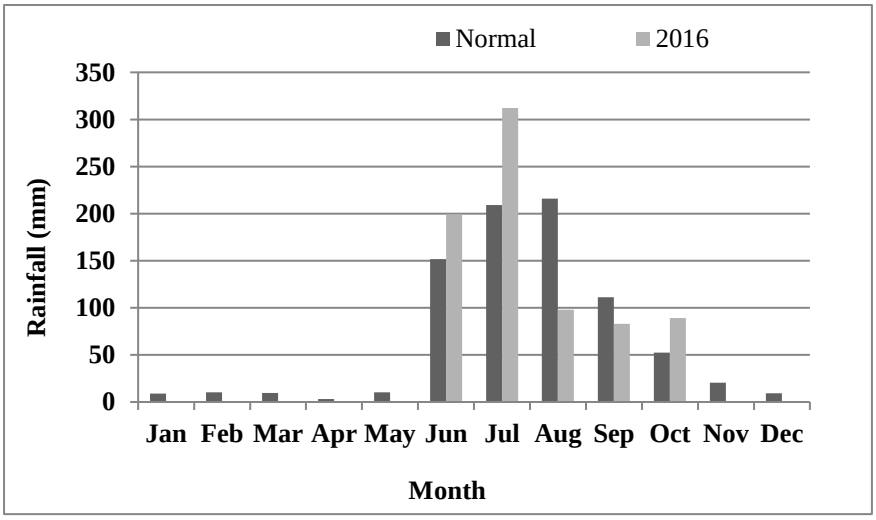


Fig : Normal and actual (2016) monthly rainfall at Barshi Takali

Dry spells during crop growing season (2016-17)

Dry spell		Crop	Stage of the crop
Duration (days)	**Dates & Months**		
13	13 to 25 July	Soybean, cotton, pigeonpea and greengram	Vegetative
12	13 to 23August	Soybean and greengram	Flowering
		Cotton and pigeonpea	Vegetative
19	25 August to 13 September	Soybean	Pod initiation and development
		Greengram	Pod development
		Cotton	Square formation and boll initiation
		Pigeonpea	Vegetative

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	Real time contingency measures implemented
Early season drought	Soybean	Vegetative	Opening of furrow in each row after 30-40 DAS
	Cotton		
	Green Gram		
	Pigeon pea		
Mid season drought	Cotton	Boll development	Spraying of 2% urea at flowering and 2% DAP at boll development
	Pigeonpea	Pod initiation	Mulching

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Early season drought

At Varkhed, during 2016, a dry spell of 13 days occurred during 13-25 July coinciding with early vegetative stage of soybean. Opening of furrow in each row after 30-35 DAS was demonstrated in sixty two farmers' fields at vegetative stage of soybean (JS-335). Furrow opening recorded higher seed yield of 1302 kg/ha compared to farmers' practice (without furrow) (1202 kg/ha). Further, furrow opening resulted in 8.35% increase in yield and higher B: C ratio of 1.38 over the farmer's practice (1.28) (Table 2.1.9).

Table 2.1.9: Effect of opening of furrow on yield and economics of soybean

Treatment	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Without furrow opening	1202	1.67	7788	1.28
With furrow opening	1302	1.81	10561	1.38

In-situ moisture conservation (opening of furrow in each row after 30-40 DAS) in cotton resulted in higher yield of 1899 kg/ha compared to farmers' practice (1755 kg/ha). Furrow opening resulted in 8.2% increase in yield and higher B:C ratio of 1.74 over the farmer's practice (1.63)

Situation: Midseason drought

A dry spell of 19 days occurred during 25 August to 13 September coinciding with pod development stage of soybean and square formation in cotton. Supplemental irrigation of 50 mm depth from harvested rainwater in farm pond during the pod development stage in soybean recorded 13.7 and 15.5% increase in yield (1489 kg/ha) compared to control (Table 2.1.10).

Table 2.1.10: Effect of supplemental irrigation from harvested rainwater on soybean yield

Treatment	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Supplemental irrigation	1489	2.12	15749	1.58
Control	1274	1.85	10474	1.39

Foliar spray of 2% urea at the time of flowering along with 2% DAP at boll development stage in cotton gave 5.9% higher yield compared to farmers' practice. Foliar spray also gave higher net returns (Rs.58382/ha) and B:C ratio (2.17) as compared to farmers' practice (Table 2.1.11).

Table 2.1.11: Effect of foliar spray in cotton + greengram intercropping system

Treatment	Yield (kg/ha)	RWUE (kg/ ha-mm)	Net returns (Rs/ha)	B:C ratio
With foliar spray	1701	2.42	58382	2.17
Without foliar spray	1605	2.28	54761	2.11

Preparedness

Rainwater management

In-situ moisture conservation through opening of furrow in each row at 30-35 DAS in cotton resulted in higher seed cotton yield of 1899 kg/ha compared to farmers practice (1755kg/ha). Opening of furrows also resulted in higher B:C ratio (1.74) and net returns (Rs.34646/ha) as compared to farmers' practice (Table 2.1.12).

Table 2.1.12: Effect of opening of furrow on yield and economics of cotton

Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed cotton (2016)	Mean (4 yrs)	Stalk				

Furrow opening	1899	1535	2374	47130	34646	1.74	2.70
Without furrow opening	1755	1386	2194	46410	29115	1.63	2.50

In-situ moisture conservation through furrow opening in each row at 30-35 DAS in soybean resulted in higher yield of 1302 kg/ha compared to farmers practice (1202 kg/ha). It also recorded higher B: C ratio (1.38) and net returns (Rs10561/ha) compared to farmers' practice (Table 2.1.13).

Table 2.1.13: Effect of opening of furrow 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 (2016)	Mean (5 yrs)	Stalk				
Furrow opening	1302	1395	1627	27282	10561	1.38	1.81
Without furrow opening (Control)	1202	1073	1502	27152	7788	1.28	1.67

Cropping systems

Soybean varieties JS-335 (100-105 days), JS-93-05 (95-100 days) and JS-9560 (90-95 days) were demonstrated during *kharif* 2016-17. Among varieties, JS-9560 produced highest yield of 1288 kg/ha, followed by JS-93-05 (1219 kg/ha) compared to JS-335 (1161 kg/ha). Early maturing verities recorded 10.8 and 4.7% increase in yield over regular variety JS-335 (Table 2.1.14).

Table 2.1.14. Performance of soybean varieties

Variety	Yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
JS-335	1154	-	1.65	6645	1.24
JS-9305	1219	4.7	1.73	8265	1.30
JS-95-60	1288	10.8	1.83	10170	1.37

About 17.8% increase in soybean equivalent yield was observed in soybean + pigeonpea (4:2) intercropping system as compared to soybean + pigeonpea (6:1) (Table). Soybean + pigeonpea intercropping system (4:2) also gave in higher B:C ratio (2.17) and net returns (Rs34656/ha) as compared to soybean + pigeonpea (6:1) system (Table 2.1.15).

Table 2.1.15: Effect of soybean + pigeonpea intercropping system on yield and economics

Intercropping system	Yield (kg/ha)	% yield increase	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Soybean + pigeonpea (4:2)	2218	17.78	3.16	34656	2.17
Soybean + pigeonpea (6:1)	1884	-	2.91	24835	1.83

Cotton + greengram (1:1) intercropping gave 35.6% increase in cotton equivalent yield as compared to sole cotton and also gave higher B:C ratio (3.36) and net returns (Rs.54761/ha) as compared to sole cotton (Table 2.1.16).

Table 2.1.16: Effect of cotton+ greengram intercropping system on crop productivity and economics

Intercropping system	CEY (kg/ha)	% yield increase	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Bt. cotton + greengram (1:1)	2365	35.6	3.36	54761	2.11
Sole *Bt*. cotton	1742	-	2.48	28689	1.62

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 2016-17

During 2016, the onset of monsoon was normal (1st of June). A rainfall of 694.9 mm was received which was deficit by 225.5 mm (24.5%) compared to normal (920.4 mm) (Fig.2.2.1). During *kharif* season (June–September), 480.8 mm rainfall was recorded which was deficit by 27.5 mm (5.41%) against normal of 508.3 mm. In *rabi* season, it was 93.7 mm which was deficit by 160.2 mm (63.1%) than the normal of 253.9 mm and in summer 118 mm rainfall was recorded and was deficit by 56.8 mm (32.5%) than normal of 174.8 mm.

Normal onset of monsoon : 2nd June
Onset of monsoon during 2016-17 : 1st June
Annual mean rainfall : 920.4 mm
Annual rainfall during 2016-17 : 694.9 mm
Mean crop seasonal rainfall during *kharif* & *rabi* : 508.3 & 253.9 mm
Crop seasonal rainfall during 2016-17 *kharif* & *rabi* : 480.8 & 93.7 mm

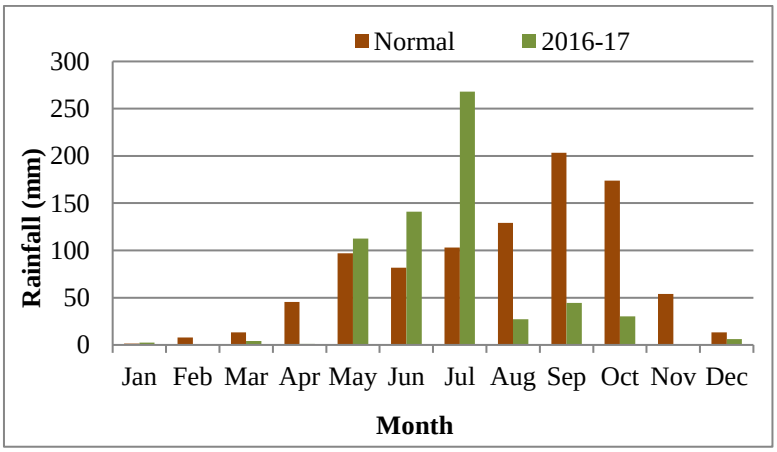


Fig.2.2.1: Normal and actual (2016) monthly rainfall at Bengaluru

Dry spells during crop growing season (2016-17)

Dry spell		Crop	Stage of the crop
Duration (Days)	**Dates and months**		
18	18th August to 04th September	Fingermillet	Germination to establishment
		Pigeonpea, cowpea	Vegetative
		Groundnut	Flowering
		Field bean, castor	Pod filling
13	16th September to 28th September	Fingermillet	Seedling to tillering
		Pigeonpea	Vegetative to flowering
		Groundnut	Pod formation
		Castor	Primary spike initiation

		Sunflower, minormillets niger, grain amaranth, fodder crops, cowpea, field bean, horsegram, rice bean	Germination
10	30th September to 9th October	Finger illet	Tillering to flag leaf
		Pigeonpea	Flowering to pod formation
		Groundnut	Maturity
		Castor	Secondary spike initiation
		Horsegram	Germination to establishment
		Sunflower, minor millets niger, grain amaranth , fodder crops, cowpea, field bean, horse gram, rice bean	Vegetative
49	14th October to 2nd December	Fingermillet	Grain filling to maturity
		Pigeonpea	Pod formation
		Groundnut	Harvesting
		Castor	First picking
		Horse gram	Vegetative
		Sunflower, minor millets niger, grain amaranth, cowpea, field bean, horsegram, rice bean	Flowering

Real Time Contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	Real time contingency measure implemented
Early season drought	Fingermillet and pigeonpea	Sowing	Transplanting of fingermillet and pigeonpea
Mid season drought	Fingermillet	Tillering to flag leaf	1.Foliar spray of % KCl during dry spell
	Chilli	30-45 DAT	Tied ridging and mulching with crop residue
Terminal drought	Field bean, cowpea and pigeonpea	Maturity	Harvesting crop for vegetables
	Fingermillet, maize and minor millets	Maturity	Harvesting crop for fodder

Salient achievements of on-station experiments

Real time contingency planning

Situation: Early season drought

During early season drought, fingermillet can be established through dry sowing, drill sowing and transplanting. Among different methods of fingermillet establishment, transplanting recorded higher grain yield (380 kg/ha) and B:C ratio (0.74) compared to other methods (Table 2.2.1).

Table 2.2.1: Different method of establishment in fingermillet

Treatment	Date of sowing (duration)	Yield (kg/ha)		% increase/ decrease in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Grain	Straw				
Transplanting (MR-1)	08-08-2016 (93 days)	380	3100	58.33	3.73	-5728	0.74
Dry sowing (MR-1)	14-07-2016 (117 days)	220	2050	-8.33	0.61	-12103	0.44
DAP+ seed drill sown (MR-1)	20-07-2016 (113 days)	260	2120	8.33	0.90	-10798	0.50
Normal method of sowing	20-07-2016 (113 days)	240	2200	-	0.83	-11278	0.48

Transplanting

Dry sowing

DAP + seeds drill sown

Situation: Mid season drought

A dry spell of 10 days occurred during 30th September to 9th October coinciding with littering to flag leaf stage of fingermillet. Foliar application of 1% KCl (MoP) during drought when plants started wilting, recorded higher grain yield (500 kg/ha) and B:C ratio (0.95) compared to water spray and control (no spray) (Table 2.2.2).

Table 2.2.2: Response of fingermillet to different foliar sprays

Treatment	Yield (kg/ha)		% increase in yield	RWUE (kg/ha/mm)	Net returns (Rs/ha)	B:C ratio
	Grain	Straw				
Water spray	360	3150	20	0.86	-6253	0.71
1% KCl	500	3810	66	1.20	-1063	0.95
Control (No spray)	300	3310	-	0.72	-7813	0.64

Preparedness

Rainwater Management

Growing chilli varieties Samrudhi and Chikkaballapur local with tied ridges and mulching (crop residue) in the furrow recorded higher dry fruit yield (702 and 369 kg/ha, respectively) compared to without mulching (591and 295 kg/ha, respectively) with a overall yield increase of 13 to 18% (Table 2.2.3).

Table 2.2.3: Effect of mulching in chilli

Variety	Dry fruit yield (kg/ha)		increase in yield (%)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With mulch	Without mulch				
Samrudhi	702	591	18	5.68	59279	3.38
Chikkaballapur local	369	295	13	2.99	19390	1.78

Mulching

Without mulching

Cropping systems

Although there was no significant difference between methods of establishment in fingermillet, higher grain yield (2103 kg/ha) was recorded with transplanting compared to direct sowing (1975 kg/ha). Among the planting geometry, planting with recommended spacing of 30 cm × 10 cm was on par with 30 cm × 30 cm spacing and recorded significantly higher grain yield (2224 kg/ha) compared to the spacing of 45 cm × 30 cm (1788 kg/ha). Among the sources of nutrients, significantly higher grain yield (2179 kg/ha) was recorded with application of recommended dose of FYM @ 7.5 t/ha + RDF (50:40:37.5 kg/ha) compared to application of FYM on N equivalent basis + FYM @ 7.5 t/ha (1899 kg/ha) (Table 2.2.4).

Table 2.2.4: Fingermillet yield as influenced by method of establishment, planting geometry and nutrient source

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)
Method of establishment		
Direct sowing	1975	3797
Transplanting	2103	3899
CD @ 5 %	NS	NS
Planting geometry		
Recommended spacing (30 cm × 10 cm)	2224	4155
30 cm × 30 cm	2104	3872
45 cm × 30 cm	1788	3518
CD @ 5 %	341	489
Nutrient source		
N_1: Recommended dose of FYM 7.5 t/ha + RDF (50:40:37.5 kg/ha)	2179	4221
FYM on N equivalent basis + FYM 7.5 t /ha	1899	3476
CD @ 5 %	278	399

Improved varieties of field bean, cowpea, horsegram and rice bean were demonstrated as contingent crops for delayed sowing (15th September). Among pulses, field bean (HA-4) recorded higher field bean equivalent yield (416 kg/ha), net return (Rs. 1596 /ha) and B:C ratio (1.07) compared to other pulses (Table 2.2.5).

Table 2.2.5: Performances of different pulse crops under delayed sowing

Crop/variety	Duration (days)	Seed yield (kg/ha)	FBEY (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Rice bean (RBL-1)	136	50	38	0.31	-21066	0.10
Horsegram (PHG-9)	121	471	275	2.22	-6853	0.71
Field bean (HA-4)	121	416	416	3.36	1596	1.07
Cowpea (IT-38956-1)	121	346	289	2.34	-6022	0.74
Cowpea (PKB-6)	121	263	219	1.77	-10177	0.56

FBEY=Field bean equivalent yield

Among minor millets sown on 15th September (late sowing), little millet recorded higher grain yield (656 kg/ha), net returns (Rs. 21723/ha) and B:C ratio (2.23) compared to other millets (Table 2.2.6).

Table 2.2.6: Performance of different minor millets under late sown condition

Crop/variety	Duration (days)	Grain yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Kodo millet (PSC-1)	97	379	3.06	5103	1.29
Foxtail millet (RS-118)	97	74	0.60	-13180	0.25
Little millet (OLM-203)	118	656	5.31	21723	2.23
Proso millet (GPUP-21)	97	185	1.49	4549	1.26

In an assessment of fingermillet based intercropping systems, fingermillet (MR-1) + transplanted pigeonpea (BRG-2) in 8:2 ratio with conservation furrow between paired rows of pigeonpea recorded higher fingermillet equivalent yield (3748 kg/ha), net return (Rs. 87790/ha) and B:C ratio (4.12) (Table 2.2.7).

Table 2.2.7: Performance of fingermillet based intercropping systems

Cropping system	Yield (kg/ha)		FEY (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Main crop	Inter crop				
Fingermillet + pigeonpea (DS)	110	347	1268	3.60	12633	1.45
Fingermillet + pigeonpea (TP)	120	1088	3748	22.67	87790	4.12
Fingermillet + *akkadi*	-	9	20	0.12	-28746	0.02

DS: Direct sown pigeonpea, TP: Transplanted pigeonpea, FEY= Fingermillet equivalent yield

Among pulse based intercropping systems, pigeonpea + cowpea (1:1), recorded higher pigeonpea equivalent yield (1150 kg/ha), RWUE (2.0 kg/ha-mm), net returns (Rs. 88282/ha) and B:C ratio (4.31) compared to sole pigeonpea (Table 2.2.8).

Table 2.2.8: Evaluation of pigeonpea based intercropping systems

Cropping system	Yield (kg/ha)		PEY (kg/ha)	% increase in yield	RWUE (kg /ha-mm)	Net returns (Rs/ha)	B:C ratio
	Main crop	Inter crop					
Pigeonpea + soybean (1:1)	637	120	691	78	1.20	43134	2.66
Pigeonpea + cowpea (1:1)	640	1020	1150	196	2.00	88282	4.31
Pigeonpea + field bean (1:1)	637	828	1134	192	1.97	86194	4.17
Sole pigeonpea (BRG-5)	388	-	388	-	1.32	14374	1.59

PEY-Pigeonpea equivalent yield

Intercropping of groundnut (ICGV-91114) + pigeonpea (BRG-2) (8:2) and groundnut (ICGV-91114) + nipped castor (8:1) recorded higher groundnut equivalent yield (1208 and 1236 kg/ha, respectively) compared to sole groundnut (753 kg/ha) (Table 2.2.9).

Table 2.2.9: Evaluation of groundnut based intercropping systems

Cropping system	Yield (kg/ha)		GEY (kg/ha)	% increase in yield	RWUE (kg /ha-mm)	Net returns (Rs/ha)	B:C ratio
	Main crop	Inter crop					
Groundnut (ICGV-91114) + pigeonpea (BRG-2) (8:2)	619	324	1208	60	3.38	35438	2.14
Groundnut (ICGV-91114) + nipped castor (8:1)	1126	133	1236	64	3.46	36973	2.19
Sole groundnut (GKVK-5)	753	-	753	-	2.56	12785	1.45

GEY-Groundnut equivalent yield

Alternate land use

In amla based agri-horti system involving cereals and pulses, leguminous intercrops *viz.*, field bean, cowpea and horse gram enhanced the growth parameters of amla compared to fingermillet, grain amaranth and fodder maize (Table 2.2.10).

Table 2.2.10: Growth parameters of amla as influenced by intercrops

Treatment	Plant height (cm)	No. of branches	Collar diameter (cm)	Canopy spread (cm)	Biomass (kg/tree)
Amla + fingermillet	350	2.3	41.8	345.7	386.1
Amla + cowpea	444	2.7	43.8	365.0	363.3
Amla + horsegram	482	1.7	46.3	342.7	414.5
Amla + field bean	506	2.0	45.5	402.1	404.8
Amla + fodder maize	364	3.0	43.7	306.8	383.6
Amla + grain amaranth	328	2.3	43.3	317.8	380.0
Amla	456	2.3	43.7	404.0	384.7
CD at 5%	106	NS	NS	46.15	NS

Note: Biomass (kg/tree) = 2.994 (Collar diameter) $^{1.285}$

Significantly higher amla equivalent yield was recorded with intercropping of amla + field bean (914 kg/ha) compared to amla + fodder maize (591 kg/ha) and was on par with other intercropping systems. Germination and establishment of intercrops was poor due to failure of follow up rains (Table 2.2.11).

Table 2.2.11: Performance of inter crops in amla based agri-horti system

Treatment	Amla yield	Intercrop yield	AEY	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha- mm)
	(kg/ha)					
Amla + fingermillet	728	-	728	10824	1.59	1.05
Amla + cowpea	861	-	861	16794	1.95	1.24
Amla + horsegram	838	-	838	17914	2.15	1.21
Amla + field bean	914	-	914	19037	2.09	1.32
Amla + fodder maize	591	-	591	5591	1.31	0.85
Amla + grain amaranth	699	-	699	13635	1.95	1.01
Fingermillet	-	-	-	-16193	-	-
Cowpea	-	-	-	-15555	-	-

Horse gram	-	-	-	-13522	-	-
Field bean	-	-	-	-15435	-	-
Fodder maize	-	-	-	-15955	-	-
Grain amaranth	-	-	-	-12232	-	-
Amla	846	-	846	23039	3.14	1.22
CD at 5%	NS	-	164.4	-	-	-

RWUE: Rain water use efficiency; AEY: Amla equivalent yield

Amla + field bean

Sole amla

In custard apple based Agri-horti system involving cereals and pulses, intercropping of custard apple + field bean recorded significantly higher custard apple equivalent yield (985 kg /ha), B:C ratio (3.20) and RWUE (1.42 kg/ha- mm) compared to other intercrops in custard apple based agri-horti system. Germination and establishment of inter crops was poor due to failure of follow up rains (Table 2.2.12).

Table 2.2.12: Performance of intercrops in custard apple based agri-horti system

Treatment	Custard apple yield (kg/ha)	Intercrop yield (kg/ha)	CEY (kg/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Custard apple + fingermillet	850	-	850	34492	3.09	1.22
Custard apple + fodder maize	723	-	723	24848	2.34	1.04
Custard apple + field bean	985	-	985	40643	3.20	1.42
Custard apple + niger	624	-	624	21563	2.36	0.90
Custard apple + green chilli	744	-	744	15468	1.53	1.07
Custard apple + cow pea	899	-	899	36301	3.06	1.29
Custard apple + foxtail millet	721	-	721	20288	1.88	1.04
Custard apple	787	-	787	28734	2.56	1.13
Fingermillet	-	-	-	-13418	-	-
Fodder maize	-	-	-	-15460	-	-
Field bean	-	-	-	-15403	-	-
Niger	-	-	-	-12793	-	-
Green chilli	-	-	-	-26136	-	-
Cow pea	-	-	-	-14603	-	-
Fox tail millet	-	-	-	-19936	-	-
CD at 5%	NS	-	324.43	-	-	-

RWUE: Rain water use efficiency; CEY: Custard apple equivalent yield

Short duration variety of fingermillet (GPU- 48 with105-110 days) sown during 1st fortnight of July and August, respectively recorded higher grain yield (580 and 260 kg/ha) compared to

medium (GPU-28 with 110-120 days) and long (MR-1with 120-130 days), duration varieties. However, GPU- 28 performed better with July 2nd fortnight sowing (Table 2.2.13).

Table 2.2.13: Performance of fingermillet varieties under different sowing dates

Sowing time	Variety	Duration (days)	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
			Grain	Straw			
July first fortnight	GPU-48	105-110	580	3100	7.76	272	1.01
	GPU-28	110-120	440	3200	5.89	-3778	0.83
	MR-1	120-130	300	4600	4.01	-5878	0.73
July second fortnight	GPU-48	105-110	260	4600	0.90	-7078	0.67
	GPU-28	110-120	280	2500	0.97	-9628	0.56
	MR-1	120-130	240	3200	0.83	-9778	0.55
August first fortnight	GPU-48	105-110	260	2380	3.92	-10408	0.52
	GPU-28	110-120	240	3160	3.62	-9838	0.55
	MR-1	120-130	180	3380	2.72	-15928	0.40
August second fortnight	GPU-48	105-110	0	1580	0.00	-19408	0.11
	GPU-28	110-120	0	1590	0.00	-19393	0.11
	MR-1	120-130	0	1520	0.00	-19498	0.10

Among weed management treatments, pre-emergence spray of Alachlor followed by one hand weeding recorded higher groundnut pod yield (757 kg/ha), net returns (Rs. 14519/ha) and B:C ratio (2.58) compared to control (Table 2.2.14).

Table 2.2.14: Yield of groundnut as influenced by weed management treatments

Weed management	Pod yield (kg/ha)	Net returns (Rs/ha)	B:C Ratio	RWUE (kg/ha-mm)
Pre-emergent spray of Alachlor coupled with one hand weeding	757	14519	1.54	2.58
Two hand weeding	753	12785	1.45	2.56
Control (Weed check)	46	-23606	0.10	0.16

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 vulnerability 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 (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 2016-17

During the year 2016, in Chikkamaranahalli village, onset of monsoon was normal. A rainfall of 554.9 mm was received which was deficit by 198.5 mm (26.6%) compared to normal (753.4 mm). Out of total rainfall, kharif season received 340.3 mm, which was deficit by 74.8 mm (18.0%) compared to normal of 415.1 mm. *Rabi* season received 81.2 mm which was deficit by 160.4 mm (66.4%) than normal of 241.6 mm and in summer, it was 131.4 mm against normal of 95.6 mm which was excess by 35.8 mm (37.4%) (Fig 2.2.2).

Normal onset of monsoon : 2nd June
Onset of monsoon during 2016 -17 : 1st June
Annual mean rainfall : 753.4 mm
Annual mean rainfall during 2016-17 : 554.9 mm
Mean crop seasonal rainfall during *kharif* and *rabi* : 415.1 & 241.6 mm
Crop seasonal rainfall during 2016-17 *(kharif* and *rabi)* : 340.3 & 81.2mm

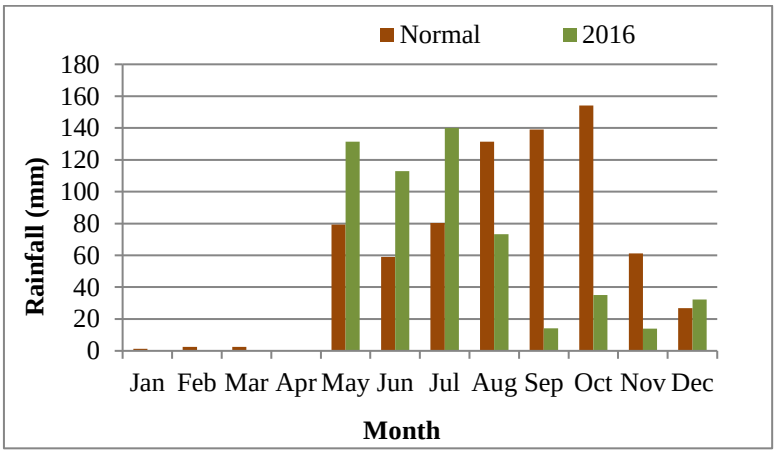


Fig.2.2.2: Normal and actual (2016) monthly rainfall at Chikkamaranahalli

Dry spells during crop growing season (2016-17)

Dry spell		Crop	Stage of the crop
Duration (days)	**Dates & Months**		
14	10th to 23rd August	Fingermillet, pigeonpea, castor	Germination to establishment
		Groundnut	Flowering to peg initiation
		Field bean, cowpea	Pod filling
23	4th to 27th September	Fingermillet	Seedling to tillering
		Pigeonpea	Peak vegetative to flowering
		Groundnut	Pod formation to maturity
		Castor	Primary spike initiation
13	29th September to 11th October	Fingermillet	Tillering to flag leaf
		Pigeonpea	Flowering to pod formation
		Groundnut	Harvesting
		Castor	Secondary spike initiation
		Horse gram	Germination
19	13th October to	Fingermillet	Flowering

	1st November	Pigeonpea	Grain filling
		Castor	Tertiary spike initiation
39	3rd November to 12th December	Fingermillet, pigeonpea, castor	Maturity/ harvest

Real time contingency practices (RTCP) implemented

Weather aberration	Real Time Contingency practices (RTCP) implemented	
	Crop	**RTCP implemented**
Early season drought	Fingermillet, pigeonpea	Fingermillet + pigeonpea (8:2) with conservation furrow Groundnut + pigeonpea (8:2) with conservation furrow

Salient achievements of on-farm demonstrations

Realtime contingency planning

Long duration variety (MR-1) recorded higher grain yield, net returns and B:C ratio (1300 kg/ha, Rs. 23147/ha and 2.06, respectively) compared to other medium duration variety (GPU-28) (Table 2.2.15).

Table 2.2.15: Performance of drought tolerant varieties of fingermillet

Variety	Duration (days)	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Grain	Straw			
MR-1	113	1300	3950	4.92	23147	2.06
GPU-28	95	1200	3770	11.63	19877	1.91

Transplanted fingermillet (MR-1) recorded higher grain yield (1350 kg/ha), Net returns **(**Rs**.** 25097/ ha) and B:C ratio (2.15) as compared to direct sown fingermillet (1300 kg/ha, Rs**.** 23147/ ha and 2.06 respectively) (Table 2.2.16).

Table 2.2.16: Effect of transplanted and direct sown methods in fingermillet

Treatment	DOS/ DOT	Duration (days)	Yield (kg/ha)		% yield increase	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
			Grain	Straw				
Transplanting	25th August	87	1350	4250	4	13.10	25097	2.15
Direct sown	21st July	113	1300	3950	-	4.92	23147	2.06

Situation: Early season drought

During 2016, a dry spell of 14 days occurred during 10-23 August coinciding with germination to establishment stage of crops. Intercropping of fingermillet (MR-1) + pigeonpea (BRG-2) in (8:2) with conservation furrow between paired rows of pigeonpea recorded higher fingermillet grain equivalent yield, net returns and B:C ratio (2150 kg/ha, Rs. 33560/ha and 2.19, respectively) compared to farmers' practice of fingermillet + *Akkadi* cropping with an yield advantage of 90%.

Preparedness

Rainwater management

Excavation of pits/filters with dimensions of length: 3.00 m; width: 3.00 m; depth: 2.9 m and filling of materials was completed for two bore wells with 250 ft depth and multi stage submersible

pump (5HP) during 2011-12. Observations were recorded twice in a week at Hosapalya, Nelamangala taluk of 1ha catchment during 2016. After implementing ground water recharge treatment, the average discharge rate of bore well with filter bed was 9.4 L/min throughout the year (Table 2.2.17).

Table 2.2.17: Discharge rate of borewell (with filter bed) after recharging

Month	Discharge (L/min)
January	10.6
February	10.1
March	9.2
April	8.6
May	8.8
June	9.9
July	9.8
August	9.2
September	9.1
October	9.9
November	8.8
December	8.8

Cropping systems

In pulse based intercropping systems, pigeonpea (BRG-1) + field bean (HA-4) recorded higher pigeonpea equivalent yield (942 kg/ha), RWUE (2.42 kg/ha-mm), net returns (Rs. 60680/ha) and B:C ratio (2.81). While, the farmers' practice of pigeonpea (sole crop) gave lower pigeonpea seed yield (523 kg/ha), RWUE (1.34 kg/ha-mm), net returns (Rs. 22433/ha) and B:C ratio (1.75) (Table 2.2.18).

Table 2.2.18: Performance of pulse based intercropping systems

Cropping system	PEY (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Pigeonpea + cowpea (1:1)	853	63	2.19	52265	2.58
Pigeonpea + field bean (1:1)	942	80	2.42	60680	2.81
Sole pigeonpea	523	-	1.34	22433	1.75

PEY= Pigeonpea equivalent yield

Pigeonpea + cowpea (1:1)

Pigeonpea + field bean (1:1)

Among fingermillet based intercropping systems, fingermillet (MR-1) + pigeonpea (BRG-2) in 8:2 row proportion, recorded higher fingermillet equivalent yield, net returns and B:C ratio (1884 kg/ha, Rs.34291/ha and 2.22, respectively) as compared to farmers' practice (1126 kg/ha, Rs.1847/ha and 0.91, respectively) (Table 2.2.19).

Table 2.2.19: Yield and economics of fingermillet based intercropping system

Cropping system	Duration (days)	FEY (kg/ha)	% yield increase	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Fingermillet + pigeonpea (8:2)	126	1884	67	11.38	34291	2.22
Fingermillet + Akkadi	119	1126	-	8.26	-1847	0.91

FEY=Fingermillet equivalent yield

Fingermillet + pigeonpea (8:2)

Fingermillet + Akkadi

Intercropping of nipped castor + fingermillet (1:2) demonstrated as resilient intercropping system recorded higher castor bean equivalent yield (996 kg/ha), net returns (Rs. 30478/ha) and B:C ratio (2.70) compared to sole castor (Table 2.2.20).

Table 2.2.20: Performance of castor based intercropping system

Treatment	Yield (kg/ha)		CEY (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Main crop	Inter crop				
Castor + fingermillet (1: 2)	388	913	996	3.36	30478	2.70
Sole castor	413	-	413	1.39	598	1.03

CEY – Castor equivalent yield

Castor + fingermillet (1: 2)

Sole Castor

Nutrient management

Fingermillet (MR-1) + pigeonpea (BRG-2) (8:2), intercropping system with application of 100% RDF + 12.5 kg/ha of $ZnSO_4$ (micronutrient) recorded maximum fingermillet grain equivalent yield (2075 kg/ha), net returns (Rs. 21134/ ha) and B:C ratio (1.73) compared to application of only 100% RDF (2032 kg/ha). Groundnut (GKVK-5) + pigeonpea (BRG-1) (8:2) intercropping system with 100% RDF + 12.5 kg/ha of $ZnSO_4$ recorded 11% higher groundnut equivalent yield (2861 kg/ha), net returns (Rs. 122953/ha) and B:C ratio (4.57) compared to application of only 100% RDF (2546 kg/ha).

Energy management

Sowing fingermillet with modified bullock drawn seed drill recorded higher grain yield (1300 kg/ha), net returns **(**Rs. 23147/ha) and B:C ratio (2.06) compared to farmer's practice (1126 kg/ha).

Alternate land use

Mango + fingermillet recorded higher mango equivalent yield (825 kg/ha) compared with intercropping of horse gram in mango. However, horsegram in mango registered higher net returns and B:C ratio (Rs. 14923/ha and 2.56, respectively). Since the mango trees are six years old, no economic yield was recorded (Table 2.2.21).

Table 2.2.21: Performance of fingermillet and horsegram in mango orchard

Crop	Grain/seed yield (kg/ha)	Mango equivalent yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Mango + fingermillet	1100	825	1.49	8725	1.40
Mango + horsegram	800	700	1.27	14923	2.56

Fingermillet in mango orchard

2.3 INDORE

a. Agro-ecological setting

Indore centre is located in Central highlands (Malwa) Gujarat plain Kathiawar peninsula semi-arid 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 2016-17

During 2016, the onset of monsoon was normal (15 June), and an annual rainfall of 1110.8 mm was received which was excess by 152.8 mm compared to normal (958 mm) (Fig.2.3.1). During south-west monsoon (*kharif)*, the rainfall received was 1062.8 mm against the normal (854.5 mm) which was excess by 208.3 mm. During winter October-December, 17.1 mm rainfall was received which was deficit by 47.4 mm (73.48%) compared to normal (64.5 mm). During summer, 30.9 mm rainfall was received which was similar to normal (30.6 mm).

Normal onset of monsoon	: 12-18 June
Onset of monsoon during 2016-17	: 15 June
Annual mean rainfall	: 958 mm
Annual rainfall during 2016-17	: 1110.8 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	: 854.5 mm and 64.5 mm, respectively
Crop seasonal rainfall during 2016-17 (*kharif* and *rabi)*	: 1062.8 mm and 17.1 mm, respectively

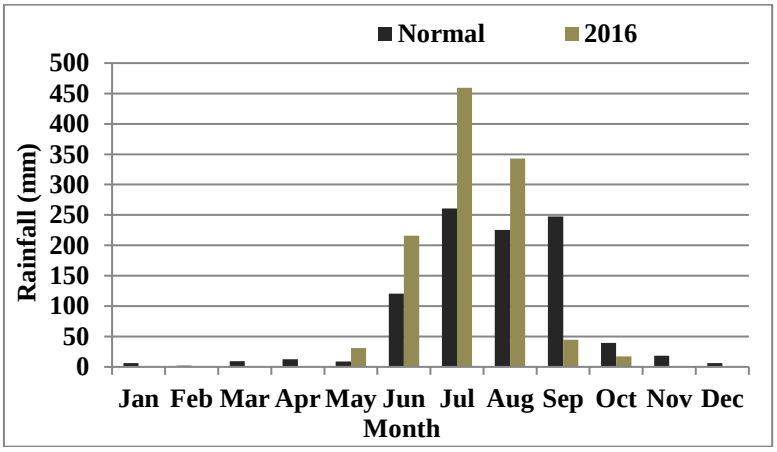


Fig.2.3.1: Normal and actual (2016) monthly rainfall at Indore

Since, the onset of monsoon was normal and there were no dry spells during crop growing season, RTCPS was not implemented

Salient achievements

Preparedness

Cropping systems

In an evaluation of soybean varieties for better productivity, all four varieties recorded higher seed yield compared to local check and, RVS-20-34 recorded highest seed yield (1826 kg/ha), net returns (Rs. 35128/ha), RWUE (2.06 kg/ha-mm) and B:C ratio (2.20) than other varieties (Table 2.3.1).

Table 2.3.1: Performance of soybean varieties

Variety	Seed yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
NRC-86	1204	17.1	1.36	17701	1.11
RVS-2001-4	1711	66.5	1.93	31914	1.99
RVS-20-34	1826	77.6	2.06	35128	2.20
RVS-20-29	1776	72.8	2.00	33728	2.11
Local	1028	-	-	-	-

Pigeonpea varieties, KPL 88039 and JKON 189 both recorded higher seed yield compared to local variety, further, ICPL88039 recorded highest seed yield (1006kg/ha), net returns (Rs.44360/ha), RWUE of 1.04 kg/ha-mm and B:C ratio (3.77) (Table 2.3.2).

Table 2.3.2: Performance of pigeon pea varieties in semiarid, flat topography deep Vertisol farming situation

Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Improved variety	Local variety				
ICPL88039	1006	907	10.9	1.04	44360	3.77
JKM 189	992		8.5	0.93	43520	3.72

In an evaluation of methods of sowing in pigeonpea (C11), the Dharwar method of planting improved the pigeonpea seed yield by 6.4% (1056 kg/ha) compared to normal sowing (992 kg/ha) with higher net returns (Rs.47360/ha) and B:C ratio (3.96). In an assessment of maize based intercropping systems, maize + soybean (2:4) resulted in additional seed yield of 400 kg/ha and additional income of Rs.12000/ha compared to sole maize. The maize equivalent yield (MEY), net returns, B:C and RWUE from maize + soybean intercropping system were 5866 kg/ha, Rs.40400/ha, 2.35 and 3.52 kg/ha-mm, respectively.

Among the 2 sowing methods of chickpea (Digvijay) with **s**owing on residual soil moisture and one irrigation at 40 DAS gave highest yield (1834 kg/ha), net returns (Rs.77685/ha) and B:C ratio (6.55), whereas sowing under residual soil moisture, chickpea variety JAKI 9218 performed well with respect to seed yield (556 kg/ha), net returns (Rs.15280/ha) and B:C ratio (2.22) among all varieties (Table 2.3.4).

Table 2.3.4: Performance of chickpea varieties

Variety	Seed yield (kg/ha)	Net returns (Rs/ha)	B:C ratio
Sowing on residual soil moisture			
JAKI 9218	556	15280	2.22
JG 593	440	9493	1.76
RVS 203	523	13660	2.09
Sowing at residual soil moisture and one irrigation at 40 DAS			
Digvijay	1834	77685	6.55

Nutrient management

The foliar application of NPK 19:19:19 recorded maximum seed productivity (1872 kg/ha) followed by foliar spray of 1% KNO_3 (1850 kg/ha) with higher net returns, RWUE and B:C ratio (Table 2.3.5).

Table 2.3.5: Performance of spraying of chemicals on soybean seed productivity

Treatments	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With improved practice	With normal practice				
1% KNO_3	1850	1400	32.1	2.08	35800	2.24
2% KCl	1730		23.6	1.95	32451	2.03
Thio-urea @ 250g/ha	1644		17.4	1.85	30054	1.88
19:19:19 NPK	1872		33.7	2.11	36427	2.28
19:19:19 NPK + Trizo	1500		7.1	1.69	26000	1.63
Vam –C @ 350 ml/ha	1731		23.6	1.95	32474	2.03

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 1082.8 mm during *kharif* (June-September 2015). 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 vulnerability in general

In general, the climate in this zone is semi-arid. 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 2016-17

During 2016, the onset of monsoon was normal (17 June) and annual rainfall of 912.2 mm was received which was deficit by 45.8 mm compared to normal (958.0 mm) (Fig.2.3.2). During

south-west monsoon (*kharif)*, 890.2 mm of rainfall was received where as the normal was 854.5 mm, which was excess by 35.7 mm (4.17%). During winter, 12.3 mm of rainfall was received against the normal of 64.5 mm and in summer, 9.7 mm of rain was received against 30.7 mm.

Normal onset of monsoon	: 12-18 June
Onset of monsoon during 2016-17	: 17 June
Annual mean rainfall	: 958.0 mm
Annual rainfall during 2016-17	: 912.2 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	: 854.5 and 64.5 mm, respectively
Crop seasonal rainfall during 2016-17 (*kharif* and *rabi*)	: 890.2 mm and 12.3 mm, respectively

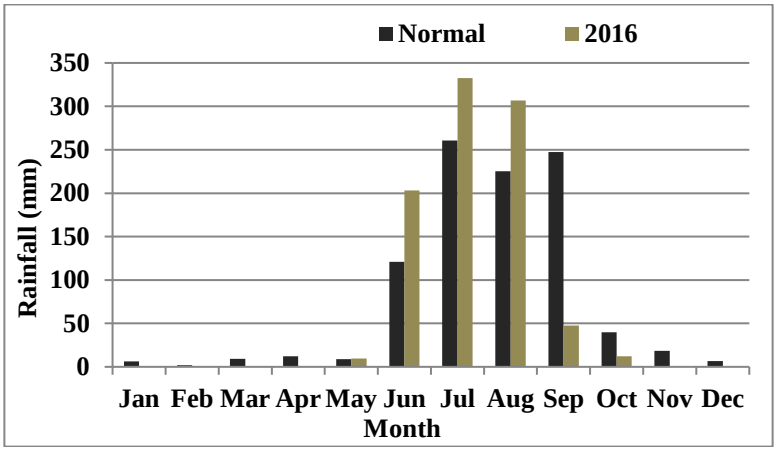


Fig.2.3.2: Normal and actual (2016) monthly rainfall at Nignoti village

Silent achievement of on-farm demonstrations

Preparedness

Rainwater management

Sowing of soybean with ditcher attachment at both sides of the ordinary seed drill, 6 -11% more seed yield and net returns resulted in over yield recorded under sowing with normal seed drill (Table 2.3.6).

Table 2.3.6: Performance of ditcher attached seed drill in the farmers' fields

Name of the farmer	Variety	Seed yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With sowing with ditcher	Sowing only seed drill				
Nignoti							
Kalu Singh	JS-95-60	2000	1805	10.8	2.19	34000	2.13
Abhay Singh	JS-95-60	2120	1970	7.6	2.32	37000	2.31
Bisakhedi							
Raju Upmanyu	JS-95-60	1250	1170	6.8	1.37	15250	0.95
Jujhar Singh	JS-95-60	1500	1370	9.5	1.64	21499	1.34

Cropping systems

Soybean cv JS 95-60 gave maximum seed yield (1600 kg/ha), net returns (Rs.28790/ha), RWUE (1.8 kg/ha-mm) and B:C ratio (1.8) at Bisakhedi village. Similarly at Nignoti village, JS 95-60 produced higher seed yield and net returns than other varieties (Table 2.3.7).

Table 2.3.7: Performance of soybean varieties

Variety	Seed yield (kg/ha)	Net returns (Rs/ha)	RWUE (kg/ha-mm)	B:C ratio
JS-20-29	1800	34400	2.0	2.2
JS-95-60	1880	36529	2.1	2.3

Among new pigeonpea varieties evaluated in semiarid flat deep black soil farming situation, variety ICPL-85063 gave higher seed yield (963 kg/ha), net returns (Rs.25320/ha), RWUE (1.02 kg/ha-mm) and B:C ratio (2.11) (Table 2.3.8).

Table 2.3.8: Productivity of pigeonpea variety in semi arid flat topography deep black soil farming situation

Location	Variety	Seed yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Bisakhedi & Nignoti	Pusa-992	885	0.97	23400	1.95
	ICPL-85063	963	1.02	25320	2.11
	JKM 189	915	1.0	24600	2.05

At Bisakhedi village, new wheat variety HI-8713 gave higher grain yield (4520 kg/ha), net returns (Rs.42376/ha) and B:C ratio (1.73) compared to farmers' local variety. Similarly, at Nignoti, the same variety gave higher grain yield of 5192 kg/ha, net returns of Rs.54957/ha and B:C ratio of 2.2 compared to local variety (Table 2.3.9).

Table 2.3.9: Performance of new wheat varieties

Location	Yield (kg/ha)		% increase in yield	Net returns (Rs/ha)	B:C ratio
	improved variety	Normal variety			
Bisakhedi	4520	3500	29.1	43376	1.73
Nignoti	5192	4500	15.4	54957	2.2

In an evaluation of new chickpea varieties in semi arid flat deep black soil farming situation, at Bisakhedi, variety RVG-202 gave higher seed yield (1260 kg/ha), net returns (Rs.50528/ha) and B:C ratio (3.16) compared to farmers' local variety. Similarly, at Nignoti village, variety RVKG-101 gave higher seed yield (1296 kg/ha), net returns (Rs.68240/ha) and B:C ratio (4.27) compared to farmers' local variety (Table 2.3.10).

Table 2.3.10: Performance of new chickpea variety

Location	Chickpea variety	Seed yield (kg/ha)		% increase in yield	Net returns (Rs/ha)	B:C ratio
		Improved variety	normal variety			
Bisakhedi	RVG-202	1260	1000	26	50528	3.16
Nignoti	RVKG-101	1296	950	36.4	68240	4.27

Nutrient management

In Bisakhedi village, foliar spray of soluble fertilizers (0:0:50 and 19:19:19) in soybean gave 6.7 and 10.6% higher soybean seed yield over no fertilizer spray. The net returns, RWUE and B:C ratio were also high with foliar spray of soluble fertilizers treatments (Table 2.3.11).

Table 2.3.11: Effect of foliar spray of nutrients on yield soybean

Treatment	Seed yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With foliar spray	Without foliar spray				
Foliar spray of 0:0:50	1733	1624	6.7	1.90	27340	1.71
Foliar spray of 19:19:19	1821	1646	10.6	1.99	29517	1.84

2.4 PARBHANI

a. Agro-ecological setting

Parbhani centre is located in Central and Western Maharashtra plateau eco-sub-region. The climate is hot moist semi-arid. Annual normal rainfall is 901 mm.

b. On-station experiments

Experienced weather conditions during 2016-17

During 2016, the onset of monsoon was early by 2 days (18th June). A rainfall of 1175.1 mm was received which was excess by 212.1 mm (22.0%) compared to normal (963 mm) (Fig.2.4.1). During *kharif* season, 963.7 mm rainfall was recorded which was excess by 163.2 mm (20.4%) than normal rainfall of 800.5 mm; *rabi* season received 166.4 mm rainfall and was excess by 55.9 mm (50.6%) than normal of 110.5 mm and summer season received 40.8 mm which was excess by 4.3 mm (11.8%) as against normal of 36.5 mm.

Normal onset of monsoon : 20th June
Onset of monsoon during 2016 -17 : 18th June
Annual mean rainfall : 963 mm
Annual mean rainfall during 2016-17 : 1175.1mm
Mean crop seasonal rainfall during *kharif* and *rabi* : 800.5 &110.5 mm, respectively
Crop seasonal rainfall during 2016-17 : 963.7 mm in *kharif* and166.4 mm in *rabi*

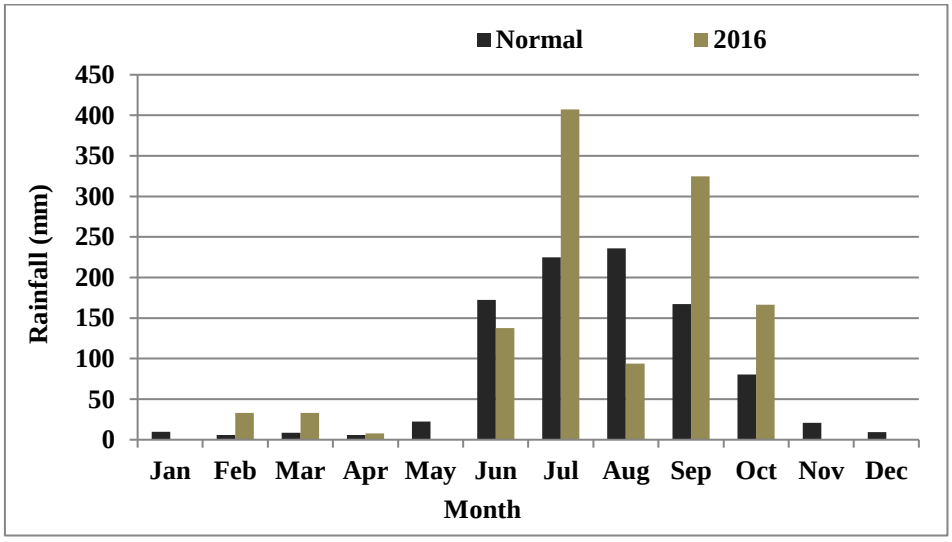


Fig.2.4.1: Normal and actual (2016) monthly rainfall at Parbhani

Dry spells during crop growing season (2016-17)

Dry spells		Crops	Stage of the crop
Duration (days)	Dates & Months		
18	5 to 22 August	Soybean, pigeonpea, cotton, sorghum, greengram, black gram	Vegetative and flowering

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	Real time contingency measure implemented
Midseason drought	Soybean Cotton	Vegetative	Conservation furrow after every 4 rows Residue mulching Foliar spray of KNO_3, kaoline

Salient achievements of on-station experiments

Real time contingency planning

.Situation: Mid season drought

During 2016, a dry spell of 18 days occurred (5 to 22 August) at vegetative and flowering stage of crops. To overcome the mid season drought, dust mulching and straw mulching was done on 20 August to prevent soil moisture losses through evaporation and thereby *in-situ* moisture conservation. All crops with mulching recorded higher yield compared to without mulching. The yield increase due to mulching ranged from 9.8 to 12.6%. Cotton (Ajit 155) recorded higher net returns and B: C ratio (Rs.62832/ha and 2.74) followed by pigeonpea (Rs.30680/ha and 2.61) with mulching compared to without mulching. However, soybean (MAUS-71 recorded higher RWUE of 1.87 kg/ha-mm due to higher yield (1881 kg/ha) (Table 2.4.1).

Table 2.4.1: Effect of mulching on *kharif* crop yields under midseason drought

crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With mulch	Without mulch				
Soybean	MAUS-71	1881	1685	11.7	1.87	24550	2.22
	MAUS-81	1739	1545	12.6	1.73	23025	2.15
	JS-9560	1795	1598	12.3	1.78	24055	2.20
Bt cotton	Ajit 155	1725	1547	9.8	1.71	62832	2.74
Pigeonpea	BDN- 711	867	783	10.7	0.87	30680	2.61

A protective irrigation at sensitive stage to overcome mid season drought produced higher yield of 1693 kg/ha (33.1% increase) with higher RWUE of 1.68 kg/ha-mm, net returns (Rs.25057/ha) and B:C ratio (2.16) compared to control (Table 2.4.2).

Table 2.4.2: Soybean yield and economics as influenced by protective irrigation

Treatment	Seed yield (kg/ha)	Increase in yield (%)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
One protective irrigation	1693	33.1	1.68	25057	2.16
Control (no protective irrigation)	1272	--	1.26	14980	1.74

The first weeding operation followed by hoeing or interculture was carried out at 21 to 30 days after sowing. Among soybean varieties, MAUS-71 produced maximum increase in yield of 23.4% and RWUE of 1.94 kg/ha-mm over no weeding/hoeing where as JS-9560 resulted in higher net returns (Rs.23890/ha) and B:C ratio (2.19) over other varieties with one hoeing and one weeding (Table 2.4.3). Among crops, *Bt* cotton produced higher net returns (Rs.51232/ha) and B:C ratio (2.42) followed by pigeonpea with higher net returns (Rs.26738/ha) and B:C ratio (2.40) with one hoeing and one weeding.

Table 2.4.3: Effect of intercultural operations on *kharif* crop yields under mid season drought

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With hoeing and weeding	Without weeding /hoeing				
Soybean	MAUS-71	1956	1585	23.4	1.94	23202	2.16
	MAUS-81	1779	1456	22.2	1.77	21855	2.09
	JS-9560	1861	1522	22.3	1.85	23890	2.19
Cotton *Bt*	Ajit 155	1783	1442	25.1	1.77	51232	2.42
Pigeonpea	BDN- 711	863	683	26.4	0.86	26738	2.40

Foliar spray of KNO_3 (1% and 2%), water spray and kaoline (7%) were undertaken in soybean at grand growth (35 DAS) and flowering (60 DAS) stage to cope with midseason drought. Whereas, in cotton foliar spray of KNO_3 (1% and 2%), water sprays and Kaoline (7%) were applied at vegetative and square formation stage (35 DAS) during midseason drought. Foliar spray of KNO_3 (1% and 2%) proved to be more effective to overcome mid season drought and recorded higher yield (1574 kg and 16365 kg/ha), net returns (Rs.23285 and Rs.11400/ha), B:C ratio (2.16 and 1.45) and RWUE (1.56 and 2.87 kg/ha-mm), respectively in both soybean and cotton compared to other treatments (Table 2.4.4).

Table 24.4: Effect of foliar sprays on soybean (MAUS-71) and cotton (Ajit-155) yield

Crop	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Foliar spray	Without foliar spray				
Soybean						
KNO_3 (1% and 2%)	1574	1415	11.23	1.56	23285	2.16
Water spray	1405	1375	2.18	1.39	18637	1.93
Kaoline (7%)	1465	1378	6.30	1.45	20287	2.01
Cotton						
KNO_3 (1% and 2%)	16365	14285	13.25	2.87	11400	1.45
Kaoline (7%)	15362	14432	3.00	2.81	7525	1.30
Water spray	15738	14689	6.01	2.69	8254	1.31

Preparedness

Rainwater management

In-situ moisture conservation in both soybean (MAUS-71) and cotton (Ajit-155) with broad bed and furrow system resulted in higher yield (1675 and 1863 kg/ha), net returns (Rs. 24282 and Rs.70180/ha), B:C ratio (2.11and 2.85) and RWUE of 1.66 and 1.84 kg/ha-mm, respectively compared to other methods. The yield increase due to BBF was 24.5% in soybean and 22.4% in cotton over flat bed method (Table 2.4.5).

Table 2.4.5: Effect of *in-situ* rainwater management on soybean (MAUS-71) and cotton (Ajit-155)

Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)	% yield increase
	Seed/ kapas (2016)	Mean (2yrs)	Stalk					
Soybean								
Ridge and furrow	1560	1031	1823	21245	21655	2.01	1.54	15.9
BBF	1675	1145	1968	21780	24282	2.11	1.66	24.5
Flat bed	1345	737	1261	20634	16353	1.79	1.32	-
Cotton								
Ridge and furrow	1750	1245	6248	36983	64517	2.74	1.73	14.9

BBF	1863	1324	6996	37874	70180	2.85	1.84	22.4
Flat bed	1522	1072	5574	36283	51993	2.43	1.51	-

Cropping systems

Short duration variety of soybean MAUS 71 recorded higher yield of1899 kg/ha over local variety (1595 kg/ha). Drought tolerant variety (BDN 711) of pigeonpea recorded 11.7% increase in seed yield (840 kg/ha) compared to local variety (752 kg/ha). BM2003-2, an improved variety of greengram gave higher yield (770 kg/ha) compared to local variety (650 kg/ha). Bt cotton (Ajit 155) produced kapas yield of 1650 kg/ha as compared to local variety (1432 kg/ha) with highest net returns (Rs.59700/ha) compared to other treatments (Table 2.4.6).

Table 2.4.6: Yield and economics of improved varieties of various crops

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Improved variety	Local variety				
Soybean (local: Sartaj variety)	MAUS- 71	1899	1595	19.1	1.88	22405	2.1
	MAUS-81	1739	1565	11.1	1.73	18665	1.3
	JS-9560	1789	1545	15.8	1.78	20287	2.01
Pigeonpea (local:Daithna variety)	BDN- 711	840	752	11.7	0.83	26360	2.38
	BDN- 708	796	576	17.8	0.79	23984	2.26
Greengram (local:Kopergaon variety)	BM 2003-2	770	650	18.4	0.76	25270	2.80
Blackgram (local:Parbhani local)	TAU-1	654	584	11.9	1.63	18700	2.33
Cotton *Bt*	Ajit 155	1650	1432	15.2	1.63	59700	2.65
Sorghum (local:Pivali variety)	PVK- 801	1857	1675	10.8	1.84	19712	2.97

Among intercropping systems, soybean + pigeonpea (4:2) recorded higher crop equivalent yield of 2438 kg/ha, LER (2.79), MAI (18966), B:C ratio (2.73) and RWUE of 2.41 kg/ ha-mm. However, cotton + greengram (1:1) intercropping system gave higher net returns of Rs.60615/ha (Table 2.4.7).

Table 2.4.7: Performance of intercropping systems

Treatment	Yield (kg/ha)		CEY	LER	MAI	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Main crop	Inter crop						
Soybean + pigeonpea (4:2)	1278	560	2438	2.79	18966	42545	2.73	2.41
Cotton + greengram (1:1)	1397	446	1781	2.27	7859	60615	2.42	1.76

LER: Land equivalent ratio; CEY: Crop equivalent yield; MAI: Monetary advantage index

Nutrient management

Foliar spray of 19:19:19 (0.5%) and micronutrients mixture (0.5%) comprised of Fe-2.5%, Mn-1%, Zn- 3%, Cu- 1%, Mo-0.10%, B- 0.5% were done on 20-21 August in soybean at 35 and 60 DAS coinciding with grand growth stage and flowering and in cotton at 35 DAS and 65 DAS coinciding vegetative stage and square formation. Foliar spray of 19:19:19 (0.5%) recorded higher yield of soybean and cotton (1796 kg and 1720 kg/ha), with net returns of Rs.22362 and Rs. 62307/ha, B:C ratio (2.08 and 2.66) and RWUE of 1.78 and 1.71 kg/ha-mm in soybean and cotton, respectively

followed by micronutrients mixture (0.5%) (1712 kg and 1706 kg/ha) compared to no foliar spray (Table 2.4.8).

Table 2.4.8: Effect of foliar sprays on yield and economics of soybean and cotton

Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)	% yield increase
	Seed/ Kapas	No foliar spray	Stalk					
Soybean								
19:19:19 (0.5%)	1796	1545	2034	20675	22362	2.08	1.78	16.28
Micronutrients mixture (0.5 %)	1712	1584	1889	20843	20297	1.97	1.70	08.09
Cotton								
19:19:19 (0.5%)	1720	1546	5432	37453	62307	2.66	1.71	11.25
Micronutrients mixture (0.5%)	1706	1524	5069	36514	62432	2.70	1.69	11.94

c. On-farm demonstrations

Village profile

The program is being implemented in Babulgaon village in Jintur Taluka, Parbhani district, Maharashtra. The total cultivated area is 951.06 ha out of which 880.00 ha is rainfed. The mean annual rainfall is 835 mm with seasonal rainfall of 637 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 number of small and medium, marginal and large farmers is 374, 75 and 25, respectively. The ground water table is 50 m below surface. The source of irrigation is wells covering 5% of cultivated area.

Climate vulnerability in general

The climate in this agro-climatic zone is semi-arid. Out of the total annual average rainfall of 835 mm, 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.

Experienced weather conditions during 2016-17

The rainfall data of Parbhani centre was taken. During 2016, the onset of monsoon was early by 2 days (18th June). A rainfall of 1175.1 mm was received which was excess by 212.1 mm (22.0%) compared to normal of 963 mm (Fig.2.4.2). During *kharif* season, 963.7 mm rainfall was recorded which was excess by 163.2 mm (20.4%) than normal rainfall of 800.5 mm; *rabi* season received 166.4 mm rainfall and was excess by 55.9 mm (50.6%) than normal of 110.5 mm and summer season received 40.8 mm which was excess by 4.3 mm (11.8%) as against normal of 36.5 mm.

Dry spells during crop growing season (2016)

Dry spells		Crops	Stage of the crop
Duration (days)	**Dates & Months**		
18	5 to 22 August	Soybean, pigeonpea, cotton, sorghum, greengram, blackgram	Vegetative and flowering

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	RTCP implemented
Mid season drought	Soybean	Mulching
		Conservation furrow after every 4 rows
		Protective irrigation from farm pond using sprinkler irrigation
	Cotton	Conservation furrow after every 2 rows
		Mulching
	Soybean, pigeonpea	Foliar sprays of KNO_3

Situation: Midseason drought

A dry spell of 18 days occurred during 5 to 22 August at vegetative and flowering stage of *kharif* crops. To overcome the midseason drought, dust and straw mulching was done on 10 August to prevent soil moisture losses through evaporation in soybean and cotton crops. Soybean and cotton with mulching recorded higher yield compared to without mulching. The yield increase due to mulching was ranged from 9.2 to 14.1%. Cotton (Ajit 155) with mulching recorded higher net returns, B:C ratio and RWUE (Rs.70670/ha, 2.80 and 1.82 kg/ha-mm) compared to without mulching (Table 2.4.9).

Table 2.4.9: Effect of mulching on soybean and cotton yields under midseason drought

Crop	Variety	Yield (kg/ha)		% yield increase	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With mulching	Without mulching				
Soybean	MAUS-71	1734	1588	9.21	1.72	27658	2.30
	MAUS-81	1564	1405	1135	1.55	24872	2.17
	JS-9560	1517	1354	12.09	1.51	22727	2.06
Cotton *Bt*	Ajit 155	1832	1606	14.12	1.82	70670	2.80
	Ajit 199	1751	1566	11.87	1.74	61390	2.63
	Malika	1687	1498	12.68	1.64	61404	2.61

Supplemental irrigation from harvested rainwater to soybean crop at a depth of 5 cm using 4 nozzle sprinkler set at flowering stage (on 20 August) to overcome midseason drought, produced higher yield of 1998 kg/ha (28.1% increase) with higher RWUE of 1.98 kg/ha-mm, net returns (Rs.32945/ha) and B:C ratio (2.49) compared to control (1560 kg/ha, net returns of Rs.22900/ha, B:C ratio of 2.14 and RWUE of 1.54 kg /ha-mm) (Table 2.4.10).

Table 2.4.10: Effect of supplemental irrigation from harvested rainwater on soybean crop

Treatment	Yield (kg/ha)	Increase in yield (%)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
One protective irrigation	1998	28.1	1.98	32945	2.49
Control (no protective irrigation)	1560	--	1.54	22900	2.14

Foliar spray of KNO_3 (1% and 2%) and water spray were done in soybean at grand growth (35 DAS) and flowering 60 DAS) stage during mid-season drought. Whereas, in cotton the foliar spray were done at vegetative and square formation stage (35 DAS). Foliar spray of KNO_3 (1% and 2%) proved to be more effective to overcome mid season drought and recorded higher yield 1712 and 1672 kg/ha, net returns (Rs.24762 and Rs.64652/ha), B:C ratio (2.17 and 2.77) and RWUE (1.70 and 1.66 kg/ha-mm), respectively in both soybean and cotton compared to other treatments (Table 2.4.11).

Table 2.4.11: Effect of foliar sprays on soybean and cotton yield and economics

crop	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Foliar spray	No foliar spray				
Soybean (MAUS-71)						
KNO_3	1712	1505	13.8	1.70	24762	2.17
Water spray	1517	1465	3.6	1.51	20179	1.96
Cotton(Ajit-155)						
KNO_3	1672	1432	16.78	1.66	64652	2.77
Water spray	1421	1360	4.50	1.41	48596	2.34

Preparedness

Rainwater management

In-situ moisture conservation in soybean (MAUS-71) with broad bed and furrow system resulted in higher yield (1769 kg/ha), net returns (Rs. 22791/ha), B:C ratio (2.0) and RWUE of 1.76 kg/ha-mm compared to farmer's method (flat bed) (Table 2.4.12).

Table 2.4.12: Effect of *in-situ* rainwater management on soybean (MAUS-71)

Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed 2016	Mean (2yrs)	Stalk				
BBF	1769	1200	2260	22584	22791	2.0	1.76
Farmers' practice (Flat bed)	1480	983	1626	20380	17570	1.86	1.47

Cropping systems

Among intercropping systems, soybean + pigeonpea (4:2) recorded higher crop equivalent yield of 2461 kg/ha, LER (2.95), MAI (14737), B:C ratio (2.74) and RWUE of 2.44 kg/ha-mm. However, cotton + green gram (1:1) intercropping system gave higher net returns of Rs.56854/ha (Table 2.4.13).

Table 2.4.13: Effect of intercropping systems on crop yields and economics

Treatment	Yield (kg/ha)		MCEY	LER	MAI	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Main crop	Inter crop						
Cotton +green gram (1:1)	1097	540	1662	2.13	7370	56854	2.43	1.64
Farmers practice – sole cotton	1254		-	-	-	36280	1.99	1.24
Soybean + pigeonpea (4:2)	992	748	2461	2.95	14737	43044	2.74	2.44
Farmers practice -sole soybean	1403		-	-	-	38582	1.90	1.39

MCEY: Main crop equivalent yield; LER: Land equivalent yield; MAI: Monitory advantage index

Nutrient management

Foliar spray of 19:19:19 (0.5%) was done in pigeonpea at 55 DAS coinciding with grand growth and flowering stage whereas in cotton, foliar spray of micronutrients mixture (0.5%) comprising of Fe- 2.5%, Mn-1%, Zn- 3%, Cu- 1%, Mo-0.10%, B- 0.5% at 55 DAS coinciding with vegetative and square formation stage. Foliar spray of micronutrients mixture (0.5%) in cotton recorded higher kapas yield of 1858 kg/ha with net returns of Rs.66728/ha, B:C ratio of 2.82 and RWUE of 1.84 kg/ha-mm compared to pigeonpea and no foliar spray (Table). The increase in yield with foliar spray in pigeonpea was 10.7% and in cotton 18.7% over no foliar spray (Table 2.4.14).

Table 2.4.14: Effect of foliar spray on yield and economics of pigeonpea and cotton

Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed/ kapas	Farmers practice	Stalk				
Pigeonpea 19:19:19 (0.5%)	847	765	-	21458	24280	2.13	0.84
Cotton Micronutrients mixture (0.5%)	1858	1565	6101	36512	66728	2.82	1.84

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 2016-17

During 2016, the onset of monsoon was normal on 25 June (26th SMW). A rainfall of 779.8 mm was received which was deficit by 37.7 mm (4.61%) compared to normal (817.5 mm). During *kharif*, mm rainfall was received which was deficit by mm than normal (742.3 mm). During north-east monsoon (October- December), mm of rainfall was received which was excess by mm than normal (29.8 mm) and during summer (March-May), mm of rainfall was received which was excess by mm compared to normal (24.2 mm). No rainfall was recorded during August 28 to 14 September (16days) and 20 September-2 October (12days) (Fig 2.5.1)

Normal onset of monsoon : 25 June
Onset of monsoon during2016-17 : 19 June (25 SMW)
Annual mean rainfall : 817.5 mm
Annual rainfall during 2016-17 : 779.8 mm
Mean crop seasonal rainfall : 742 and 30 mm, during *kharif* and *rabi* respectively
Crop seasonal rainfall during 2016-17 : 779.8 and25.8 mm in *kharif* and *rabi*, respectively

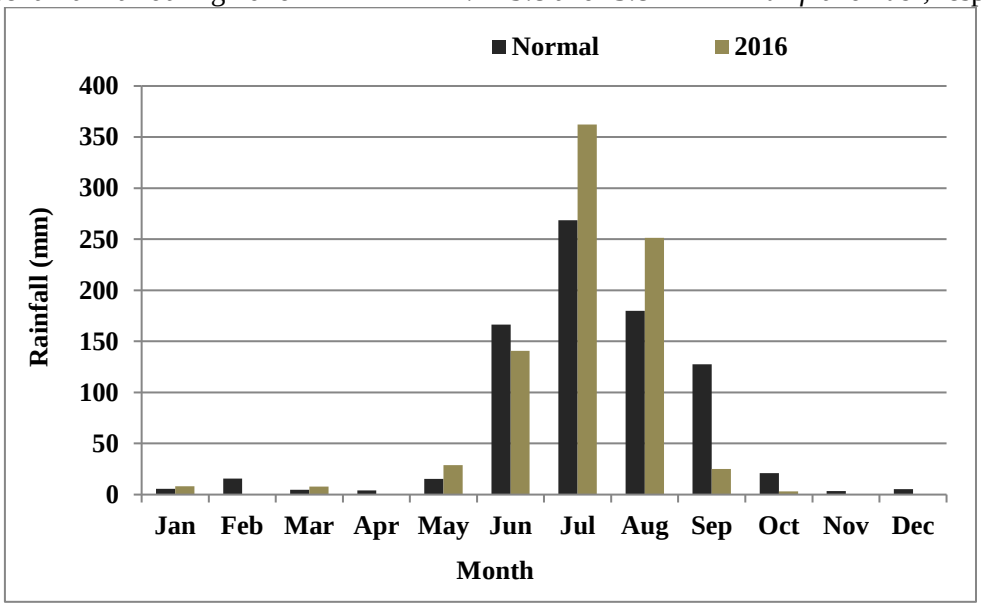


Fig. 2.5.1: Normal and actual (2016) monthly rainfall at Jhansi

Dry spells during crop growing season (2016-17)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & months		
16	28 August to 14 September	Blackgram, groundnut, sesame	Pod development & maturity
12	20 September to 2 October		

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Mid season drought	Blackgram, sesame	Pod development	Dust mulching and life saving irrigation
	Groundnut	Pod development	Life saving irrigation

Salient achievements of on-station experiments

Preparedness

Cropping systems

During *kharif* 2016, drought tolerant variety of Groundnut (Utkarsh) performed better and produced 1212 kg/ha pods and 1708 kg/ha haulm yield and recorded maximum FEY (401.6 q/ha) (Table 2.5.1). It also recorded maximum net returns of Rs. 31821/ha with B:C ratio of 1.7 followed by fodder sorghum with FEY of 390.3 q/ha, net retuns of Rs. 30408/ha and B:C ratio of 1.6.

Table 2.5.1: Performance of different crops in *Kharif* 2016

Treatment	Yield (kg/ha)		FEY (q/ha)	Returns (Rs/ha)		B:C ratio	RWUE (kg/ha-mm)
	Grain /fodder	Straw/ Stover		Gross	Net		
Sorghum(fodder)	39032	-	390.3	48791	30408	1.6	-
Cowpea(BL-1)	31038	-	310.4	38798	20415	1.1	-
Black gram (Azad)	691	1292	242.6	30328	11945	0.6	0.9
Maize (PHM 5)	1382	2709	164.1	20511	2128	0.1	1.8
Black gram (Uttara)	535	1055	188.4	23549	5166	0.3	0.7
Sesamum (Sekhar)	579	1779	222.4	27802	9419	0.5	0.7
Sesamum (JTS 8)	564	1694	216.9	27114	8731	0.5	0.7
Groundnut (Utkarsh)	1212	1708	401.6	50204	31821	1.7	1.6

FEY: Fodder equivalent yield

Alternate land use

Under Aonla based horti-pastoral system with different soil and water conservation measures during the fifth year of productive phase, plant height, collar diameter and DBH of Aonla was higher in contour staggered trenches (5.4 m, 18.5cm and 12.4 cm). Further, Aonla fruit yield was significantly higher (14.1 t/ha) with contour staggered trenches followed by continuous trenches (11.4 t/ha) and vegetative barriers (11.3 t/ha). The dry fodder yield was also maximum in staggered trenches (7.3 t/ha) which was 91.2% higher over control (Table 2.5.2).

Table 2.5.2: Growth and productivity of Aonla and forage crops under different treatments

Treatment	Plant growth				Yield (t/ha)			
	Height (m)	Collar diameter (cm)	DBH (cm)	Canopy spread (m)	Fruit	*C. ciliaris*	*S. ebrana*	Total forage
Contour staggered trenches	5.4	18.5	12.4	5.6	14.1	6.8	1.2	7.3
Continuous contour trenches	4.7	17.3	11.9	5.0	11.4	5.3	0.9	6.3
Deep basin stone mulch	4.1	12.0	8.7	4.3	8.9	4.4	0.78	5.4
Vegetative barrier	4.2	15.7	11.8	4.6	11.3	3.9	0.97	5.6
Control	4.4	14.6	10.8	4.2	10.2	3.4	0.65	3.8
CD at 5%	0.7	2.2	2.3	0.9	1.3	1.9	0.25	1.6

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 vulnerability 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 vulnerabilities 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 (27^{th} 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 2016-17

The onset of monsoon was on 25 June (26^{th} SMW) which was normal. During 2016, in Kadesara kalan village, a rainfall of 882.4 mm was received which was excess by 64.9 mm compared to normal of 817.5 mm. During south-west monsoon (*kharif*), 831.2 mm rainfall was received which was 88.9 mm excess compared to normal of 742.3 mm and during north-east monsoon (October to December), there was 10.5 mm rainfall as against normal of 29.8 mm. During summer, 35.1 mm rainfall was received which was 10.9 mm excess against normal of 24.2 mm (Fig 2.5.2).

Normal onset of monsoon	: 25 June
Onset of monsoon during 2016-17	: 25 June
Annual mean rainfall	: 817.5 mm
Annual rainfall during 2016-17	: 508 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	: 742.3 and 29.8 mm, respectively
Crop seasonal rainfall during 2016-17 *kharif* and *rabi*	: 387 and 10.5 mm, respectively

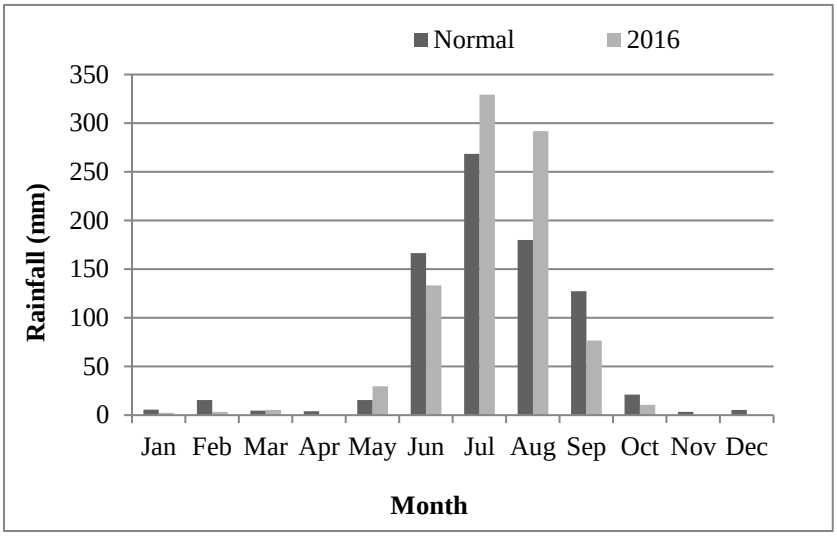


Fig 2.5.2: Normal and actual (2016) monthly rainfall at Kadesara Kalan village

Dry spells during crop growing season (2016-17)

Dry spell		Crop	Stage of the crop
Duration (days)	**Dates & months**		
18	28 August to 14 September	Blackgram, groundnut, sesame	Pod development & maturity
		Sorghum	Grain filling & maturity
14	17-30 September		

Salient achievements of on-farm demonstrations

Real time contingency planning: Nil

Preparedness

Cropping systems

The improved variety of black gram (Azad-3) gave 66 to 178% higher yield over local varieties and recorded seed yield of 688 kg/ha, stover yield of 1641 kg/ha, RWUE of 0.80 kg/ha-mm, net returns of Rs. 11155/ha and B:C ratio of 0.70. Maize variety (PHM-5) recorded grain yield of 1784 kg/ha which was 42.8% higher than local variety. The groundnut variety, Utkarsh recorded mean pod and haulm yield of 1103 and 1448 kg/ha, respectively. Further, the pod yield was 44.6% higher than local variety (763 kg/ha) (Table 2.5.3).

Table 2.5.3: Performance of improved varieties of different crops

Crop	Variety	Yield kg/ha		FEY (q/ha)	RWUE (kg/ha-mm)	Income		B:C ratio
		Grain/ seed	Straw			Gross returns	Net returns	
Blackgram	(Azad-3)	688	1641	220.3	0.8	27537	11155	0.70
	Local variety	312	1314	99.9	0.3	12492	12492	0.76
Maize	(PHM-5)	1784	4819	233.0	2.1	29182	12800	1.00
	Local variety	1026	4236	146.0	1.2	18245	1863	0.10
Groundnut	(Utkarsh)	1103	1448	239.6	1.3	46334	29952	1.83
	Local variety	763	1414	194.2	0.9	32046	32046	1.96

Among different fodder crops, MP Chari variety of sorghum recorded green fodder yield of 298.7 q/ha, gross returns of Rs 37342/ha and the yield was 78.6% higher than local variety (Table). Similarly, oat variety JHO-99-2 produced green fodder yield of 314.6 q/ha with gross returns of Rs. 39331/ha compared to local (186 q/ha). Further, berseem variety Wardan gave green fodder yield of 232 q/ha compared to local (186 q/ha) (Table 2.5.4).

Table 2.5.4: Performance of different fodder varieties in farmer's fields

Crop	Variety	Gross returns (Rs/ha)	FEY (q/ha)
Sorghum	MP Chari	37342	298.7
	Local	20900	167.2
Fodder-oat	JHO-99-2	39331	314.6
Berseem	Wardan	29000	232.0
Local fodder	-	23250	186.0

2.6 RAKH DHIANSAR

a. Agro-ecological setting

Rakh Dhiansar is located in Western Himalayas of South Kashmir and Kumaon, warm moist to dry sub-humid transitional eco-sub-region (AESR 14.2) and low altitude sub-tropical agro-climate zone in Jammu & Kashmir. Annual average rainfall is 800 mm. Annual potential evapotranspiration is 1100 mm. Length of growing period is 150-210 days.

b. On station experiments

Experienced weather condition during 2016-17

During 2016, the onset of monsoon was during first week of July and was delayed by 9 days. The annual rainfall recorded during 2016 was 838.1 mm which was deficit by 309.9 mm than the normal (1148 mm). Out of the total rainfall received, 757.9 mm was received during the *kharif* season (June to September) which was deficit by 127.9 mm (14.4%) as against normal of 885.8 mm. In *rabi*, 69.6 mm rainfall was received which was 22 mm excess (46.2%) than normal of 47.6 mm. In summer season, 10.6 mm rainfall was received which was deficit by 103.5 mm as against normal of 114.1 mm (Fig.2.6.1).

Normal onset of monsoon	: 27 June
Onset of monsoon during 2016-17	: 6 July
Annual mean rainfall	: 1150.9 mm
Annual rainfall during 2016-17	: 838.1mm
Mean crop seasonal rainfall: *kharif*	: 885.8 mm
rabi	: 47.6 mm
Crop seasonal rainfall during 2016-17: *kharif*	: 757.9 mm
rabi	: 69.6 mm

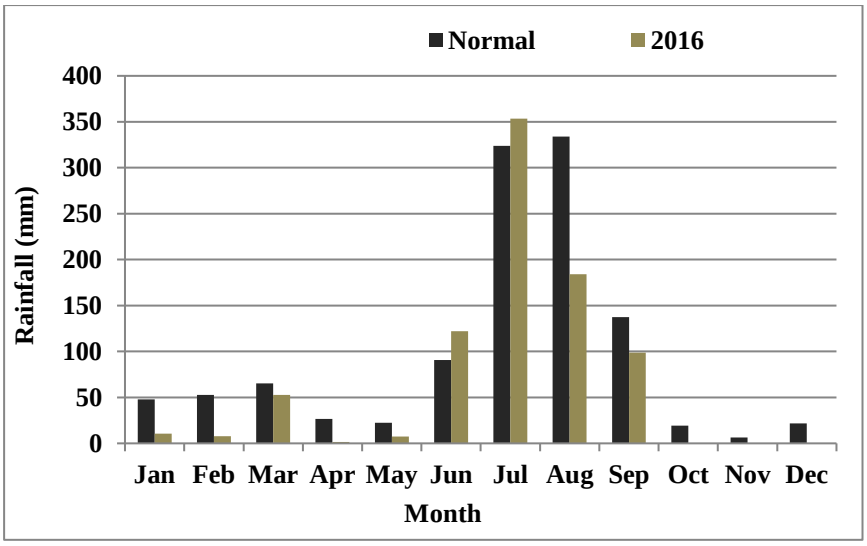


Fig.2.6.1: Nromal and actual (216) monthly rainfall at Rakh Dhiansar

Table: Dry spells during crop growing season (2016-17)

Dry spell		Crop	Stage of the crop
Duration (days)	**Dates & Months**		
10 days	2-11September	Maize, greengram, blackgram, sesame	Reproductive

Table : Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	Real time contingency measure implemented
Delayed onset of monsoon	Maize	-	Improved varieties

Salient achievements of on-station experiments

Real time contingency planning

Situation: Delayed onset of monsoon

During 2016, the onset of monsoon was during first week of July and was delayed by 9 days. Among the four maize hybrids sown with the onset of monsoon, hybrid Double Dekalb produced maximum yield of 2742 kg/ha with the highest net returns (Rs.34362/ha), B.C ratio (2.73) and RWUE (4.38 kg/ha-mm). Maize sown one week after onset of monsoon, Double Dekalb produced maximum yield of 2680 kg/ha with highest net returns (Rs.33494/ha), B.C ratio (2.68) and RWUE (4.50 kg/ha-mm) (Table 2.6.1).

Table 2.6.1: Performance of different maize hybrids as influenced by two monsoonal events

Variety	Crop duration (days)	Rainfall (mm)	Yield (kg/ha)		HI	RWUE (kg/ha-mm)	COC (Rs/ha)	Net returns (Rs/ha)	B:C ratio
			Grain	Stover					
Onset of monsoon									
K-517	94	626	2452	5963	30.0	4.07	18710	31751	2.62
Double Dekalb	92	626	2742	6424	29.9	4.38	19890	34362	2.73
PC-55	93	626	2120	5126	29.3	3.38	18780	23484	2.25
Tip Top	93	626	2430	5964	28.9	3.88	19320	29301	2.51
1 week after onset of monsoon									
K-517	92	595	2456	5866	29.5	4.12	18710	30108	2.61
Double Dekalb	94	595	2680	6458	29.3	4.50	19890	33494	2.68
PC-55	93	595	2036	4872	29.5	3.42	18780	21708	2.16
Tip Top	94	595	2356	5624	29.5	3.95	19320	27504	2.42

HI: Harvest index; COC: Cost of cultivation

The intercropping of blackgram (Uttra) and greengram (SML 668) with maize (Double Dekalb) in additive series (2:1) revealed that maize + blackgram intercropping system registered a maize equivalent yield of 3136 kg/ha, B:C ratio of 2.68 and RWUE of 4.19. Similarly, maize + greengram intercropping system registered a maize equivalent yield of 3168 kg/ha, B:C ratio of 2.82 and RWUE of 4.16 (Table 2.6.2).

Table 2.6.2: Performance of intercropping systems in additive series

Intercropping system	Yield (kg/ha)				MEY (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Grain/seed		Stover					
	Maize	Intercrop	Maize	Intercrop				
Maize + black gram (2:1) (Additive series)	2457	171	5642	402	3136	4.19	36784	2.68
Maize + moong (2:1) (Additive series)	2421	188	5596	428	3168	4.16	39949	2.82

Preparedness

Cropping systems

In an evaluation of seven different cropping sequences, greengram-mustard, blackgram-chickpea, greengram-wheat, maize-wheat, maize-mustard, sesame-mustard and fodder-fodder, maize

under maize-wheat system recorded highest net returns of Rs.31977ha with B:C ratio and RWUE of 2.61 and 4.2 kg/ha-mm, respectively followed by maize under maize-mustard, and mixed fodder systems which produced net returns of Rs. 30156/ha and 20160/ha with B:C ratio of 2.52 and 2.70, respectively (Table 2.6.3).

Table 2.6.3: Performance of *kharif* crops under various cropping sequences

Cropping system	Crop	Yield (kg/ha)		RWUE (kg/ha-mm)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
		Grain	Stover / Fodder				
Greengram-mustard	Greengram	354	_	0.6	15490	11060	1.71
Blackgram-chickpea	Black gram	378	_	0.6	16800	5880	1.35
Greengram-wheat	Greengram	371	_	0.6	15490	12335	1.80
Maize-wheat	Maize	2654	5896	4.2	19890	31977	2.61
Maize-mustard	Maize	2548	5786	4.1	19890	30156	2.52
Sesame-mustard	Sesame	256	_	0.4	12985	16455	2.27
Pastoral-pastoral	Mixed fodder	32045	_	54.9	11885	20160	2.70

Energy management

Sowing of maize with maize planter resulted in maximum grain and stover yield of 2252kg/ha and 5630kg/ha, respectively with benefit cost ratio and RWUE of 2.59and 3.6, respectively compared to sowing with broadcasting and liner. Similarly, sowing with maize planter gave higher input and output (7008 and 103479 MJ/ha) with higher energy use efficiency (14.77) compared to other two methods of sowing (Table 2.6.4).

Table 2.6.4: Effect of sowing with maize planter on yield, economics and energy use efficiency in maize

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns Rs/ha)	B:C ratio	RWUE (kg/ha-mm)	Energy (MJ/ha)		EUE (MJ/ha)
	Grain	Stover					Input	Output	
Maize planter	2252	5630	17480	27785	2.59	3.6	7008	103479	14.77
Broadcasting	1854	4635	18575	18690	2.01	3.0	6650	85191	12.81
Liner	2040	5100	19560	21444	2.10	3.3	6950	93738	13.49

c. On-farm demonstrations

Village profile

The program is being implemented in Khaner village, Purmundal Block, tehsil & district Samba, Jammu and Kashmir. The total cultivated area is 55 ha. The mean annual rainfall is 1140 mm with seasonal rainfall of 860 mm during *kharif* season (June-September). The major soil types are sandy loam. The major rainfed crops during *kharif* are maize, blackgram, greengram, sesame, fodder pearlmillet, 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.

Climate vulnerability in general

In general, the climate in this agro-climatic zone is sub-humid. The rainfall is received through south- west monsoon (monsoon season), western disturbances (winter season) and summer (pre- monsoon) and contributes about 75, 13 and 12% of the annual rainfall. The historical rainfall

data (25 years) 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 (south - west) monsoon was during 26th SMW. For the past 15 years, the dry spells during the crop season were experienced during August, September and October and at initial and reproductive stages of the major rainfed crops. There was 20% probability of occurrence of severe drought during *rabi* season in the Kandi belt of Jammu region. The chances of occurrence of normal and moderate drought were 7 and 12% during *kharif* season and 8 and 8% during *rabi* season, respectively. In the district, the chances of normal season were more than 60% during crop growing season, whereas, the chances of normal (25% less from normal rainfall) and moderate (25- 50% less from normal rainfall) drought were 24 and 12%, respectively. The chances of early, normal and late onset of monsoon are 16, 72 and 12%, respectively; whereas 28, 68 and 4% chances of early, normal and late withdrawal of monsoon, respectively. The soil moisture status remained deficit during establishment and reproductive stages of major rainfed crops. There was an increase in the maximum temperature during *kharif* season at the rate of 0.03^0C per year while during *rabi* season the mean temperature had also gone up by 0.04^0C per year.The day temperature decreased by 0.7^0C from the last two decades and the night temperature had gone up by 0.6^0 C during this period. The rainfall showed an increasing trend at the rate of 2.0 mm per year for the past 20 years. The extreme events like unusual and high intensity rainfall in short span had been increasing in the month of August. The region had also been experiencing other extreme events like floods and cold waves.

Experienced weather conditions during 2016 -17

The annual rainfall recorded during 2016 was 1297.6 mm, which was 146.5mm (12.73%) excess than the normal annual rainfall of 1151.1 mm. Out of total rainfall, 1170.8 mm was received during the *kharif* season (June to September) as against normal of 896.9 mm. In *rabi*, no rainfall received which was 46.6 mm deficit than normal of 46.6 mm and in summer season, it was 93.4 mm which was deficit by 13.1 mm as against normal of 106.5 mm (Fig 2.6.2).

Normal onset of monsoon	: 27 June
Onset of monsoon during *kharif*, 2016 -17	: 3 July
Annual mean rainfall	: 150.9 mm
Annual rainfall during 2016-17	: 1297.6 mm
Mean crop seasonal rainfall during *kharif*	: 896.9 mm
and *rabi*	: 46.6 mm
Crop seasonal rainfall during 2016-17 *Kharif*	: 1170.8 mm
and *rabi*	: 0.0 mm

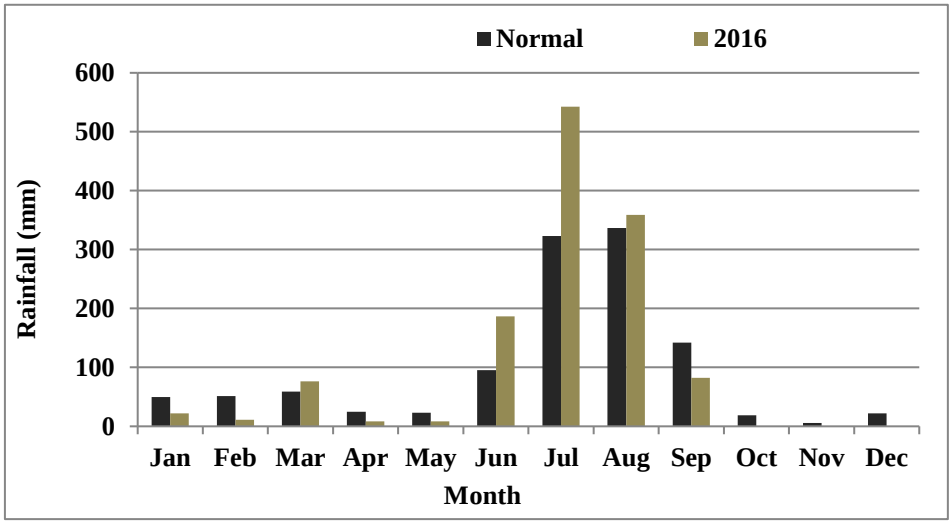


Fig. 2.6.2: Normal and actual (2016) monthly rainfall at Khaner village

Salient achievements of on-farm demonstrations

Preparedness

Cropping systems

Among, four hybrids of maize, maximum mean grain yield, B: C ratio and RWUE of 2453 kg/ha, 2.42 and 2.67 kg/ha-mm, respectively was recorded with Double Dekalb with 59% increase in yield over farmer's local variety. The variety PSC 105 registered the minimum mean grain yield, B:C ratio and RWUE of 2007 kg/ha, 2.11 and 2.19 kg/ha-mm, respectively (Table 2.6.5).

Table 2.6.5: Performance of maize varieties/hybrids at village Khaner

Variety/hybrid	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Improved variety	Local variety				
Tip Top	2066	1635	26.3	2.25	21465	2.11
K-517	2127		30.0	2.32	22990	2.23
Double dekalb	2453		50.0	2.67	28206	2.42
PC 55	2007		22.7	2.19	20872	2.11

Among different cropping sequences, it was observed that maize under cereal-oilseed system gave the highest net returns of Rs 28840/ha followed by maize under cereal-cereal system and fodder under pastoral-pastoral system with net returns of Rs. 27783 and Rs. 25422/ha, respectively. However, fodder under pastoral-pastoral system gave highest B:C ratio of 3.1 and RWUE of 42.9 over other cropping sequences (Table 2.6.6).

Table 2.6.6: Yield and economics of crops under various cropping systems during *kharif* 2016

Cropping Sequence	Variety	Yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Cereal-cereal (Maize- wheat)	Double dekalb	2460	50	2.7	27783	2.4
Cereal-oilseed (Maize- mustard)	Double dekalb	2509	53	2.9	28840	2.5
Pulse-pulse (Mash- chickpea)	Uttara	395	42.0	0.43	6900	1.4
Oilseed-oilseed (Til- mustard)	PB Til-1	240	53.0	0.26	14615	2.1
Pastoral-pastoral (Mixed fodder)	Local (maize)- MP Chari (Jowar)- Local (Bajra)	37307	45.4	42.9	25422	3.1

Intercropping of blackgram (var. *Uttara*) with maize (var. Double Dekalb) (2:1) in additive series maize equivalent yield of 3207 kg/ha with net returns of Rs 26740/ha, B: C ratio of 2.2 and RWUE of 2.7 kg/ha-mm compared to farmers' practice of sole maize (1635 kg/ha). Under pastoral-pastoral system, mixed fodder system with maize + sorghum + pearlmillet gave mixed fodder yield of 30040 kg/ha with net returns of Rs. 18155/ha, B:C ratio of 2.52 and RWUE of 34.6 kg/ha-mm compared to farmers' practice of sole fodder system (21240 kg/ha).

Alternate land use

The maize yield under aonla + maize (100% NPK) system ranged from 1950 to 2120 kg/ha with mean yield of 2035 kg/ha, with RWUE of 3.25 kg/ha-mm, net returns of Rs. 19595/ha and B:C ratio of 1.99. Farmer's practice (FP) included broadcasting of local maize variety with imbalanced dose of fertilizers. Similarly, blackgram yield under aonla + blackgram system was 233 kg/ha, with RWUE of 0.37 kg /ha-mm and B:C ratio of 0.89 compared to farmers' practice (185 kg/ha).

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

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 condition during 2016-17

The annual rainfall recorded during the year 2016 was 801.9 mm, which was deficit by 292.4 mm than the normal annual rainfall of 1094.3 mm. Out of the total rainfall; 673.8 mm was received during the *kharif* season (June to September) which was deficit by 188.2 mm (21.8%) as against normal of 862 mm. In *rabi*, 8.2 mm rainfall was received which was182.3 mm deficit (95.7%) than normal of 190.5 mm. In summer season, 90.3 mm rainfall was received which was excess by 8.2 mm as against normal of 82.1 mm (Fig.3.1.1).

Normal onset of monsoon : 1 July
Onset of monsoon during 2016-17 : 27 June
Annual mean rainfall : 1094.3 mm
Annual rainfall during 2016-17 : 801.9 mm
Mean crop seasonal rainfall during *kharif* and *rabi* : 862 and 190.5 mm, respectively
Crop seasonal rainfall during 2016-17: 673.8 and 8.2 mm, respectively *kharif* and *rabi*

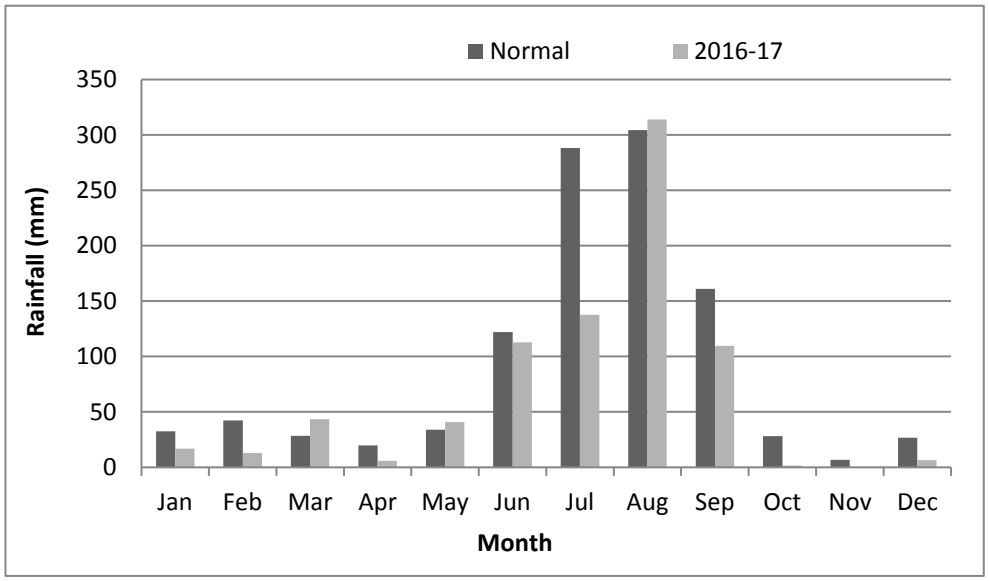


Fig 3.1.1: Normal and actual (2016) monthly rainfall at Ballowal Saunkhri

Dry spells during crop growing season (2016)

Dry spell		Crop	Stage of the crop
Duration (days)	**Dates & months**		
28	21 August -19 September	Maize	Silking /dough
		Greengram/blackgram	Flowering/pod formation
		Sesame	Flowering/pod formation

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Mid season drought	Maize	Silking / dough	Reduction in plant population, Foliar spray Soil mulching
	Greengram/ blackgram	Flowering/pod formation	
	Sesame	Flowering/pod formation	

Salient achievements of on-station experiments

Real time contingency planning

Situation: Mid season drought

During 2016, the rainfall was deficit by 50.7% in the month of July. There was a dry spell of 28 days occurred at silking/dough stage in maize and flowering/pod formation stage in greengram, blackgram and sesame. Residue mulching along with foliar spray of 1% KNO_3 gave highest grain yield (4163 kg/ha), straw yield (10560 kg/ha) net returns (Rs**.** 36871/ha), RWUE (7.6 kg/ha-mm**)** and B: C ratio (2.04) (Table 3.1.1).

Mulching + soliar spray 1% KNO_3

No intervention

Table 3.1.1. Effect of real time contingency measures on yield and economics of maize

Treatment	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Grain	Straw				
T1: No intervention	3459	9112	-	6.4	29884	1.96
T2: Crop residue mulching	3772	9797	8.3	6.9	32828	1.98
T3: Foliar spray of 1% KNO_3	3980	10817	13.1	7.3	35847	2.03
T4: Reduction in plant population	3690	9291	6.3	6.8	32805	2.03
T5: T2+T3	4163	10560	16.9	7.6	36871	2.04
T6: T2+T4	3827	9824	9.6	7.0	33090	1.97
T7: T3+T4	3878	9934	10.8	7.1	34570	2.03
CD at 5%	NS	NS				

Growing of alternate crops like blackgram and sesame resulted in highest MEY (3520 and 3153 kg/ha) which was higher over maize crop raised without intervention by 24.3 and 13.7% respectively. Alternate crops also resulted in highest net returns (Rs. 28800 and 29491/ha) and B:C ratio (2.20 and 2.66) compared to maize treated with soil mulching + foliar spray of 1% KNO3 (Table 3.1.2).

Table 3.1.2. Effect of RTCP measures on maize equivalent yield (MEY) and economics

Treatment	MEY (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
T1:No intervention	2664		5.17	10302	1.34
T2: Soil mulching with wheel hoe	2871	7.2	5.57	13150	1.40

T3: Foliar spray of 1% KNO_3	3007	11.4	5.83	17199	1.51
T4: Reduction in plant population	2802	4.9	5.44	13262	1.43
T5: T2+T3	3282	18.8	6.37	20989	1.60
T6: T2+T4	3190	16.5	6.19	20173	1.60
T7: T3+T4	3255	18.2	6.31	22058	1.67
Blackgram as alternate crop	3520	24.3	2.28	28800	2.20
Sesame as alternate crop	3153	13.7	1.02	29491	2.66

Preparedness

Rainwater management

Sowing of maize, greengram and blackgram on ridges proved to be superior than flat sowing. The increase in grain/seed yield of maize, greengram and blackgram was 11.0, 17.6 and 21.1% over flat sowing, respectively with corresponding net returns of Rs. 47505/ha, Rs. 27224/ha and Rs. 31062/ha and B:C ratio of 2.29, 1.9 and 1.9 respectively (Table 3.1.3).

Flat sowing

Ridge sowing

Table 3.1.3: Effect of crop establishment methods on yield and economics

Crop	Grain/Seed yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)		Net returns (Rs/ha)		B:C ratio	
	RP	FP	RP	RP	FP	RP	FP	RP	FP
Maize	4462	3970	11.0	8.20	7.29	47505	39469	2.48	2.29
Greengram	898	740	17.6	1.89	1.56	27224	19303	2.24	1.90
Blackgram	1028	811	21.1	2.17	1.71	31062	20361	2.34	1.90

Ridge planting (RP), Flat planting (FP)

Cropping systems

Maize hybrid PMH 2 gave higher grain yield of 3460 kg/ha with net returns of Rs.33176/ha and B:C ratio 2.10 compared to Prakash (3140 kg/ha). Among the blackgram cultivars, Mash 114 gave highest seed yield (540 kg/ha), net returns (Rs.5618/ha) and B:C ratio (1.25) over Mash 338. Green gram cultivar ML 2056 recorded higher yield (635 kg/ha), net returns (Rs.13291/ha) and B:C ratio (1.61) over ML 818. Sesame cultivar Punjab Til No-2 recorded higher yield (420 kg/ha), net returns (Rs.24507/ha) and B: C ratio (2.42) over RT 346 (Table 3.1.4).

Table 3.1.4: Performance of improved crop varieties during *kharif* 2016

Crop	Variety	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Maize	PMH 2 (82 days)	3460	6.69	33176	2.10
	Prakash (82 days)	3140	6.07	27574	1.92
Greengram	ML 2056 (75 days)	635	1.23	13291	1.61
	ML 818 (80 days)	590	1.14	11041	1.50
Blackgram	Mash 114 (83 days)	540	1.04	5618	1.25
	Mash 338 (90 days)	480	0.93	2745	1.12
Sesame	RT 346 (87 days)	405	0.78	23007	2.32
	Punjab Til No. 2	420	0.81	24507	2.42

Intercropping of maize with greengran and blackgram gave higher maize equivalent yield (MEY) of 4069 and 3724 kg/ha with yield improvement of 20.3 and 12.9%, respectively over sole maize. Maiz + greengram intercropping also recorded higher RWUE (6.71 kg/ha-mm), net returns (Rs.37030/ha) and B: C ratio (2.08) (Table 3.1.5).

Table 3.1.5: Performance of intercropping systems

Cropping system	MEY (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Sole maize	3244	-	6.29	27638	1.92
Sole greengram	2822	-15.0	1.64	20399	1.93
Sole blackgram	3261	0.5	1.90	25096	2.05
Maiz + greengram	4069 (184)*	20.3	6.71	37030	2.08
Maize + blackgram	3724 (213)	12.9	5.85	30476	1.90

Figures in parentheses are intercrop yields

Wheat var. PBW 725 gave highest grain yield of 3480 kg/ha with net returns of Rs 43027/ha and B:C ratio of 2.51, followed by PBW 677 (Table 3). Chickpea var. PBG 7 gave higher seed yield over other cultivars (1040 kg/ha) with B:C ratio of 2.92. Lentil var. LL 931 gave higher yield of 610 kg/ha with net returns of Rs 18710/ha and B:C ratio of 1.89 (Table 3.1.6).

Table 3.1.6: Performance of improved varieties during *rabi* 2016-17

Crop	Variety	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Wheat	PBW 660	3380	16.7	40322	2.42
	PBW644	3250	16.1	37934	2.34
	PBW 677	3460	17.1	42514	2.49
	PBW 725	3480	17.2	43027	2.51
	HD 3086	3320	16.4	39134	2.38
Chickpea	PBG 7	1040	5.6	44481	2.92
	PBG 5	960	4.8	39281	2.70
Lentil	LL 931	610	3.0	18710	1.89
	LL 699	540	2.7	14160	1.68

Intercropping of wheat with raya, chickpea, lentil and linseed gave higher wheat equivalent yield (WEY) by 4.3 to 18.9% with higher RWUE, net returns and B:C ratio. Wheat + chickpea and wheat+ raya intercropping systems were economically superior to sole cropping of wheat and wheat + lentil and wheat + linseed intercropping systems with higher net returns ((Rs 68900 and Rs. 56334/ha), B:C ratio (3.25 and 3.02) and LER (1.13 and 1.11) (Table 3.1.7).

Table 3.1.7: Performance of intercropping systems

Treatment	Wheat equivalent yield (kg/ha)	LER	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Sole wheat	3828	-	13.3	55481	3.01
Sole raya	2307	-	8.0	19971	2.14
Sole chickpea	4617	-	16.0	64885	3.73
Sole lentil	2311	-	8.0	23252	2.10
Sole linseed	3670	-	12.7	37143	2.65
Wheat + raya	4001	1.11	13.9	56334	3.02
Wheat + chickpea	4722	1.13	16.4	68900	3.25
Wheat + lentil	4026	1.07	14.0	56080	2.91
Wheat +linseed	4215	1.06	14.6	57638	2.97

Among various double cropping systems evaluated, greengram - chickpea system followed by maize-chickpea and greengram-wheat performed better than traditional maize-wheat system and other cropping systems. The highest net returns of Rs 100941/ha and B:C ratio of 3.24 with wheat equivalent yield (WEY) of 9058 kg/ha were obtained in greengram – chickpea cropping system (Table 3.1.8).

Table 3.1.8: Productivity and economics of double cropping systems under rainfed conditions

Treatment	System productivity (kg/ha)	% increase in yield	Net returns (Rs/ha)	B:C ratio
Maize-wheat	6760	-	72547	2.26
Maize-raya	6166	-9.6	54528	2.12
Maize-chickpea	8444	19.9	86731	2.61
Greengram-wheat	6896	2.0	80647	2.63
Greengram-raya	6186	-9.3	59701	2.50
Greengram-chickpea	9058	25.4	100941	3.24
Sesame-wheat	6141	-10.1	63760	2.45
Sesame-raya	5067	-33.4	43062	2.22
Sesame-chickpea	6529	-3.5	61298	2.51

Nutrient management

In maize, application of 100% N based on LCC gave highest grain yield (4253 kg/ha), net returns (Rs. 40489/ha) and B:C ratio (2.28) followed by soil test based N application, with grain yield of 4166 kg/ha, net returns of Rs. 38926/ha and B:C ratio (2.23). Application of 75% N (141 kg urea/ha) as per LCC was at par with blanket application of recommended N (176 kg urea/ha) and gave yield of 3796 kg/ha, net returns of Rs.35363/ha and BC of 2.14 (Table 3.1.9).

Table 3.1.9: Effect of nutrient management on yield and economics of maize

Treatment	Yield (kg/ha)	% increase in yield	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Blank application of recommended N	3744	-	34401	2.10	6.67
N application on soil test basis	4166	8.3	38926	2.23	7.23
100% N application as per LCC	4253	9.8	40489	2.28	7.39
75 % N application as per LCC	3796	1.3	35363	2.14	6.77
50% N application as per LCC	3462	-7.4	29662	1.97	6.17
Control	2878	-23.1	21058	1.71	5.13

In wheat, application of 100% N based on LCC gave highest grain yield (4034 kg/ha), net returns (Rs. 59550/ha) and B:C ratio (3.13) followed by N application on soil test basis, with grain yield of 3863 kg/ha, net returns of Rs. 56418/ha and B:C ratio of 3.05. Application of 75% N (141 kg urea/ha) as per LCC gave yield (3832 kg/ha), net returns (Rs. 55506/ha) and B:C ratio (2.97) at par with 100% N applied as per LCC and N applied on soil test basis and better than blanket application of recommended N (176 kg urea/ha) (Table 3.1.10).

Table 3.1.10: Effect of nutrient management on yield and economics of wheat

Treatment	Yield (kg/ha)	% increase in yield	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Blanket application of rec. N	3743		53063	2.89	12.7
N application on soil test basis	3863	3.11	56418	3.05	13.1
100% N application as per LCC	4034	7.22	59550	3.13	13.7

75 % N application as per LCC	3832	2.31	55506	2.97	13.0
50% N application as per LCC	3515	-6.49	50084	2.86	12.0
Control	2940	-	38502	2.50	10.0

Energy management

Sowing of wheat with energy efficient implements viz. tractor operated seed drill, *pora* and manual seed drill resulted in remarkable increase in the yield of wheat which was higher by 35.4, 28.0 and 26.5%, respectively over broadcasting. The maximum increase in yield (3621 kg/ha), net returns (Rs. 50926/ha) and B:C ratio of 2.81 was recorded with seed-cum-fertilizer drill. Highest energy use efficiency (11.07) was also observed in sowing with tractor operated seed-cum-fertilizer drill (Table 3.1.11).

Table 3.1.11: Productivity and economics of sowing implements under rainfed conditions

Treatment	Yield (kg/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)	Input energy (MJ/ha)	Output energy (MJ/ha)	Energy use efficiency
Broadcasting	2339	25466	2.01	8.2	10476	79823	7.62
Seed-cum-fertilizer drill	3621	50926	2.81	12.7	11327	125417	11.07
Manual sowing with pora	3250	41874	2.46	11.4	10713	111075	10.37
Sowing with manually operated seed drill	3183	42209	2.56	11.1	10547	109361	10.37

Alternate land use

In the four year old plantation of guava (Shweta), galgal (GS -6), mango (Dusheri) and baramasi lemon, blackgram (Mash 114) during *kharif* and taramira (TMLC-2) during *rabi* were sown. The plant to plant and row to row spacing for guava, galgal, mango, baramasi lemon, blackgram and taramira was 6 x 6 m, 4 m x 4 m, 7 x 7 m, 5 x 5 m, 30 cm and 30 cm, respectively. The plantation of guava, galgal, mango and baramasi lemon are in 3rd year and no fruit yield was recorded. The average plant height was 2.4, 1.2, 0.9 & 1.4 m in case of guava, guava, galgal, mango and baramasi lemon, respectively. The collar diameter was 12.2, 4.5, 9.8 and 5.3 cm, respectively for guava, galgal, mango and baramasi lemon (Table 3.1.12).

Table 3.1.12: Growth parameters of fruit crops

Fruit crop	Fruit plant growth parameters			
	Tree height (m)	Collar diameter (cm)	Tree spread (m)	
			N-S	E-W
Guava (Shweta)	2.4	12.2	2.9	2.7
Galgal (GS-6)	1.2	4.5	0.75	0.71
Mango (Dusheri)	0.9	9.8	2.4	2.3
Baramasi lemon	1.4	5.3	1.1	1.0

The yield of blackgram with guava, galgal, mango & baramasi lemon was 580, 540, 570 & 564 kg/ha, respectively. During *rabi*, taramira yield in association with guava and amla plantation was 548, 524, 560 & 568 kg/ha, respectively (Table 3.1.13).

Table 3.1.13: Crop yields under different agri-horticulture systems

Season	Crop yield (kg/ha)							
Kharif	Guava + black gram	black gram	Galgal + black gram	black gram	Mango + black gram	black gram	Lemon + black gram	black gram
	580	620	540	608	570	598	564	586
Rabi	Guava + taramira	taramira	Galgal + taramira	taramira	Mango + taramira	taramira	Lemon + taramira	taramira
	548	632	524	624	560	604	568	614

c. On-farm demonstrations

Village profile

The program is being implemented by AICRPDA centre, Ballowal-Saunkhri in Achalpur and Nainwan 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 southwest 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 2016-17

The annual rainfall recorded during the year 2016 was 994.1 mm, which was deficit than the normal annual rainfall of 1094.3 mm. Out of total 994.1 mm rainfall; 754.1 mm was received during the *kharif* season (June to September) which was deficit by107.9 mm (12.52%) as against normal of 862 mm. In *rabi*, 123.4 mm rainfall received which was 61.5 mm excess than normal of 61.9 mm and in summer season, it was 87.7 mm which was excess by 5.6 mm as against normal of 82.1 mm (Fig 3.1.2)

Normal onset of monsoon : 1 July

Onset of monsoon during 2016-17 : 27 June
Annual mean rainfall : 1094.3 mm
Annual rainfall during 2016-17 : 994.1 mm
Mean crop seasonal rainfall during *kharif* and *rabi* : 862 and 61.9 mm, respectively
Crop seasonal rainfall during 2016-17 *kharif* and *rabi* : 754.1 and 123.4 mm, respectively

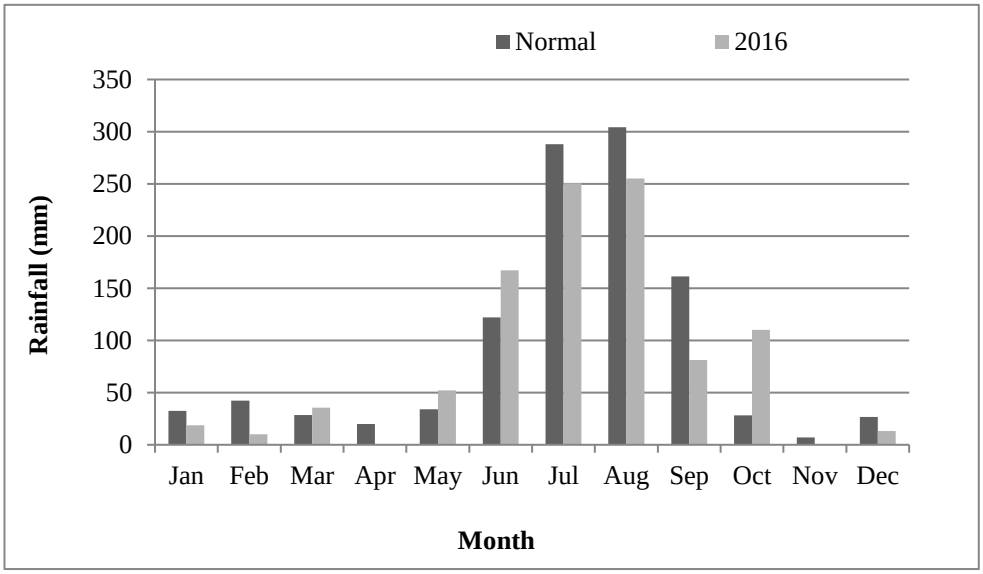


Fig 3.1.2: Normal and actual (2016) monthly rainfall at Ballowal Saunkhri

Salient achievements of on-farm demonstrations

Preparedness

Rainwater management

At village Achalpur, summer ploughing of field immediately after wheat harvest conserved moisture and gave the maize yield of 3450 kg/ha with net returns of Rs.30795/ha and B:C ratio of 1.97 compared to sowing without summer ploughing. At village Nainwan, summer ploughing gave yield of 3550 kg/ha in maize with net returns of Rs33071/ha and B: C ratio of 2.04. At village Achalpur, sowing of maize across the slope gave the grain yield of 3360 kg/ha with net returns of Rs.31426/ha with B: C ratio of 2.05 over sowing of maize along the slope. At village Nainwan, sowing of maize across the slope gave the higher grain yield of 3480 kg/ha with net returns of Rs.33526/ha with B:C ratio of 2.11. Earthing up in maize resulted in yield of 3450 kg/ha with net return of Rs.32405/ha and B:C ratio of 2.06 compared to without earthing up at village Achalpur. Earthing up of maize at village Nainwan also gave higher grain yield of 3460 kg/ha over flat sowing (Table 3.1.14).

Table 3.1.14: Effect of different methods of sowing on yield of maize

Intervention	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Improved practice	Farmers' practice				
Achalpur						
Summer ploughing	3420	3280	4.3	4.91	30795	1.97
Sowing across slope	3360	3200	5.0	4.82	31426	2.05
Earthing up	3450	3220	7.1	4.95	32405	2.06
Nainwan						

Summer ploughing	3550	3340	6.3	5.09	33071	2.04
Sowing across slope	3480	3320	4.8	4.99	33526	2.11
Earthing up	3460	3340	3.6	4.96	32580	2.06

Cropping systems

Among different maize cultivars demonstrated during *kharif* 2016 at village Achalpur, PMH 1 hybrid recorded higher yield of 3880 kg/ha, net returns of Rs. 40580/ha and B:C ratio of 2.33 followed by PMH 2 with grain yield of 3660 kg/ha and net returns of Rs36678/ha. Similarly at village Nainwan, PMH 1 gave highest grain yield of 3950 kg/ha, with net returns of Rs. 41755/ha and B: C ratio of 2.37 (Table 3.1.15).

Table 3.1.15: Performance of maize hybrids under rainfed condition

Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Improved variety	Farmers variety				
Achalpur						
PMH 1	3880	3050	27.2	5.57	40,580	2.33
PMH 2	3660	3050	20.0	5.25	36,678	2.21
Prakash	3250	3050	6.6	4.66	29,500	1.99
Nainwan						
PMH 1	3950	3180	24.2	5.67	41,755	2.37
PMH 2	3740	3180	17.6	5.36	38,078	2.26
Prakash	3460	3180	8.8	4.96	33,176	2.10

Among different wheat cultivars (PBW 725, HD 3086 and PBW 660) with pre-sowing irrigation and irrigation at tillering stage, PBW 725, PBW 677 and PBW 660 sown with pre-sowing irrigation gave 70.5, 62.9 and 49.1% higher grain yield compared to the rainfed crop with net returns of Rs.49936, 46301 and 40907/ha and B:C ratio of 2.71, 2.73 and 2.29, respectively (Table 3.1.16).

Table 3.1.16: Yield and economics of wheat cultivars with pre-sowing and one life saving irrigation in village Nainwan

Variety	Yield (kg/ha)		% increase in yield	WUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With improved practice	With normal practice				
PBW 725	3820	2240	70.5	16.9	49936	2.71
PBW 677	3650	2240	62.9	16.1	46301	2.61
PBW 660	3340	2240	49.1	14.8	40907	2.44

At village Achalpur, pearlmillet fodder variety, FBC 16 gave maximum fodder yield of 32440 kg/ha with net returns of Rs.8903/ha and B:C ratio of 1.64. Similarly, at village Nainwan, FBC 16 gave maximum fodder yield of 31710 kg/ha with a net return of Rs.8392/ha. Improved blackgram variety, Mash 114 recorded grain yield of 640 kg/ha at village Achalpur and 620 kg/ha at village Nainwan. In sesame, RT 346 cultivar recorded higher seed yield of 410 and 440 kg/ha at village Achalpur and Nainwan, respectively. In Chickpea, PBG 7 gave seed yield of 880 kg & 920 kg with net returns of Rs.34081 and 36681/ha, respectively at Achalpur and Nainwan. In lentil, LL 931 gave yield of 790 and 820 kg/ha, respectively at Achalpur and Nainwan. RLM 619 var. of raya gave seed yield 1137 and 1123 kg/ha, respectively at Achalpur and Nainwan. In taramira, TMLC 2 gave seed yield of 650 and 680 kg/ha, respectively at Achalpur and Nainwan. Linseed variety LC 2063 gave yield of 880 kg/ha with B:C ratio of 2.66 at Achalpur and yield of 940 kg/ha with B:C ratio of 2.84 at Nainwan (Table 3.1.17).

Table 3.1.17: Varietal performance of different crops under rainfed condition

Crop	Improved variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With improved variety	Farmers variety				
Achalpur							
Pearlmillet (fodder)	FBC 16	32440	23930	35.6	54.2	8903	1.64
Blackgram	Mash 114	640	440	45.5	1.1	10406	1.46
Sesame	RT 346	410	-	-	0.7	23510	2.34
	Pb Til 2	390	-	-	0.7	21507	2.23
Chickpea	PBG 7	880	540	63.0	4.7	34081	2.47
Raya	RLM 619	1137	850	33.8	6.1	28229	2.64
Taramira	TMLC 2	650	540	20.4	3.5	15610	2.20
Lentil	LL 931	790	590	33.9	4.2	30410	2.45
Linseed	LC 2063	880	780	12.8	4.7	36260	2.66
Nainwan							
Pearlmillet (fodder)	FBC 16	31710	23760	33.5	53.0	8392	1.61
Blackgram	Mash 114	620	480	29.2	1.0	9448	1.42
Sesame	RT 346	440	-	-	0.7	26507	2.52
	Pb Til 1	425	-	-	0.7	25007	2.43
Chickpea	PBG 7	920	580	58.6	4.9	36681	2.59
Raya	RLM 619	1123	880	27.6	6.0	27719	2.61
Taramira	TMLC 2	680	540	25.9	3.7	16930	2.30
Lentil	LL 931	820	580	41.4	4.4	32360	2.55
Linseed	LC 2063	940	760	23.7	5.0	40220	2.84

In wheat, PBW 660, HD 3086, WH 1105, PBW 725 and PBW 677 were demonstrated at villages Achalpur and Nainwan. PBW 725 gave highest grain yield of 3821 and 3640 kg/ha with net returns of Rs 50151 and 46150/ha with B:C ratio of 2.74 & 2.61, respectively at Achalpur and Nainwan (Table 3.1.18)

Table 3.1.18: Performance of wheat varieties under rainfed condition

Improved variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With improved practice	With normal practice				
Achalpur						
HD 3086	3549	2420	46.7	19.0	45472	2.59
PBW 725	3821	2420	57.9	20.5	50151	2.74
PBW 660	3340	2420	38.0	17.9	39857	2.41
PBW 677	3713	2420	53.4	19.9	47955	2.67
WH 1105	3077	2420	27.1	16.5	34614	2.23
Nainwan						
HD 3086	3360	2380	41.2	18.0	40159	2.42
PBW 725	3640	2380	52.9	19.5	46150	2.61
PBW 660	3280	2380	37.8	17.6	38458	2.36
PBW 677	3580	2380	50.4	19.2	45101	2.58
WH 1105	3140	2380	31.9	16.9	35708	2.27

Field demonstrations of raya, chickpea intercropping in wheat at row distance of 3 meters and toria + gobhi saron intercripping in 1:1 ratio were conducted in both the adopted villages. Wheat +

chickpea intercropping system gave highest WEY than sloe wheat cropping as well as wheat + raya and toria+ gobhi saron intercropping. The net return and B:C ratio of wheat+chickpea intercropping was Rs 59695/ha and 2.85 at village Achalpur and Rs 60951/ha and 2.88 at village Nainwan, respectively (Table 3.1.19).

Table 3.1.19: Yield and economics of intercropping systems

Improved practice	WEY (kg/ha)	Net returns (Rs/ha)	B:C ratio
Achalpur			
Sole wheat	4119	60551	3.17
Sole raya	2941	30291	2.73
Sole chickpea	4733	54057	3.37
Sole Gobhi saron	3167	33536	2.87
Sole toria	2276	22836	2.61
Wheat + raya	4098	58948	3.11
Wheat + chickpea	4342	59695	2.85
Toria + gobhi saron	2870	27797	2.37
Nainwan			
Sole wheat	4274	63706	3.27
Sole raya	2480	24051	2.37
Sole chickpea	4098	45802	3.01
Sole Gobhi saron	2895	29096	2.62
Sole toria	2311	24551	2.73
Wheat + raya	4186	60720	3.17
Wheat + chickpea	4402	60951	2.88
Toria + gobhi saron	2428	19177	1.95

Among different cropping sequences, ash gourd based cropping system with wheat gave maximum net returns (Rs 95758/ha) and B:C ratio (3.08) ratio compared to maize-wheat cropping system (Table 3.1.20).

Table 3.1.20: Productivity and economics of different cropping systems under rainfed conditions

Cropping system	MEY(kg/ha)	% increase in yield	Net returns (Rs/ha)	B:C ratio
Maize-wheat	7465	-	78369	2.35
Maize-taramira	5122	-45.7	43206	2.04
Ash gourd - taramira	5982	-24.8	60595	3.08
Ash gourd - wheat	8325	10.3	95758	3.10

The maize equivalent (MEY) yield of sesame in wild and stray animals' prone areas was 1867 and 1600 kg/ha with B:C ratio of 1.76 and 1.51 compared to 1220 and 1030 kg/ha of maize in Achalpur and Nainwan, respectively. Hence, sesame crop has potential for its cultivation in areas adjoining to forest and prone to stray/wild animal damage. In *rabi*, wheat grain yield of 1020 and 980 kg/ha was recorded in the wild animal damage prone areas, however the average wheat equivalent yield (WEY) of taramira was 1680 and 1733 kg/ha with B:C ratio of 2.10 & 2.17, respectively in village Achalpur and Nainwan (Table 3.1.21).

Table 3.1.21: Performance of different crops in wild animal damage prone areas

Crop	Variety	MEY/WEY* (kg/ha)		% increase in yield	Net returns (Rs/ha)	B:C ratio
		With improved practice	With normal practice			
Achalpur						
Sesame/ maize	Punjab Til No. 2	390 (2600*)	1380	88.4	21,507	2.23
Wheat/ taramira	TMLC 2	620 (1680*)	1020	64.7	14290	2.10
Nainwan						
Sesame/ maize	Punjab Til No. 2	360 (2400*)	1540	55.8	18,507	2.06
Wheat/ taramira	TMLC 2	640 (1733*)	980	84.4	15170	2.17

* MEY – Maize equivalent yield and WEY – Wheat equivalent yield

Energy management

Sowing of wheat with seed cum fertilizer drill gave net returns of Rs 32866 and Rs. 31427/ha, grain yield of 2957 and 2862 kg/ha with B:C ratio of 2.18 and 2.13, respectively at village Achalpur & Nainwan. Similarly, sowing of taramira with seed drill at village Achalpur & Nainwan gave seed yield of 720 and 690 kg/ha, respectively (Table 3.1.22).

Table 3.1.22: Effect of sowing method on productivity and economics of wheat, raya & taramira under rainfed conditions

Normal crop/ any change in crop	Sowing Methods	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With improved practice	With normal practice				
Achalpur							
Wheat	Drill Sowing	2957	2380	24.2	15.9	32866	2.18
Taramira		720	520	38.5	3.9	18690	2.44
Nainwan							
Wheat		2862	2410	22.9	15.4	31427	2.13
Taramira	Drill Sowing	690	480	43.8	3.7	17370	2.34

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.

b. On-station experiments

Experienced weather conditions during 2016-17

During 2016, the onset of monsoon was delayed by 2 weeks (23rd June). The annual rainfall of 1405.8 mm was received which was excess by 225.5 mm compared to normal (1180 mm) (Fig.3.2.1). During *kharif* (June–September), 1224.6 mm of rainfall was received which was excess by 186.6 mm compared to normal (1038 mm). During *rabi* season, 84.2 mm rainfall was received which was excess by 18.3 mm compared to normal (65.9 mm) and in summer, rainfall was 79.8 mm which was excess by 37.1 mm as against normal (42.7 mm).

Normal onset of monsoon : 4-10 June
Onset of monsoon during 2016-17 : 23 June
Annual mean rainfall : 1180 mm
Annual rainfall during 2016-17 : 1405.8 mm
Mean crop seasonal rainfall during *kharif* and *rabi* : 1038 and 65.9 mm, respectively
Crop seasonal rainfall during 2016-17 (*kharif* and *rabi*) : 1224.6 & 84.2 mm, respectively

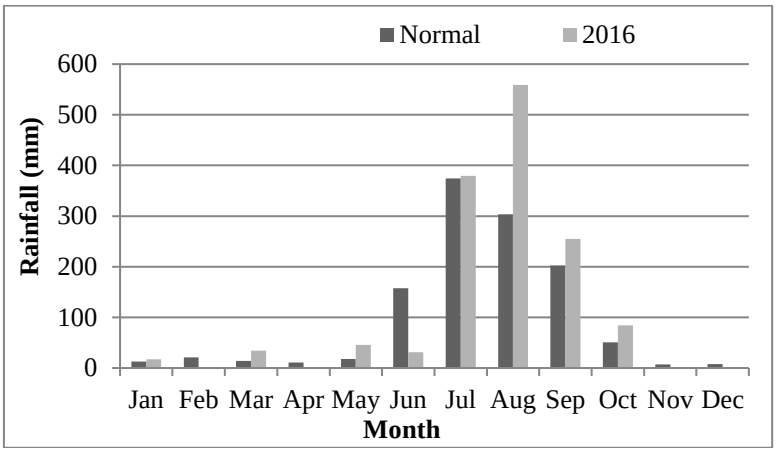


Fig.3.2.1: Normal and actual (2016) monthly rainfall at Chianki

Dry spells during crop growing season (2016)

Dry spell		Crop	Stage of the crop
Duration (Days)	**Dates & Months**		
9	24 June to 2 July	Rice, maize, sesame, pigeonpea, sorghum	Seedling
9	18 July to 26 July	Rice, maize, sesame, pigeonpea, sorghum	Early vegetative
12	26 August to 6 September	Rice, maize, sesame, pigeonpea	Rice: flowering; Maize: cob formation Sesame: capsule formation Sorghum: grain formation Pigeonpea: vegetative

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	Real time contingency measure implemented
Delayed onset of monsoon	Rice, maize, sesame, pigeonpea, sorghum, fingermillet	-	• Aerobic rice and drought tolerant varieties of upland rice • Early duration maize variety • Intercropping of pigeonpea+ okra (1:1)

Salient achievements

Real time contingency crop planning

Situation: Delayed onset of monsoon

During 2016, the onset of monsoon was delayed by 2 weeks (23rd June). The improved varieties of rainfed upland rice were demonstrated to cope with delayed monsoon situation. All the varieties gave higher yield (83.2 to 149.8%) over local variety (Bakar Dhan). IR-94313-1-1-B-10 recorded higher grain yield (3660 kg/ha), net returns (Rs.44560/ha), RWUE (3.03 kg/ha-mm) and B:C ratio (4.18) followed by IR-9333940-B18-13 (2970 kg/ha) with RWUE of 2.46 kg/ha-mm (Table 3.2.1).

Table 3.2.1: Performance of drought tolerant high yielding varieties of upland rice

Variety	Grain yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
IR-94313-1-1-B-10	3660	149.8	3.03	44560	4.18
IR-9333940-B18-13	2970	102.7	2.46	33520	3.39
IR-92545-546-1-4	2840	93.8	2.35	31440	3.25
Vandana	2685	83.2	2.23	28960	3.07
Bakar Dhan (local)	1465	-	1.21	11440	1.67

Similarly, four varieties of medium land transplanted rice were demonstrated out of which Arize-Tej was superior with higher grain yield (6599 kg/ha) and RWUE of 5.47 kg/ha-mm followed by BAU/IRRI-496 and Naveen (5969 and 5559 kg/ha). The increase in grain yield with drought tolerant varieties of medium land varieties Arize-Tej, BAU/IRRI-496 and Naveen were 66.4, 50.5 and 40.2%, respectively, over local variety (Table 3.2.2).

Table 3.2.2: Performance of drought tolerant high yielding varieties of rice for medium land situation

Variety	Grain yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Arize-Tej	6599	66.4	5.47	86884	5.65
BAU/IRRI-496	5969	50.5	4.94	76804	5.11
Naveen	5559	40.2	4.60	70244	4.76
Akchay Dhan	5429	36.9	4.50	68164	4.65
Local	3965	-	3.28	47440	3.96

Three varieties/hybrids of maize were evaluated for their suitability in rainfed ecology of Palamau region to cope with delayed onset of monsoon. Rasi-4215 gave higher seed yield (5029 kg/ha), net returns (Rs.39919/ha), B:C ratio (4.16) and RWUE (4.17 kg/ha-mm) compared to local (2759 kg/ha) (Table 3.2.3).

Table 3.2.3: Performance of drought tolerant high yielding varieties/hybrids of maize

Hybrid/ variety	Yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Rasi-4212	5029	82.2	4.17	39919	4.16
MBP -X08	4813	74.4	3.99	37543	4.01
P-3377	4354	57.8	3.61	32494	3.68
Local	2759	-	2.28	18999	2.2

Four varieties of sesame were evaluated for suitability under delayed onset of monsoon. All the varieties gave increased yield (107 to 140%) over the local variety. Among the varieties, Shekhar gave higher seed yield (680 kg/ha), net returns (Rs.20960/ha), RWUE (0.71 kg/ha-mm), and B:C ratio (2.91) (Table 3.2.4).

Table 32.4: Performance of drought tolerant varieties of sesame

Variety	Seed yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Shekhar	680	140.2	0.71	20960	2.91
Kanke White	627	121.5	0.71	18469	2.68
JG-11	586	107.0	0.67	16542	2.50
JLT-408	613	116.6	0.66	17811	2.62
Local	283	-	0.29	3301	1.33

c. On-farm demonstrations

Village profile

The program is being implemented by AICRPDA centre, Chianki 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.

Experienced weather conditions during 2016-17

During the year 2016, the onset of monsoon was delayed by 12 days (22th June). A rainfall of 1236.2 mm was received which was excess by 83.8 mm compared to normal of 1152.4 mm (Fig 3.2.2). During *kharif* (June - September), 1089.0 mm rainfall was received which was excess by 96.5 mm (9.72%) compared to normal (992.5) mm. During *rabi* season, 56.8 mm rainfall was received which was deficit by 20.8 mm (26.8%) compared to normal (77.6 mm) and in summer (March - May), 77.6 mm rainfall was received which was excess by 29.6 mm compared to normal (48 mm).

Normal onset of monsoon : 4 - 10 June
Onset of monsoon during 2016-17 : 22 June
Annual mean rainfall : 1152 mm
Annual rainfall during 2016-17 : 1236.2 mm
Mean crop seasonal rainfall during *kharif* and *rabi* : 993 and 77.6 mm, respectively
Crop seasonal rainfall during 2016-17 (*kharif* and *rabi*) : 1089 and 56.8 mm, respectively

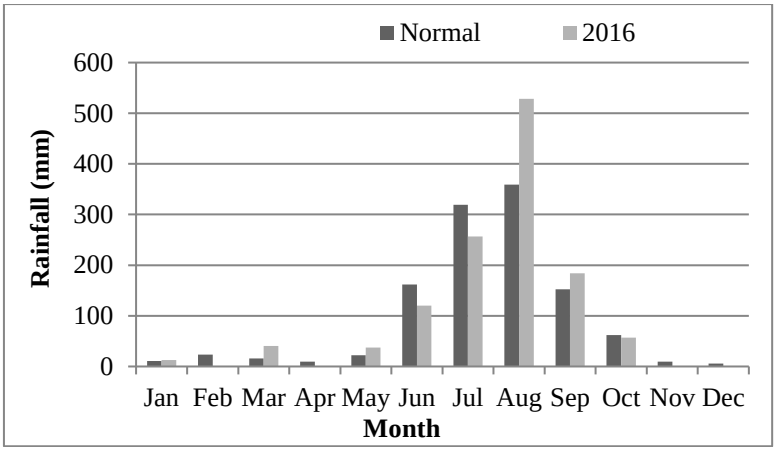


Fig.3.2.2: Normal and actual (2016) monthly rainfall at Garhwa (Kumbhi Bankheta)

Salient achievements of on-farm demonstrations

Real time contingency crop planning

Situation: Delayed onset of monsoon

During the year 2016, the onset of monsoon was delayed by 12 days (22th June). Drought tolerant varieties of medium land rice (Arize Tej, PAC-801, Sahbhagi dhan and Naveen) were demonstrated on farmers' fields to cope with delayed onset of monsoon. Higher grain yield of 4587 kg/ha was recorded with Arize Tej along with RWUE of 4.21 kg/ha-mm and B:C ratio of 3.92 as compared to local variety. Similarly, the higher net returns (Rs.54693/ha) was also recorded with Arize-Tej compared to other varieties (Table 3.2.5).

Table 3.2.5: Performance of drought tolerant varieties of rice under medium land situation

Variety	Grain yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Arize Tej	4587	50.7	4.21	54693	3.92
PAC-801	4186	37.5	3.84	48283	3.58
Sahbhagi Dhan	4261	40.0	4.15	54736	4.11
Naveen	4378	43.8	4.36	52445	3.98
Local	3043	-	-	-	-

High yielding drought tolerant hybrid of maize (Kanchan) yielded mean grain yield of 2976 kg/ha with mean RWUE of 2.73 kg/ha-mm compared to local variety (1703 kg/ha) (Table...). The A-404 variety of fingermillet gave higher yield (1797 kg/ha) with RWUE of 1.65 kg/ha-mm, net returns of Rs.14163/ha and B:C ratio (2.29) over local cultivar. In sorghum, CSV-20 recorded higher grain yield (2137 kg/ha), RWUE (1.96 kg/ha-mm), net returns (Rs.17415/ha) and B:C ratio (2.39) compared to local cultivar. Sesame variety Shekhar also gave higher seed yield (491 kg/ha) over local cultivar (254 kg/ha). Similarly, higher seed yield of blackgram (1467 kg/ha) was recorded by Birsa Urd-1 over local cultivar (860 kg/ha) with higher RWUE (1.35 kg/ha-mm), net returns (Rs.56459/ha) and B:C ratio (6.13) (Table 3.2.6).

Table 3.2.6: Performance of drought tolerant varieties of *kharif* crops

Variety/ hybrid	Grain/ seed yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Maize					
Kanchan	2976	81.9	2.73	17339	2.13
Local	1703	-	-	-	-
Fingermillet					
A-404	1797	86.5	1.65	14163	2.29
Local	969	-	-	-	-

Sorghum					
CSV-20	2137	68.1	1.96	17415	2.39
Local	1238	-	-	-	-
Sesame					
Shekhar	491	95.3	0.45	12079	2.10
Local	254	-	-	-	-
Blackgram					
Birsa Urd-1	1467	83.3	1.35	56459	6.13
Local	860	-	-	-	-

Two drought tolerant varieties of pigeonpea (Bahar and UPAS-120), gave higher seed yield (1878 and 1379 kg/ha), respectively over local cultivar (1000 kg/ha) with higher net returns (Rs.69695 and 48162/ha), B:C ratio (6.58 and 4.85) and RWUE (1.64 and 1.26 kg/ha-mm) over local cultivar (Table 3.2.8).

Table 3.2.8: Performance of drought tolerant varieties of pigeonpea

Variety	Seed yield (kg/ha)	% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Bahar	1878	87.8	1.64	69695	6.58
UPAS-120	1379	37.9	1.26	48162	4.85
Local	1000	-	-	-	-

To cope up with the delayed onset of monsoon followed by seasonal drought, pigeonpea (Bahar) + okra (SG-152) intercropping was demonstrated in 15 farmers' fields. Maximum pigeonpea equivalent yield of 2009 kg/ha was recorded in pigeonpea + okra intercropping system with RWUE of 1.75 kg/ha-mm and B:C ratio of 4.13.

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 2016-17

During 2016, the onset of monsoon was early by early (8th June). A rainfall of 766 mm was received which was deficit by 274.5 mm (26.4%) compared to normal rainfall (1040.1 mm). During south-west monsoon (*kharif*), 684.6 mm rainfall was received which was deficit by 230.5 mm (25.2%) compared to normal of 914.9 mm. During summer, 41.5 mm of rainfall was received which was excess by 8.3 mm compared to normal rainfall (33.2 mm) (Fig 3.3.1).

Normal onset of monsoon	:	21 June
Onset of monsoon during 2016-17	:	8 June
Annual mean rainfall	:	1040.1 mm
Annual rainfall during 2016-17	:	766 mm
Mean crop seasonal rainfall	:	914.9 mm (*kharif*) & 65.6 mm (*rabi*)
Crop seasonal rainfall during 2016	:	684.6 mm (*kharif*) & 35.1 mm (*rabi*)

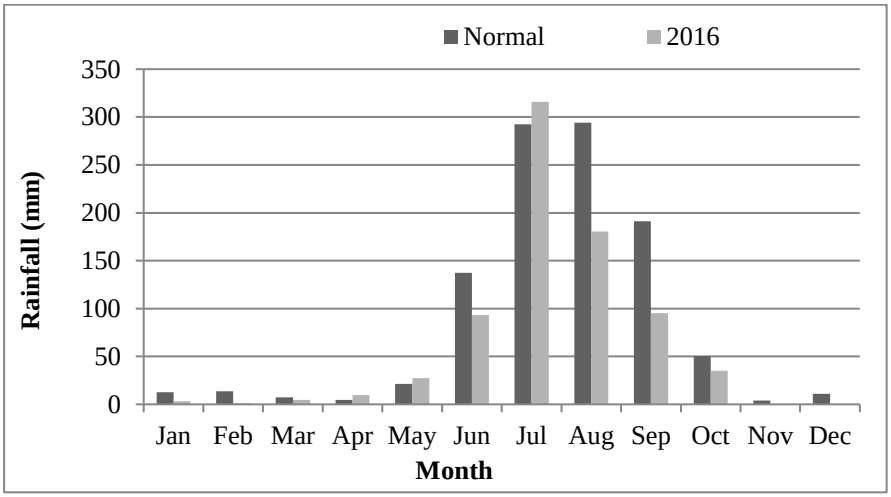


Fig 3.3.1. Normal and actual (2016) monthly rainfall at Faizabad

Dry spells during crop growing season (2016-17)

Dry spell			
Duration (days)	**Dates & months**	**Crop**	**Stage of the crop**
13	16- 23 September	Upland rice, maize, sorghum, sesame, pigeonpea, blackgram	Reproductive

Real Time Contingency Practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	Real time contingency measure implemented
Terminal drought	Rice, maize, sorghum	Reproductive stage	Mulching, weeding, interculture, foliar spray
	Pigeonpea	Vegetative	

Salient achievements of on-station experiments

Real time contingency planning

Situation: Terminal drought

During 2016, a dry spell of 13 days occurred during 16-23 September. To mitigate the moisture stress condition, mulching of green leaves of subabool @ 10 t/ha was done in paddy, pigeonpea, maize and sorghum. Mulching improved crop yields by 11-15% compared to without mulching and gave higher net returns, B:C ratio and RWUE compared to without mulching (Table 3.3.1).

Table 3.3.1. Effect of mulching on crop yields and economics

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With *in-situ* moisture conservation	With normal practice				
Rice	NDR-97	1626	1410	15.3	3.53	4988	1.25
Pigeonpea	NDA-1	1535	1380	11.2	3.05	11368	1.56
Maize	Naveen	1985	1740	14.0	4.09	4026	1.22
Sorghum	CSV-10	1400	1250	12.0	2.88	97917	6.14

Preparedness

Cropping systems

Two weedings followed by interculture done at 25 and 45 days after sowing in different crops recorded 10-33% higher yields with higher net returns and B:C ratio compared to farmers' practice of no weeding/interculture (Table 3.3.2). Among the crops, pigeonpea gave highest net returns of Rs 108585/ha than other crops.

Table 3.3.2. Effect of weeding and interculture on yields of different crops and economics

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With weeding/ interculture	Without weeding/ interculture				
Rice	NDR-97	1800	1360	32.3	4.16	7692	1.38
Pigeonpea	NDA-2	1675	1275	31.4	4.31	108585	6.70
Maize	Naveen	2045	1540	32.8	4.46	12321	1.61
Sorghum	CSV-10	1485	1180	25.9	324	5403	1.29
Sesame	T-12	525	475	10.5	1.21	7620	1.40
Blackgram	NDU-1	590	535	10.3	1.36	28622	2.50

Among different intercropping systems, pigeonpea + maize (1:1) and pigeonpea + sesame intercropping systems gave similar but higher maize equivalent yields (10067-10245 kg/ha) compared to other intercropping systems and recorded net returns of Rs 126128 to 127748/ha (Table 3.3.3).

Table 3.3.3. Performance of different intercropping systems

Treatment	Yield (kg/ha)		MEY (kg/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Main crop	Inter crop				
Pigeonpea + maize (1:1)	1680	1845	10245	127748	5.93	21.58
Pigeonpea + sorghum	1650	1340	9590	118673	5.71	20.21
Pigeonpea + sesame	1700	470	10067	126128	6.07	21.21
Maize + blackgram	1825	500	4492	46780	3.27	9.81
Maize + sesame	1770	470	3337	30955	2.62	7.29

Among different double cropping systems, maize-chickpea system gave higher rice equivalent yield (10920 kg/ha), net returns (Rs 122600/ha) and B:C ratio (3.98) compared to other cropping systems. maize-lentil system was the next best cropping system with REY of 10775 kg/ha (Table 3.3.4).

Table 3.3.4. Performance of different double cropping systems

Treatment	Yield (kg/ha)		REY (kg/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Crop 1	Crop 2					
Maize- chickpea	1880	1620	10920	41200	122600	3.98	23.00
Maize- lentil	1900	1585	10775	39400	122225	4.10	22.70
Maize- mustard	1900	1360	6930	35100	68850	2.96	14.60
Paddy- lentil	1640	1370	8490	39700	87650	3.21	17.89
Paddy- mustard	1675	1200	7675	35800	79325	3.21	16.17

REY: Rice equivalent yield

Nutrient management

In maize, application of 100% RDF (60:40:30 kg NPK/ha) gave higher grain yield (1920 kg/ha), net returns (Rs 12472/ha) and RWUE (4.19 kg/ha-mm) closely followed by integrated nutrient management with application of 75% RDF + FYM 6 t/ha (1750 kg/ha) (Table 3.3.5).

Table 3.3.5. Effect of nutrient management on maize yield and economics

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Stalk				
Control	1010	3125	16000	400	0.03	2.21
Full RDF (60:40:30 kg NPK/ha)	1920	5680	18600	12472	0.67	4.19
75% RDF + 6 t/ha FYM	1750	5060	21850	6424	0.29	3.82
75% RDF + 2.5 t/ha vermicompost	1680	4765	25450	1656	0.07	3.67

Energy management

In maize, deep ploughing 25 cm with MB plough+ 1 harrowing gave higher grain yield (1875 kg/ha), net returns (Rs 11757/ha), B:C ratio (1.64) and RWUE (3.86 kg/ha-mm) (Table 3.3.6a), with higher energy input (10649 MJ/ha), energy output (77649 MJ/ha) and energy use efficiency (7.29) compared to other treatments (Table 3.3.6b).

Table 3.3.6a. Effect of mechanization on maize yield and economics

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Stover				
Deep ploughing 25 cm with MB plough+ 1 harrowing	1875	5280	18480	11757	1.64	3.86
Ploughing with rotavator single operation	1420	4235	16870	6154	1.36	2.92
Ploughing with cultivator twice	1290	3900	17082	3828	1.22	2.65

Table 3.3.6b. Effect of mechanization on energy use efficiency

Treatment	Field efficiency (hr/ha)	Energy (MJ/ha)		EUE
		Input	Output	
Deep ploughing 25 cm with MB plough + 1harrowing	6.5	10649	77649	7.29
Ploughing with rotavator single operation	3.5	9258	55973	6.04
Ploughing with cultivator 2 operations	2.5	8367	54697	6.54

c. On-farm demonstrations

Village profile

The programme is being implemented by AICRPDA centre, Faizabad in Hardoiya village, block- Haringtonganj, tehsil-Milkipur in Faizabad district, Uttar Pradesh. The total cultivated area is 397 ha out of which 138 ha is rainfed. The mean annual rainfall is 1040.1 mm with seasonal rainfall of 967.5 mm during *kharif* (June-September). 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.

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 1041.1 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 2016-17

The rainfall data of Faizabad centre was taken.

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Terminal drought

During 2016, a dry spell of 13 days occurred during 16-23 September. To mitigate the moisture stress condition, mulching with green leaves of subabool @ 10 t/ha done in paddy, pigeonpea, maize and sorghum gave 6-15% higher crop yields compared to without mulching. Among the crops, pigeonpea gave higher net returns (Rs 79248/ha) and B:C ratio (5.16) compared to other crops (Table 3.3.7).

Table 3.3.7. Effect of *in-situ* moisture conservation through mulching on crop yields and economics

Normal crop	Normal variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With *in-situ* moisture conservation	With normal practice				
Rice	NDR-97	1500	1350	11.1	3.28	3030	1.15
Pigeonpea	NDA-1	1290	1150	12.2	2.72	79248	5.16
Maize	Naveen	1760	1535	14.7	3.84	7795	1.39
Sorghum	CSV-10	1220	1150	6.1	2.66	1110	1.06

Two weedings followed by interculture were done at 25 and 45 days after sowing were done to keep the field weed free and to break the capillaries for checking the moisture loss. Among different crops, pigeonpea gave higher net returns (Rs 95250/ha) and B:C ratio (6.00) compared to other crops (Table 3.3.8).

Table 3.3.8: Effect of weeding/ interculture on yield and economics of different crops

Normal crop	Normal variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With weeding/ interculture	Without weeding/ interculture				
Rice	NDR-97	1725	1400	23.2	3.77	6527	1.32
Pigeonpea	NDA-2	1500	1325	13.2	3.28	95250	6.00
Maize	Naveen	1850	1600	15.6	4.04	9224	1.46
Sorghum	CSV-10	1250	1100	13.6	2.73	1596	1.09
Sesame	T-12	485	400	21.2	1.06	5588	1.29
Blackgram	NDU-1	500	430	16.3	1.09	21350	2.12

Preparedness

Cropping systems

Among different intercropping systems, pigeonpea + maize system recorded higher maize equivalent yield (8825 kg/ha), net returns (Rs.106448/ha) and B:C ratio (5.11) followed by pigeonpea + sesame system (8492 kg/ha) compared to other intercropping systems (Table 3.3.9).

Table 3.3.9. Performance of different intercropping systems

Treatment	Yield (kg/ha)		MEY (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	Main crop	Inter crop				
Pigeonpea + maize	1430	1675	8825	25927	106448	5.11
Pigeonpea + sorghum	1450	1200	8450	25177	101573	5.03
Pigeonpea + sesame	1425	410	8492	24877	102503	5.12
Maize + blackgram	1600	450	4000	20600	39400	2.91
Maize + sesame	1570	400	2903	19100	24445	2.28

MEY: Maize equivalent yield

Among different double cropping systems, maize-chickpea system gave the highest rice equivalent yield (6742 kg/ha), net returns (Rs 59930/ha), B:C ratio (2.45) and RWUE (13.41 kg/ha-mm), followed by maize-lentil system (6325 kg/ha) compared to other cropping systems (Table 3.3.10).

Table 3.3.10. Performance of double cropping systems

Treatment	Yield (kg/ha)		REY	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Crop 1	Crop 2					
Rice- lentil	1600	1265	5817	39700	47555	2.20	11.57
Rice-mustard	1600	1050	3700	35800	19700	2.81	7.36
Maize- chickpea	1825	1475	6742	41200	59930	2.45	13.41
Maize-lentil	1825	1350	6325	39400	55475	2.41	12.58
Maize-mustard	1825	1125	5575	35100	48525	2.38	11.09

REY: Rice equivalent yield

Energy management

In maize, deep ploughing 25 cm with MB plough+ 1 harrowing gave higher grain yield (1920 kg/ha), net returns (Rs 12576/ha), B:C ratio (1.68) and RWUE (4.34 kg/ha-mm) (Table 3.3.11a), with higher energy input (10649 MJ/ha), energy output (76635 MJ/ha) and energy use efficiency (7.19) compared to other treatments (Table 3.3.11b).

Table 3.3.11a. Effect of mechanization one maize yield and economics

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed	Stover				
Deep ploughing 25 cm with MB plough+ 1 harrowing	1920	5640	18480	12576	1.68	4.34
Ploughing with rotavator single operation	1450	4260	16870	6584	1.39	3.28
Ploughing with cultivator 2 operations (farmers' practice)	1350	4100	17082	4808	1.28	3.05

Table 3.3.11b. Effect of mechanization on energy use efficiency in maize

Treatment	Field efficiency (hr/ha)	Energy (MJ/ha)		Output input ratio
		Input	Output	
Deep ploughing 25 cm with MB Plough + 1Harrowing	6.5	10649	76635	7.19
Ploughing with rotavator single operation	3.5	9258	52593	5.68
Ploughing with cultivator 2 operations (Farmers Practice)	2.5	8367	51345	6.14

3.4 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: Nil

c. On-farm demonstrations

Village profile

The program is being implemented in Terha Saraya Village, Mirzapur Dist., 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.

Climate vulnerability in general

The climate in this agro-climatic zone is semi- arid to sub-humid. Out of the total annual average rainfall of 1191 mm, the south-west monsoon contributes 80%, north-east monsoon contributes 15% and summer rainfall contributes 5%. Mirzapur district of Uttar Pradesh experiences intra-seasonal variability of rainfall (intermittent dry spells in standing crop), extreme events (flash floods, heat wave and cold wave) and unseasonal rains. The historical rainfall data (30 years) indicated that the variability in rainfall during south-west monsoon was 25 to 50% deficit of the average rainfall. The onset (south-west) of monsoon was during 26th SMW. For the last 15 years, the dry spells during crop season were experienced in July, August and September and at flowering and grain filling stages of the major rainfed crops. The onset of the monsoon had been early compared to the normal. The extreme events like unusual and high intensity rainfall in short span have been increasing during *kharif* and *rabi* seasons.

Experienced weather conditions during 2016-17

During 2016, at Terha Saraya village, the onset of monsoon was timely (21 June). A rainfall of 1216.2 mm was received which was excess by 387.2 mm compared to normal (836.7 mm). During south-west monsoon (*kharif*), 1210.8 mm of rainfall was received which was excess by 511.3 mm compared to normal (699.5 mm). During winter (October -December), 5.4 mm of rainfall was received which was deficit by 55.5 mm compared to normal (60.9 mm). In summer (March-May), no rainfall was received during current year.

Normal onset of monsoon	: 25th SMW (18-24 June)
Onset of monsoon during	: 21 June
Annual mean rainfall	: 836.7 mm
Annual rainfall during 2016-17	: 1216.2 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	: 699.5 & 60.9 mm, respectively
Crop seasonal rainfall during 2016-17 (*kharif* & *rabi*)	:1210.8 & 5.4 mm, respectively

Dry spells during crop growing season (2016): Nil

Salient achievements of on-farm demonstrations

Real time contingency planning

Preparedness

During *kharif* 2016, under timely on set of monsoon (21 June), maize, rice and pearlmillet produced 30, 20 and 40% higher yield with improved varieties than local varieties. Among pulses, blackgram and greengram failed due to heavy rains, but pigeonpea recorded 80-94% higher yield with improved varieties due to long duration which sustained the yield (1170-1090 kg/ha) with highest net returns of Rs. 38085/ha and B:C ratio (2.6) (Table 3.4.1).

Table 3.4.1: performance of different varieties of *kharif* crops

Crop/variety	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	Improved variety	Farmers' variety			
Maize					
Malviya makka-2	1600	-	1.3	13400	1.8
Local	-	1230		-	-
Rice					
NDR-97	2400	2000	1.9	25100	2.4
HUR3022	2000	1800	-	-	-
Pearlmillet					
Pusa-322	1400	1000	1.2	8330	8330
Local					
Blackgram – (T-9)	*200	150	0.2	-3400	
Green gram- (HUM-16)	223	175	0.2	-2965	
Pigeonpea					
Bahar	1170	*650	1.0	38085	2.6
MA-13	1090	*560	0.9	35545	2.5

*poor yield due to heavy rainfall

During *rabi* , lentil, chickpea, mustard, field pea and linseed produced 34, 41, 48, 26 and 42% higher yield respectively over farmers' practice. Further, field pea recorded higher net returns of Rs.43500/ha and B:C ratio (2.7) with RWUE of 265.6 kg/ha-mm (Table 3.4.2).

Table 3.4.2: performance of different *rabi* crops

Crop	Variety	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		With improved practice	With farmers' practice			
Lentil	HUL-57	820	610	128.1	14380	2.1
Chickpea	*Pusa*-256	1610	1140	251.5	42850	**3.9**
Mustard	Ashirvad	890	600	139.0	14700	**1.7**
Field pea	HUDP-15	1700	1350	265.6	43500	**2.7**
Linseed	Garima	980	690	153.1	13440	**2.0**

Preparedness

Rainwater management

In- situ moisture conservation practices with line sowing + weeding and soil mulching by dryland weeder in maize (Malviya makka-2) resulted in higher grain yield (1600 kg/ha), net returns (Rs. 11450/ha), B:C ratio (1.7) and RWUE (1.3 kg/ha- mm) compared to pearlmillet and sesame (Table 3.4.3).

Table 3.4.3*:* Performance of different crops under *in- situ* moisture conservation practices

Treatment	Yield (kg/ha)		Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Seed/ grain	Stover/ stalk			
Line sowing + weeding and soil mulching by dryland weeder in maize	1600	3650	11450	1.7	1.3
Line sowing + weeding and soil mulching by dryland weeder in pearlmillet	1400	3170	7970	1.6	1.2
Line sowing + weeding and soil mulching by dryland weeder in sesame	*290	1800	6730	1.7	0.2

*Poor yield due to heavy rainfall

Vegetables were cultivated with supplemental irrigation from harvested rainwater in farm pond. Among different vegetables, bottle gourd gave higher yield (10500 kg/ha), net returns (Rs.49000/ha), B:C ratio (2.4) and RWUE (8.7 kg/ha-mm) and the lowest yield (4000 kg/ha), net returns (Rs.16000/ha) and B:Cratio (3.3) in okra compared to other crops (Table 3.4.4).

Table 3.4.4: Performance of high value vegetables using supplemental irrigation from harvested water in farm pond

Crop	Yield (kg/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
Bottle gourd	10500	35000	49000	2.4	8.7
Okra	4000	32000	16000	1.5	3.3
Cowpea	5600	40000	27200	1.7	4.6
Sponge guard	7000	40000	30000	1.7	5.8

Cropping systems

All the crops grown under improved package of practices such as line sowing, improved variety with RDF produced higher yield compared to farmers practice. Among all the crops, chickpea recorded highest net returns of Rs. 42850/ha, B:C ratio of 3.9 and RWUE of 251.5kg/ha-mm(Table 3.4.5). The second best crop was pegionpea (MA-13) which produced net returns of Rs.35545/ha.

Table 3.4.5: Performance of different *kharif* and *rabi* crops under double/relay cropping systems

Crop/variety	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Improved practice	Farmers' practice				
Rice (NDR97)	2350	-	15000	20837	2.4	1.9
	-	1970	14000	16042	2.1	1.6
Rice (HUR-3022)	2480	-	15000	22200	2.4	2.4
	-	2060	14000	16900	2.2	1.7
Maize(Malviya makka-2)	1520	-	15500	11780	1.7	1.3
	-	1230	14000	8220	1.5	1.0
Pegionpea (MA-13)	1090	-	24000	35545	2.5	0.9
Chick pea	1610	-	15000	42850	3.9	251.5
	-	1140	13500	27500	3.0	178.1
Lentil(HUL57)	820	-	13500	14380	2.1	128.1
	-	610	12000	8740	1.7	95.3
Mustard (Ashirvad)	890	-	12000	14700	2.2	139.0
	-	600	10500	7500	1.7	93.7
Linseed	410	-	12200	2350	1.1	64.0
	-	320	11000	400	1.0	50.0

Energy management

Rice sowing with seed drill resulted in higher grain yield of 2372 kg/ha and straw yield of 6170/ha with net returns of Rs.23878/ha, B:C ratio of 2.5 and RWUE of 1.9 kg/ha-mm compared to farmers' method of broadcasting (Table 3.4.6).

Table 3.4.6: Effect of sowing method on rice yield and economics

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	grain	Straw				
Improved practice (Seed drill)	2372	6170	15500	23878	2.5	1.9
Farmers' practice* (Bradcasting)	1890	4725	14000	14822	2.0	1.5

Integrated farming systems

Integrated farming system (IFS) involving rice cultivation and livestock (3 buffalo + 2 buffalo calf) gave not returns of Rs. 168640/ha, B:C ratio of 1.36 and employment generation of 160 man day/ha/yr whereas agrihorti system gave not returns of Rs. 100000/ha (Table 3.4.7).

Table 3.4.7: Integrated farming systems productivity at NICRA village Terha Saraya

Farming system	Productivity (kg/ha)		COC (Rs/ha)	Net return (Rs/ha)	Employment generation (man-days/ ha/yr)
	Crop	Livestock			
IFS	Rice (2350)	3 Buffalo* (7920 Litre) + 2 buffalo calf	124300	168640	160
Agri-horti-system	Aonla* (10400)	-	4000	100000	300

Integrated animal based system

Agri-horti system

3.5 REWA: Nil

4.0 Moist Sub-humid zone (1250-1500 mm)

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 2016-17

During 2016, the onset of monsoon was normal. A total rainfall of 2061.8 mm was received which was excess by 657.4 mm compared to normal of 1404.4 mm (Fig.4.1.1). During south-west monsoon (*kharif)*, there was 1718.1 mm rainfall which was excess of 596.1 mm (53.13%) as against normal rainfall of 1122 mm. During North-east monsoon (October - December), 182.6 mm of rainfall was received which was excess 67.6 mm as that of normal (115 mm). During summer, 129.3 mm of rainfall was received which was deficit by 16.8 mm (11.5%) compared to normal rainfall of 146.1 mm.

Normal onset of monsoon	: 5 June
Onset of monsoon during 2016-17	: 8 June
Annual mean rainfall	: 1404 mm
Annual rainfall during 2016-17	: 2061.8 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	: 1122 and 115 mm, respectively
Crop seasonal rainfall during 2016-17 (*kharif* & *rabi*)	:1718.1 and 182.6 mm, respectively

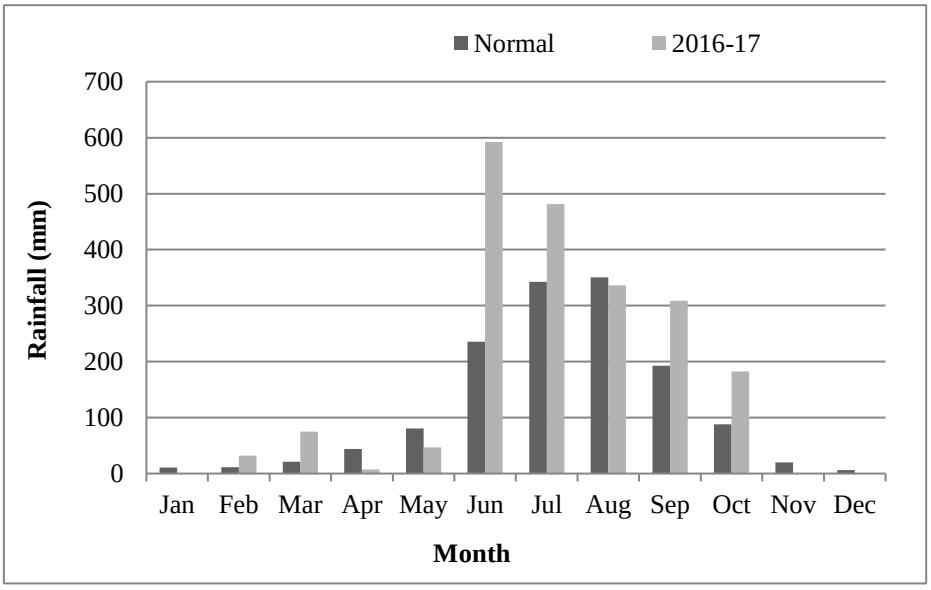


Fig. 4.1.1: Normal and actual (2016) monthly rainfall at Jagdalpur

Dry spells during crop growing season (2016)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & Months		
8	19-25 August	Rice, maize & horsegram	Booting, branching
19	12-31 October	Rice, horsegram and blackgram	Flowering and fruiting
30	1-30 November	Rice and maize	Grain filling & silking
30	1-30 December	Rice, maize & niger	Maturity

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	Real time contingency measure implemented
Early season drought	Rice	Tillering	Each 7th row opening by country plough
	Rice		Life saving irrigation
	Maize	Vegetative	Scooping in alternate row
	Rice	Late jointing	2% nitrogen foliar spray
Terminal drought	Rice	Flowering	Life saving irrigation

Salient achievements of on-station experiments

Real time contingency planning

Situation: Early season drought

A dry spell of 8 days occurred during 19-25 August coinciding with tillering stage of rice. Furrows opened after every 7th row by running country plough on 25 days after sowing with available soil moisture, gave higher grain yield of 1937 kg/ha with net returns of Rs. 11991/ ha, B:C ratio of 2.12 and RWUE of 2.83 kg/ha-mm compared to without furrow opening (Table 4.1.1).

Table 4.1.1: Effect of furrow opening on rice yield and economics

Treatment	Grain yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Without furrow opening	1487.1	2.17	9657	2.23
With furrow opening	1937.4	2.83	11991	2.12

Situation: Terminal drought

There was a dry spell of 30 days during entire December coinciding with flower initiation/grain filling stage of rice. Supplemental irrigation at flower initiation/grain filling stage in rice with 2 cm depth of water gave higher grain yield of 1989 kg/ha, with net returns of Rs. 11322/ha, B:C ratio of 1.99 and RWUE of 2.35 kg/ha-mm compared to without irrigation (Table 4.1.2).

Table 4.1.2: Effect of life saving irrigation at flower initiation stage on rice yield

Treatment	Yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Life saving irrigation	1989	2.35	11322	1.99
No life saving irrigation	942	1.11	1814	1.25

Preparedness

Alternate land use

Under alternate land use system, trench at base of trees for restoring rainwater + colocasia intercrop recorded higher yield of both mango (2575 kg/ha) and colocasia (1688 kg/ha), net returns

(Rs.48745/ha), B:C ratio (3.21) and RWUE (3.24 kg/ha) compared to other intercropping systems (Table). The higher yield of mango in T_5 may be due to maximum height (223.6cm) and biomass (16.91 kg/tree). Further, trench at base + cowpea intercrop (T_4) resulted in higher collar diameter (12.9 cm) and trench at base + bhindi intercrop (T_6) resulted in higher number of branches (4.5) (Table 4.1.3).

Table 4.1.3: Effect of treatments on growth parameters, yield and economics of mango plantation (2.0 ha)

Treatment	Plant height (cm)	No. of branches	Collar diameter (cm)	Bio mass (kg/tree)	Canopy spread (cm)		Yield (kg/ha)			Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
					N-S	E-W	Main crop	Inter crop	Stover/ stalk			
T_1	181.6	3.4	10.7	13.73	0.97	0.88	2317	736	1512	14241	1.74	2.44
T_2	195.2	4.3	9.1	14.76	1.08	0.98	2100	1369	1610	37755	2.88	2.63
T_3	205.7	3.7	12.9	15.56	1.23	1.12	2008	986	2098	21556	1.97	2.40
T_4	216.5	4.1	9.3	16.37	0.95	0.87	1801	908	1601	19326	1.91	2.16
T_5	223.6	4.2	10.9	16.91	0.98	0.89	2575	1688	1771	48745	3.21	3.24
T_6	204.8	4.5	9.1	15.48	1.08	0.98	2395	1216	2215	28973	2.21	3.02

T_1: Spading out at base on trees for restoring rainwater + cowpea intercrop; T_2: Spading out at base on trees for restoring rainwater + colocasia intercrop; T_3: Spading out at base on trees for restoring rainwater + bhindi intercrop; T_4: Trench at base on trees for restoring rainwater + cowpea intercrop T_5: Trench at base on trees for restoring rainwater + colocasia intercrop; T_6: Trench at base on trees for restoring rainwater + bhindi intercrop

c. On-farm demonstrations

Village profile

The program is being implemented by AICRPDA centre, Jagdalpur in Tahkapal, Tandpal 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 2016-17

During 2016, in Tahkapal village, onset of monsoon was delayed by 3 days (8th June). A rainfall of 1999.99 mm was received which was excess by 595.59 mm compared to normal rainfall of 1404.4 mm. During South-west monsoon (*kharif*), 1662.99 mm rainfall was received which was 540.99 mm excess compared to normal rainfall of 1122 mm; during North-east monsoon, 182.66 mm of rainfall was received which was excess by 67.66 mm compared to normal (115 mm). During summer, 145.22 mm of rainfall was received which was deficit by 0.88 mm compared to normal (146.1 mm) (Fig. 4.1.2).

Normal onset of monsoon : 5 June

Onset of monsoon during 2016-17 : 8 June

Annual mean rainfall : 1404 mm

Annual rainfall during 2016-17 : 1999.9 mm

Mean crop seasonal rainfall during *kharif* and *rabi* : 1122 and 115 mm, respectively

Crop seasonal rainfall during 2016-17 (*kharif & rabi)* : 1662.99 and 182.66 mm, respectively

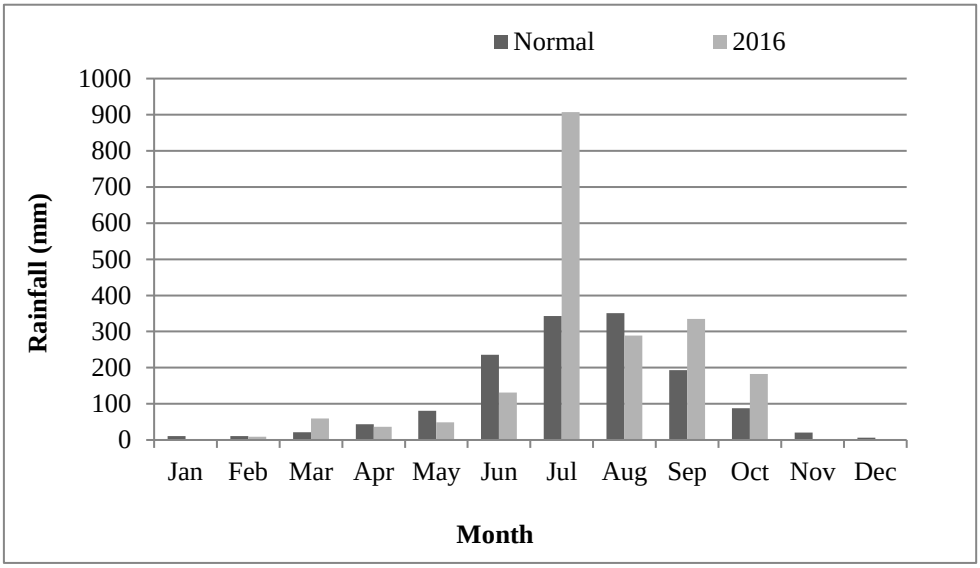


Fig.4.1.2 : Normal and actual (2016) monthly rainfall at Tahkapal village

Dry spells during crop growing season (2016)

Dry spell		Crop	Stage of the crop
Duration (days)	**Dates & Months**		
8 days	19-25 August 2016	Rice, maize & horsegram	Booting, branching
19 days	12-31 October 2016	Rice, horsegram and blackgram	Flowering and fruiting
30 days	1-30 November 2016	Rice and maize	Grain filling & silking
30 days	1-30 December 2016	Rice, maize & niger	Flowering & grain filling

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	RTCP implemented
Early season drought	Rice	Tillering	Furrow opening with country plough
	Rice	4 leaf	Supplemental irrigation from harvested rainwater
	Rice	Tillering, jointing & flowering	Supplemental irrigation from harvested rainwater
	Rice	Flowering	One life saving irrigation
	Rice	Flowering	Supplemental irrigation from harvested rainwater or mention the source of irrigation

Salient achievements of on-farm demonstrations

Real time contingency planning

Situation: Early season drought

A dry spell of 8 days occurred during 19-25 August. Supplemental irrigation from farm pond was given at tillering stage, jointing and flower initiation in rice with 2 cm depth of water. However, supplemental irrigation at tillering stage gave higher grain yield of 1503 kg/ha, with net returns of Rs. 41463/ha, B:C ratio of 3.16 and RWUE of 2.20 kg/ha-mm (Table 4.1.4).

Table 4.1.4: Effect of supplemental irrigation on yield of rice under rainfed ecosystem

Treatment	Grain yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Control	1005	1.47	15640	1.91
SI at tillering stage: 2 cm	1503	2.20	41463	3.16
SI at jointing stage: 2 cm	1083	1.66	23672	2.16
SI at flower initiation: 2 cm	997	1.57	21224	2.10

SI: Supplemental irrigation

Situation: Midseason drought

Supplemental irrigation from farm pond was given at flowering stage on 2nd October in rice with 2 cm depth of water gave higher grain yield of 1766 kg/ha, with net returns of Rs.9139/ha, B:C ratio of 1.77 and RWUE of 2.1 kg/ha-mm compared to control (Table 4.1.5).

Table 4.1.5: Effect of supplemental irrigation on yield of rice under rainfed condition

Treatment	Grain yield (kg/ha)	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
One life saving irrigation	1766	2.10	9139	1.77
Control	1214	1.44	2510	1.22

Situation: Terminal drought

To mitigate terminal drought in rice, supplemental irrigation (SI) from farm pond in 4 farmers' fields gave higher mean grain yield of 1139 kg/ha, with net returns of Rs. 25500/ha, B:C ratio of 2.33 and RWUE of 1.36 kg/ha-mm compared to without irrigation (Table 4.1.6).

Table 4.1.6: Effect of supplemental irrigation on rice crop under rainfed condition

Location	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
	With SI	Without SI			
Farmer 1	1007	606	1.19	15640	1.91
Farmer 2	1469	1052	1.78	41463	3.16
Farmer 3	1093	747	1.29	23672	2.16
Farmer 4	987	708	1.18	21224	2.10
Mean	**1139**	**778**	**1.36**	**25500**	**2.33**

Preparedness

Cropping systems

Among the drought tolerant rice varieties, sahabhagi recorded highest grain yield (1766 kg/ha), net returns (Rs. 6458/ha), B:C ratio (1.75) and RWUE (1.76 kg/ha-mm) compared to other varieties. In fingermillet, improved variety GPU 28 recorded higher yield (1496 kg/ha), with net returns of Rs. 9410/ ha, B:C ratio of 1.76 and RWUE of 1.49 kg/ha-mm compared to farmers' practice (Table 4.1.7).

Table 4.1.7: Evaluation of drought tolerant varieties of rainfed crops

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Improved practice	Farmers practice				
Paddy	Sahabhagi	1766	1212	45.7	1.76	6458	1.75
	CR 40	1717	1005	70.8	1.71	5871	1.70
	Indira Barani Dhan	1670	1105	51.1	1.67	5300	1.65
	Satka	1623	1172	38.5	1.62	4745	1.60
	Vandana	1578	970	62.7	1.57	4206	1.56
Fingermillet	GPU 28	1496	972	53.9	1.49	9410	1.76
	IR -2	1223	861	42.0	1.22	6133	1.37

Among different intercropping systems, fingermillet + pigeonpea (7:2) drilling recorded higher pigeonpea equivalent yield (MCEY) (1180 kg/ha), net returns (Rs. 26152/ha), B:C ratio (3.16) and RWUE (1.67 kg/ha-mm) compared to mixed seed (7:2) broadcasting (Table 4.1.8).

Table 4.1.8: Performance of fingermillet + pigeonpea intercropping system

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Main crop	Inter crop				
FM+PP (7:2) drilling	1798	405	11788	26152	3.16	1.67
Mixing seed (7:2) broadcasting	918	229	8841	11326	2.24	0.87
Sole fingermillet (FM) (GPU 28)	2191	-	11788	14499	2.19	1.67
Sole pigeonpea (PP) (Asha)	550	-	14735	4519	1.29	0.86

Energy management

Mechanization of rice cultivation (ploughing with cultivator, sowing with seed drill and harvesting with reaper) recorded higher yield (2687 kg/ha), net returns (Rs.32244/ha), B:C ratio (1.8) and RWUE (2.0 kg/ha-mm) compared to farmer's practice. Similarly, mechanization recorded higher energy input (1057.6 MJ/ha), output energy (39149.1 MJ/ha) and energy use efficiency was 36.4 compared to farmer's practice (Table 4.1.9ab).

Table 4.1.9a: Effect of mechanization on rice crop yield and economics

Treatment	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Grain	Stover				
Mechanization	2687	6301	17682	32244	1.8	2.0
Farmers' practice*	1106	2594	12770	13272	1.0	2.1

Farmers' practice: 3 pass of country plough and broadcasting of paddy seed and planking

Table 4.1.9b: Effect of mechanization on energy use efficiency in rice

Treatment	Field efficiency (hr/ha)	Energy (MJ/ha)		Energy use efficiency
		Input	Output	
Mechanization	6	1057.6	39149.1	36.4
Farmers' practice*	12	3042.1	13825.1	4.5

Alternate land use

Under alternate land use system, mango yield (2321 kg/ha) was more when intercropped with cowpea/bhindi, while colocasia intercrop produced more yield (1371 kg/ha). However mango + colocasia cropping system produced higher net returns of Rs.37826/ha, B:C ratio (2.9) and RWUE of 2.6 kg/ha-mm (Table). Further, Mango + colocasia recorded maximum height 204.5 cm and biomass (15.5 kg/tree) (Table 4.1.10).

Table 4.1.10: Effect of treatments on crop yield and economics of mango plantation (2.0 ha)

Treatment	Yield (kg/ha)			Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	Main crop	Inter crop	Stover/ stalk yield				
Mango + cowpea	2321	738	1515	15235	14268	1.7	2.4
Mango + colocasia	2104	1371	1613	17028	37826	2.9	2.6
Mango + bhindi	2321	738	1515	15235	14268	1.7	2.4

* 8 year old plantation

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 1378 mm. Annual normal potential evapo- transpiration is 478 mm. Length of growing period is 180-210 days.

b. On-station experiments

Experienced weather conditions during 2016-17

During 2016, the onset of monsoon was delayed by 14 days (24th June). A rainfall of 1248.8 mm was received during the year which was deficit by 149.1 mm than normal (1407.3 mm). Out of total rainfall, 1159.8 mm was received during *kharif* (June- September) and was excess by 9.3 mm (0.8%) than normal (1150 mm). In *rabi*, there was 73.1% deficit rainfall (51.6 mm) than normal (124.7 mm) and in summer, it was deficit by 81.0 mm (74.7%) than normal of 108.4 mm (Fig 4.2.1).

Normal onset of monsoon	: 10th June
Onset of monsoon during 2016-17	: 24th June
Annual mean rainfall	: 1407.3 mm
Annual rainfall during 2016-17	: 1248.8 mm
Mean crop seasonal rainfall during *kharif* and *rabi*	: 1150 & 124.7 mm, respectively
Crop seasonal rainfall during 2016-17 (*kharif* & *rabi*)	: 1159.8 & 51.6 mm, respectively

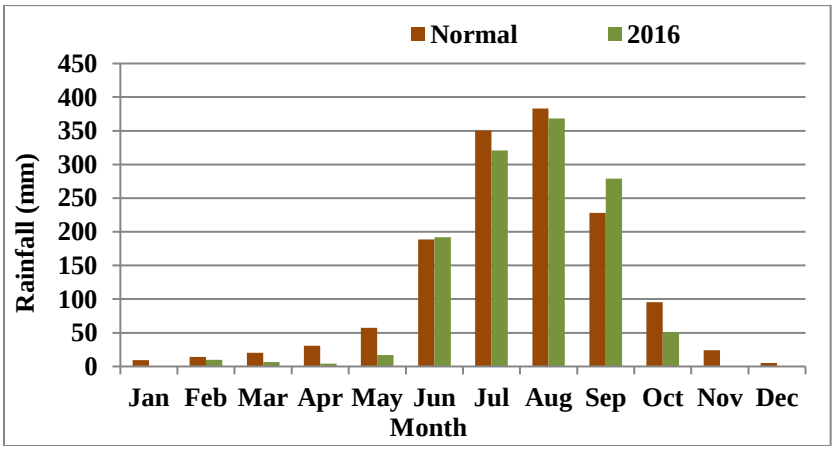


Fig.4.2.1: Normal and actual (2016) monthly rainfall at Phulbani

Dry spells during crop growing season, 2016-17

Dry spells		Crop	Stage of the crop
Duration (days)	**Dates & Months**		
9	19th to 27th July	Rice, maize, cowpea, pigeonpea, tomato, brinjal	Germination / seedling
14	19th August to 1st September	Rice, maize, cowpea, pigeonpea, greengram, blackgram	Panicle initiation, flowering, cob and pod development, veg. and flowering stage of vegetables
18	18th September to 5th October	Rice, maize, cowpea, pigeonpea, tomato, brinjal, greengram, blackgram	Milking, grain filling and maturity, cob and pod development, fruiting

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	Real time contingency measure implemented
Delayed onset of monsoon	Rice, maize, Pigeonpea	-	Improved verities
Early season drought	Rice	Germination / Seedling	Gap filling
	Maize, pigeonpea, cowpea, radish	Early veg. stage	*In-situ* moisture conservation, hoeing & weeding
Mid season drought	Rice	Late tillering/PI	Weeding by mandava weeder
	Maize	Silking and tasseling	Life saving irrigation, weeding and hoeing
	Pigeonpea	Veg.- flowering stage	Life saving irrigation, weeding and hoeing
	Cowpea, radish	Flowering, fruiting Root swelling stage	Life saving irrigation, weeding
	Green gram, black gram	Vegetative stage	Life saving irrigation, weeding
Terminal drought	Rice	Milking/grain filling	Life saving irrigation, foliar spray (1% MOP)
	Maize	Cob development /maturity	Mulching, life saving irrigation
	Pigeonpea	Flowering fruiting stage	Mulching, life saving irrigation
	Green gram, black gram	Pod development stage	Life saving irrigation

Salient achievements of on-station experiments

Real time contingency crop planning

Situation: Delayed onset of monsoon

During 2016, onset of monsoon was delayed by 14 days (24th June) than normal (10th June). Different crops and improved varieties were evaluated under late sown condition. Rice variety ZHU-11-26 gave maximum yield (2340 kg/ha), RWUE (1.93 kg/ha-mm), net returns (Rs.10398/ha) and B:C ratio (1.43) than other varieties. Likewise, among maize varieties, Hybrid maize P3501 produced maximum yield (3200 kg/ha) with higher net returns, B:C ratio and RWUE of Rs.39000/ha, 2.56 and 2.64 kg/ha-mm, respectively and among pigeonpea varieties, NTL30 **(**Durga) produced higher seed yield (1120 kg/ha), net returns (Rs. 33760/ha), B:C ratio (2.69) and RWUE (0.93 kg/ha-mm) (Table 4.2.1).

Table 4.2.1: Evaluation of improved varieties under delayed onset of monsoon

Crop	Variety (duration)	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Improved variety	Local variety				
Rice	**Local:** Saria (82 days) Jhalka (95 days) Punia (110 days)	2340	1750	33.7	1.93	10398	1.43

	Improved: ZHU -11-26 (< 90 days)						
Maize	**Local:** Kuji Makka (90 days) **Improved:** Hybrid maize (P-3501) (105 days)	3200	1700	88.23	2.64	39000	2.56
Pigeonpea	**Local:** Kandula (220 days) **Improved:** NTL30 **(**Durga) (180 days)	1120	800	40.0	0.93	33760	2.69

Situation: Early season drought

During 2016, there was a dry spell of 9 days from 19th to 27th July, and affected germination, seedling and vegetative growth of rice, maize, cowpea, pigeonpea, greengram, blackgram and other crops. *In-situ* moisture conservation practices of summer ploughing and increase in bund height before sowing and hoeing & weeding were done at vegetative/tillering stages of crops.

Rice variety Sahabhagi gave maximum yield (2450 kg/ha), RWUE (1.95 kg/ha-mm), net returns (Rs.10736/ha) and B:C ratio (1.48) than other varieties with *in-situ* moisture conservation. The yield increase with *in-situ* moisture conservation practice was 28.07% as compared to farmers' practice (1980 kg/ha). Maize (Hybrid P 3501) and pigeonpea (NTL 30-Durga) with *in-situ* moisture conservation practice gave 42.2% (3200 kg/ha) and 51.4% (1120 kg/ha) higher yield as compared to normal practice (no hoeing & no weeding) (Table 4.2.2).

Table 4.2.2: Effect of *in-situ* moisture conservation practices on performance and economics of different crops

Crop	**Variety**	**Yield (kg/ha)**		**% increase in yield**	**RWUE (kg/ha-mm)**	**Net returns (Rs/ha)**	**B:C ratio**
		With *in-situ* moisture conservation practice	**No in-situ moisture conservation practice**				
Rice	Sahabhagi, ZHU 11-26 Yogesh Lalitgiri	2450 2340 2380 2280	1980 1860 1730 1810	28.07	1.95	10736	1.48
Maize	P 3501 - Hybrid	3200	2250	42.2	3.14	39000	2.56
Pigeonpea	NTL 30 - Durga	1120	740	51.4	1.1	22560	2.13

Preparedness

Cropping systems

Maize + cowpea (2:2), maize + pigeonpea (2:2) and pigeonpea + radish (2:2) intercropping system were demonstrated during *kharif* 2016. Among maize based intercropping systems, maize + cowpea (2:2) gave higher maize equivalent yield (MEY) (4790 kg/ha) with higher net returns (Rs.65800/ha), B:C ratio (3.19) and RWUE (3.96 kg/ha-mm) (Table 4.2.3).

Table 4.2.3: Effect of intercropping systems on crop yield and economics

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Intercropping system	Without intervention				
Maize + cowpea (2:2)	Maize (P-3501) + cowpea (Gomti)	Maize (2550) Cowpea (2240 green pods) (MEY-4790)	Sole maize 2400	99.6	3.96	65800	3.19
Maize + pigeonpea (2:2)	Maize (P-3501)+ pigeonpea NTL 30	Maize (2350) Pigeonpea (640 seeds) (MEY-3886)	Sole maize 2400	61.9	3.21	45720	2.43
Pigeonpea + radish (2:2)	Pigeonpea (NTL 30) +radish (Pusa Chetki)	Pigeonpea (780 seeds) + Radish (10580) (PEY-1661)	Sole pigeonpea 840	97.6	1.37	51728	2.85

PEY – Pigeonpea equivalent yield

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 ground water table is 5 m.

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.

Dry spells during crop growing season (2016)

Dry spell		Crop	Stage of the crop
Duration (days)	Dates & Months		
9	19th to 27th July	Rice, maize, cowpea, pigeonpea	Germination / seedling
14	19th August to 1st September	-do-	Panicle initiation, flowering, cob and pod development
18	18th September to 5th October	-do-	Milking, grain filling and maturity, cob and pod development

Real time contingency practices (RTCP) implemented

Weather aberration	Real Time Contingency practices (RTCP) implemented	
	Crop	RTCP implemented
Delayed onset of monsoon	Rice, maize, pigeonpea	Improved varieties
Early season drought	Rice	Gap filling
	Maize	*In-situ* moisture conservation, gap filling, hoeing & weeding
	Pigeonpea	*In-situ* moisture conservation, gap filling, hoeing and weeding
	Cowpea	*In-situ* moisture conservation, hoeing and weeding
Mid season drought	Rice	Weeding with mandava weeder
	Maize	Life saving irrigation, weeding and hoeing
	Cowpea	Life saving irrigation, weeding
	Pigeonpea	Life saving irrigation, weeding and hoeing
Terminal drought	Rice	Life saving irrigation
	Maize	Life saving irrigation
	Pigeonpea	Life saving irrigation

Salient achievements of on-farm demonstrations

Real time contingency crop planning

Situation: Delayed onset of monsoon

During 2016, monsoon arrived 14 days later (24th June) than the normal time (10th June) of onset. Different rice varieties were demonstrated under late sown condition. Rice variety Sahabhagi gave 35% higher yield (2340 kg/ha), net returns (Rs.12015/ha), B:C ratio (1.43) and RWUE (2.02 kg/ha-mm) than other varieties (1820 kg/ha).

Situation: Early season drought

During 2016, there was a dry spell of 9 days (19 to 27 July). *in-situ* moisture conservation with raising of bund height was demonstrated in rainfed uplands (in case of rice and maize + cowpea). Rice variety (Naveen) gave 27% higher yield (2580 kg/ha), net returns (Rs.13925/ha), ratio (1.58) and RWUE (2.13 kg/ha-mm), with *in-situ* moisture conservation compared to farmers' practice (2040 kg/ha). Similarly, maize (P-3501) + cowpea (Gomti) (2:2) intercropping gave higher yield (4700 kg/ha), net returns (Rs.64000/ha) and B:C ratio (3.13), with *in-situ* moisture conservation compared to farmers' practice (2360 kg/ha) (Table 4.2.4).

Table 4.2.4: Performance of different crops under *in-situ* moisture conservation

Crop/inter cropping system	Variety	Yield (kg/ha)		RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		In-situ moisture conservation	Farmers' practice			
Rice	Sahabhagi	2450	1950	2.02	12015	1.50
	Naveen	2580	2040	2.13	13926	1.58
Maize + cowpea (2:2)	Maize (P-3501) + cowpea (Gomti)	Maize 2520 Cowpea 2180 MEY-4700	Sole maize 2360	3.88	64000	3.13

Similarly, weeding/interculture in maize, pigeonpea and cowpea recorded higher grain seed yield (3120, 1080 and 3520 kg/ha, respectively), net returns, B:C ratio and RWUE compared to farmers' practice (Table 4.2.5)

Table 4.2.5: Effect weeding/inteculture on crop yield and economics

Crop	Variety (duration)	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
		Weeding/ interculture	Farmers practice				
Maize	P 3501	3120	2220	40.5	2.58	37400	2.50
Pigeopea	Durga	1080	710	52.1	0.89	31840	2.59
Cowpea	Gomti	3520	2250	56.4	2.90	40400	2.34

5.0 Per- humid Zone

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 condition during 2016-17

During the year 2016, the onset of monsoon was normal (1st June). A rainfall of 1898.8 mm was received which was excess by 34.0 mm compared to normal (1864.8 mm). During south-west monsoon (*kharif*), a rainfall of 1210.8 mm was received against a normal rainfall of 1182.2 mm. The rainfall during *rabi* was deficit by 18.8 mm compared to normal rainfall of 120 mm (Fig 5.1.1).

Normal onset of monsoon : 1st week of June
Onset of monsoon during 2016-17 : 1st week of June
Normal annual rainfall : 1864.8 mm
Annual rainfall during 2016-17 : 2658.9 mm
Mean crop seasonal rainfall : 1182 and 120 mm during *kharif* and *rabi*, respectively
Crop seasonal rainfall during 2016-17 : 1210.8 and 101.2 mm during *kharif* and *rabi*, respectively

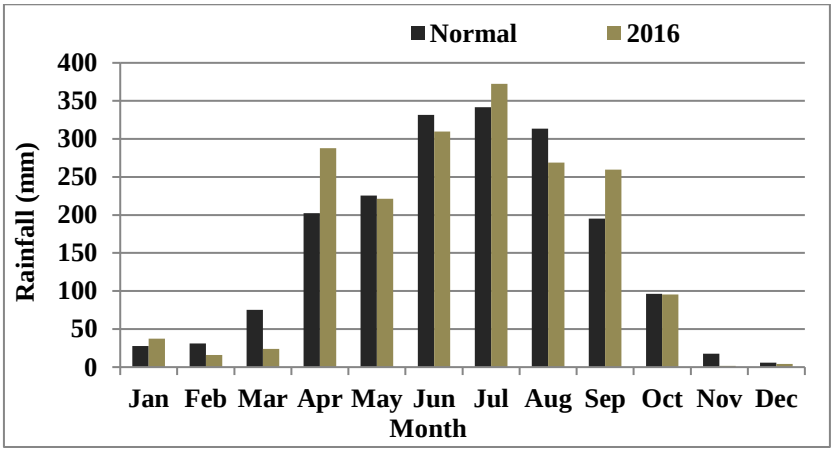


Fig 5.1.1: Normal and actual (2016) monthly rainfall at Biswanath Chariali

Dry spells during crop growing season (2016)

Dry spell		Crop	Stage of the crop
Duration (days)	**Dates & Months**		
23 days	08 March - 22 March	No crops in the field.	
20 days	11 November - 28 December	Rapeseed; potato	
32 days	30 December - 30 January, 2017	Rapeseed; potato	Grain filling stage (rapeseed) Tuber development stage (potato)

Salient achievements of on-station experiments

Preparedness

Cropping systems

Intercropping of ginger with different varieties of pigeonpea revealed that yield of ginger with long and short duration pigeonpea varieties increased substantially as compared to sole ginger. Ginger intercropped with pigeonpea variety ICPL-11305 gave ginger equivalent yield of 13251 kg/ha, net returns of Rs.427040/ha, RWUE of 7.26 kg/ha-mm and B:C ratio of 7.3 compared to other treatments (Table 5.1.1).

Table 5.1.1: Performance of ginger (Cultivar- *Jati Adda*) intercropped with different varieties of Pigeonpea

Treatment	GEY (kg/ha)	% Increase in yield	RWUE (kg/ha-mm)	Net returns (Rs/ha)	B:C ratio
Control (Sole ginger)	5684	-	3.11	134360	3.1
Ginger + ICPL-11305	13251	133.1	7.26	437040	7.3
Ginger + ICPL-88039	12645	122.5	6.93	412800	6.9
Ginger + TS-3R	9651	69.8	5.29	293040	5.3
Ginger + Local-2	8746	53.9	4.79	256840	4.8

GEY: Ginger equivalent yield

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 one of the villages namely - *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.

Brief profile of the villages

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.

Ganakdoloni village

Gankdoloni village is situated in the Dhalpur block of Lakhimpur district, Assam since 2012-13. The latitude and longitude of the village are 26°55'33"N and 93°52'17"E, respectively. Rainfall pattern of the village is same as Chamua village. The total farm families of village are 75 with cultivated area of 66 ha. Only eight farmers of the village are medium and rest are either small or marginal farmers. Ground water table is very shallow with no contamination of Arsenic. The village is affected by 3-5 flash floods of 7 to 15 days duration during *kharif* season. During *rabi* season, soil moisture deficit is a problem. Due to presence of only low lying lands there is limited scope for crop diversification. *Sali* rice grown in the village suffers from flood every year.

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 0.006^0C/year and minimum by 0.0194^0C/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 2016-17

During 2016, in Chamua Narayanpur village, the onset of monsoon was normal (1st week of June). A rainfall of 2658.9 mm was received which was excess by 680.3 mm compared to normal (1978.6 mm). During south-west monsoon (*kharif*), a rainfall of 1737.4 mm was received against a normal rainfall of 1280.1 mm. The rainfall during *rabi* was deficit by 1.1 mm compared to normal rainfall of 161.1 mm (Fig 5.1.2).

Normal onset of monsoon	: 1st week of June
Onset of monsoon during 2016-17	: 1st week of June
Normal annual rainfall	: 1978.6 mm
Annual rainfall during 2016-17	: 2658.9 mm
Normal crop seasonal rainfall	: 1280.1 and 161.0 mm during *kharif* and *rabi*, respectively
Crop seasonal rainfall during 2016-17	: 1737.4 and 160.0 mm during *kharif* and *rabi*, respectively

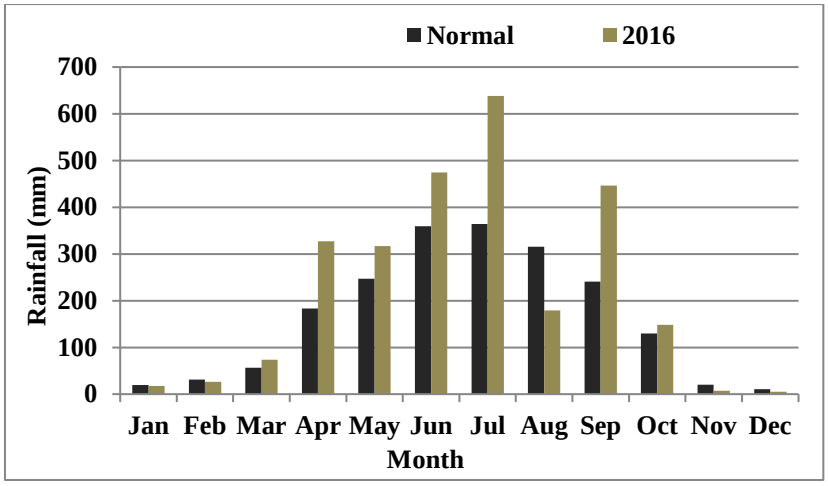


Fig 5.1.2: Normal and actual (2016) monthly rainfall at Chamua village

Dry spells during crop growing season (2016)

Dry spell		Crop	Stage of the crop
Duration (days)	**Dates & Months**		
7	8 to 14 August	*Sali* rice	Early tillering stage of short duration rice varieties
14	16 to 29 August		Panicle initiation stage of short duration variety and early tillering stage of other varieties
9	27 September to 6 October	Rice, rapeseed, potato	Grain filling stage of medium and long duration rice cultivars Early vegetative stage of rapeseed/potato of rapeseed
96 (*rabi*)	14 October, 2016 to 19 February, 2017	Rapeseed, potato, winter vegetables	Flowering/grain filling /tuber formation stages ofpotato

Real time contingency practices (RTCP) implemented

Weather aberration	Crop	Stage of crop	Real time contingency measure implemented
Early season drought	*Sali* rice	Early tillering, vegetative	Supplemental irrigation
Mid season drought	*Sali* rice, turmeric, ginger, potato, rapeseed	Grain filling, vegetative	Supplemental irrigation

Salient achievements

Real time contingency planning

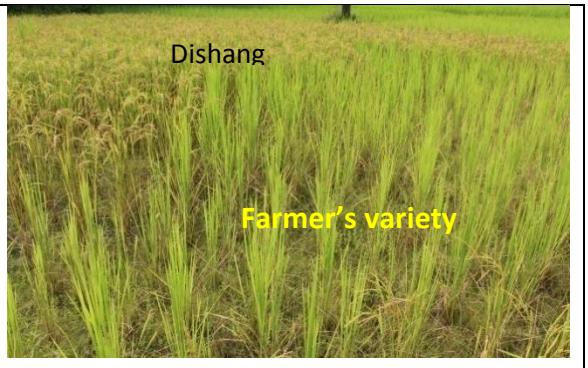
Situation: Early season drought

During August 2016, the village received rainfall of 179 mm (in 8 rainy days) which was 63% lower than the normal monthly rainfall. Considerable decrease in rainfall adversely affected *Sali* rice which was at early tillering stage. The effect of dry spell was not prominent in case of long and medium duration varieties, which were grown on lowlands. Supplemental irrigation increased the *Sali* rice yield by 59.4% (4200 kg/ha) (Table 5.1.2).

Table 5.1.2: Performance of short duration high yielding cultivar (Dishang) of rice grown under different land situations

Normal crop	Variety	Yield (kg/ha)		% increase in yield
		In upland situation	In medium land situation	
Sali Rice	Dishang	2380	3400	42.85

With irrigation (Dishang)



Without irrigation (Dishang & farmers' variety)

Situation: Terminal drought

Chamua village experienced two dry spells, a dry spell of 12 days (26 September to 7 October) and a long dry spell (14 October, 2016 to 20th February, 2017), which affected the PI and grain filling stages of long and medium duration varieties of *Sali* rice. Short duration cultivars Disang and medium duration cultivars – Kanaklata, Mulagabharu, TTB-404 and Mahsuri were demonstrated as contingency plan for management of mid season and terminal droughts. All the short duration cultivars produced higher yields (15.7 to 58.7%) with respect to local varieties (Table 5.1.3).

Table 5.1.3: Terminal drought management through short and medium duration rice cultivars

Crop	Duration (days)	Variety	Yield (kg/ha)		% increase in yield	Net returns (Rs/ha)	B:C ratio
			With improved practice*	With farmers' practice**			
Sali rice	Short (100-120)	Disang	2635	2210	58.67	5845	1.29
	Medium (135 to 140)	TTB-404	4070	2700	50.7	20195	1.98
		Mulagabharu	3125	2700	15.7	10745	1.52
		Kanaklata	3450	2700	27.7	13995	1.68
	Long duration (>140)	TTB-303-2-23	3942	3400	15.9	18915	1.92
		Ranjit	5396	3400	58.7	33455	2.63
		Gitesh	4110	3400	20.9	20595	2.00

*Improved practice: Short, medium or long duration high yielding varieties; ** Farmers' Practice: Same variety was grown in the uplands/medium lands

In Chamua village, no rainfall was received from mid October, 2016 to mid February, 2017. Supplemental irrigation form the harvested rainwater increased the yield of potato from 64.7 to 154%. The net returns (Rs.82110/ha) and B:C ratio (2.27) was higher with local (small seeded) potato variety compared to improved varieties (Table 5.1.4).

Table 5.1.4: Performance of potato with supplemental irrigation from the harvested rainwater

Variety	Yield (kg/ha)		% increase in yield	Net returns (Rs/ha)	B:C ratio
	With irrigation	Without irrigation			
Kufri Pokhraj	20943	10980	90.7	73328	2.00
Kufri Jyoti	18067	10970	64.7	53192	1.73
Local (small seeded)	9774	3846	154	82110	2.27

Potato – without irrigation

Potato – with supplemental irrigation

Situation: Intermittent flash flood

Ganakdoloni the village was affected by two flash floods during 4th to 12th September, 2016. In spite of an early submergence as well as multiple submergences, local *Bao* varieties performed well as compared to the normal varieties, which were completely damaged by the floods. The highest (2625 kg/ha) and the lowest yield (1745 kg/ha) were recorded in case of *Maguri* and *Tulshi* verities (Table 5.1.5).

Table 5.1.5: Performance of local *Bao* cultivars under intermittent flash floods at Ganakdoloni village

Cultivar	Yield (kg/ha)	Net returns (Rs/ha)	B:C ratio
Kekowa (20%) + *Refugee (80%)	2235	10350	1.86
Dhusuri	1875	6750	1.56
Maguri	2625	5810	1.48
Tulsi	1745	14140	2.18

*Flood water carried seeds/seedlings of other *bao* varieties from other areas and mixed with *kekowa bao and the bao* variety came from outside and mixed with other exiting varieties named as Refugee by the farmers of the village.

In Ganakdoliloni village, due to occurrence flash floods, field preparations as well as transplanting of rice varieties was hampered. Direct seeding of rice varieties (*Bakul bora, Chakowa* and *Kon joha* rice) was demonstrated. Performance of the directly seeded cultivars was almost at par with normal transplanted ones with an added advantage of no additional cost in land preparation and transplanting. Cost of cultivation was reduced by Rs.20000 to Rs.12000/ha and B:C ratio varied from 2.25 to 2.53 among the varieties (Table 5.1.6).

Table 5.1.6: Performance of direct seeded traditional varieties under intermittent flash flood situation during 2016 at Ganakdoloni village

Intervention	Name of the cultivars	Yield (kg/ha) Direct seeded	% increase in yield	Net returns (Rs/ha)	B:C ratio
Direct seeding	*Bakul bora*	2250	100	27000	2.25
	Chakowa	2445	100	29340	2.45
	Konjoha	2025	100	30375	2.53

Preparedness

Cropping systems

Farmers of Chamua were encouraged to take up crop diversification to cope up with rainfall variability. All the farmers earned higher income from diversified cropping as compared to mono-cropping of *Sali* rice (Table 5.1.7).

Table 5.1.7: Crop diversification with alternate crops / varieties

Name of the farmers	Crops grown (variety)	Rice equivalent yield (kg/ha)	Net returns (Rs/ha)	Increase in net returns (Rs/ha)	B:C ratio
Harendra Neog	Rice (Var. Disang) Rice (Var. Ranjit) Potato (var. Pokhraj) Potato (var. Kufri Jyoti) Potato (var. Local) Rapeseed (var. TS-36) Pumpkin, Pea, Cabbage/cauliflower (Not included in calculation)	80123	443565	423565	2.52
Ranjan Hazarika	Rice (var. Mahsuri) Potato (var. Kufri Jyoti) Potato (var. Local) Cabbage (var. Rear Ball) Ginger (var. Local) Rajmah (var. K-long)	64753	276051	256051	3.14
Balindra Neog	Rice (Var.Disang) Rice (Var.Mahsuri) Rice (Var.Punjasali) Rice (Var.Nania) Potato (Kufri Jyoti) Potato (var. Local)	29561	54491	34491	1.25
Kamal Saikia	Colocasia (var. Ahinakachu) Ridge gourd (var. Hybrid) Cucumber (var. Hybrid) Sesame (var. Local) Brinjal (var. JC-1) Tomato (var. Hybrid) Potato (Kufri Jyoti) Potato (var. Local) Cabbage (var. Rear Ball)	139771	909172	889172	3.61

Double cropping/relay cropping systems viz., *Sali* rice - maize, *Sali* rice - rapeseed, *Sali* rice - potato and *Sali* rice - pea were demonstrated in the Chamua village. *Sali* rice (Dishang) + rapeseed (JT-90-1) cropping system gave higher yield (4200 and 21250 kg/ha), rice equivalent yield (20728 kg/ha), net returns (Rs.92770/ha) and B:C ratio (1.99) compared to other cropping systems (Table 5.1.8).

Table 5.1.8: Performance of double cropping systems in Chamua village

Cropping system	Yield (kg/ha)		Rice equivalent yield	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	B:C ratio
	Crop 1	Crop 2				
Sali rice (Dishang) - potato (K. jyoti)	4200	20000	19757	57556	84020	1.90
Sali rice (Dishang) - rapeseed (JT-90-1)	4200	21250	20728	57556	92770	1.99
Sali rice (Dishang) - rapeseed (TS-36)	4200	562	6385	38490	57470	1.5
Rice (var. Mahsuri) rajmah (var. K-long)	2600	625	3472	51755	11845	3.2
Sali rice (Mahshuri) - potato (K. pokhraj)	4380	8750	13130	93555	37745	1.40

6. NICRA - Strategic Research

Adaptation strategies through cropping systems at selected soil benchmark sites

Risk coping production systems resilient to climate, land and water modifications require diversified structures in space and time such as cropping systems. Inter-annual and intra-annual seasonal climate variability is one of the major factors influencing biophysical systems. Further, the spatial variability of soils in turn affects the ability of the crops to cope with drought and finally yields. The present study was undertaken at Varkhed watershed, Akola district, Maharashtra, to assess the climate risks and to identify cropping systems as an adaptation strategy at selected soil sites. During 2016, the onset of monsoon was early by 5 days (7 June). A seasonal rainfall (June-September) of 662 mm was received which was deficit by 28.2 mm compared to normal (690.2 mm). There were two dry spells during the crop season i.e. 16-24 July (9 days) and 13 August to 13 September (31 days) coinciding with the pod filling and maturity stages of soybean and greengram, and vegetative growth stages of cotton and pigeonpea. In general, *in-situ* moisture conservation through opening of conservation furrow at 30-35 DAS in soybean (JS 335) resulted in 7.5% higher seed yield compared to farmers' practice of no conservation furrow across all soil types. Higher seed yield (1320 kg/ha) of soybean was recorded with opening of conservation furrow in very fine smectitic, calcareous Typic Haplusterts followed by Calcareous vertic Ustochrepts (1239 kg/ha) compared to Calcareous Typic Ustochrepts (1198 kg/ha) and Typic Ustochrepts (1077 kg/ha) (Fig 6.1). *In-situ* moisture conservation through broad bed furrow (BBF) in soybean (JS 335) gave 9.5% higher seed yield (1359 kg/ha) in Typic Ustochrepts compared to Typic Ustorthens (1241 kg/ha). Similarly, higher seed yield (908 kg/ha) of greengram and rainwater use efficiency (1.37 kg/ha-mm) was recorded under deep to very deep soils (very fine smectitic, calcareous, Typic Haplusterts) followed by yields under medium to deep soils (892.5 kg/ha), medium soils (827.5 kg/ha) and shallow soils (770 kg/ha).

Opening of conservation furrow in soybean

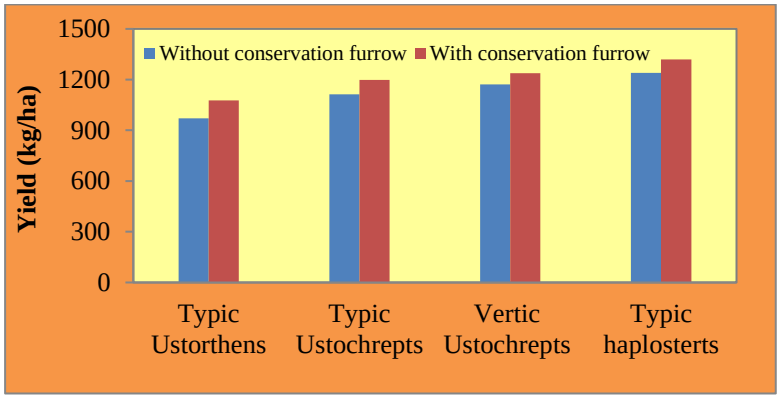


Fig 6.1. Performance of soybean under *in-situ* moisture conservation in various soil types

Similarly, in soybean + pigeonpea intercropping system (4:2), higher soybean equivalent yield (SEY) was recorded under Typic Haplusterts soil (2504 kg/ha) followed by Vertic Ustochrepts (2329 kg/ha) and Typic Ustochrepts (2152 kg/ha) (Fig 6.2).

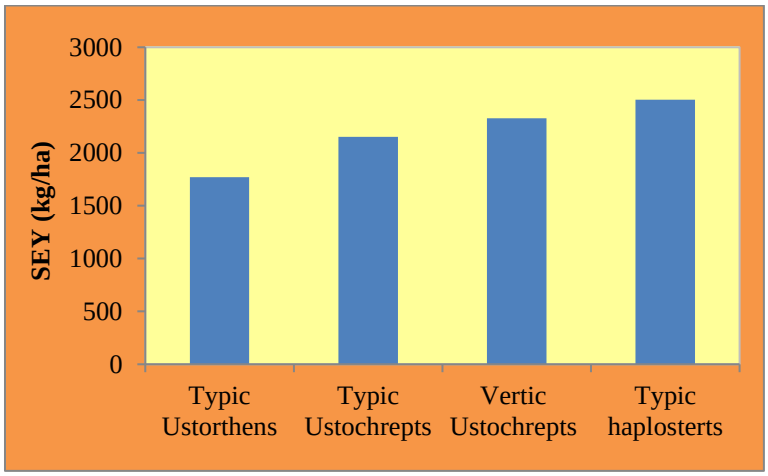


Fig 6.2. Performance of soybean + pigeonpea intercropping system (4:2) in different soil types

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* 2016 at GRF of the institute 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.

In general, the seed yield of all three crops was poor across different treatments due to poor rainfall distribution during crop season with 2 dry spells of 17 and 10 days. The seed yield of sunflower was 12 and 20% higher in the plots under integrated management (1023 kg/ha) than that under inorganic and organic management, respectively. However, both integrated and organic management recorded similar seed yield of greengram (458-480 kg/ha) while the yield was 8% lower (440 kg/ha) under inorganic compared to integrated management. Similarly, pigeonpea seed yield was similar in the plots under organic and inorganic management (379-398 kg/ha) and the plots under organic management produced 16% higher seed yield compared to inorganic management (344 kg/ha) (Fig 6.3). In general, pigeonpea yield was low due to no rainfall after 25 September till crop harvest in December.

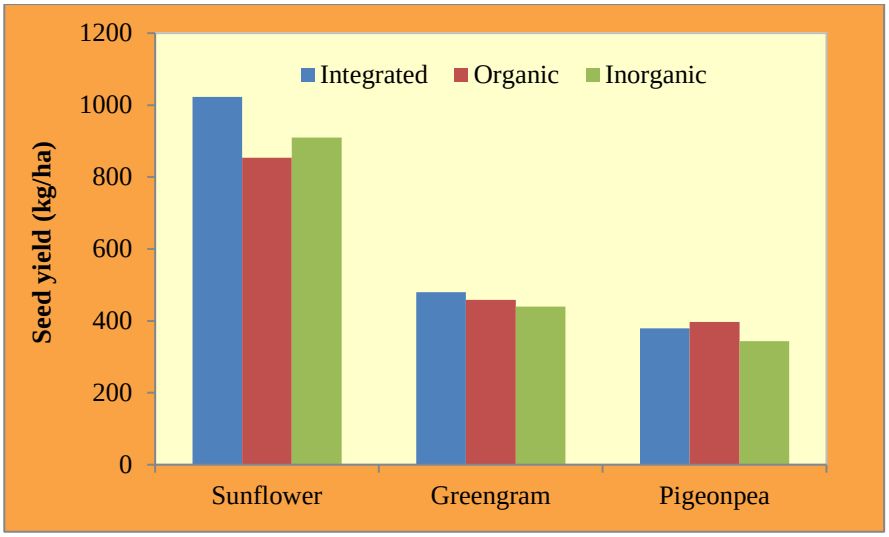


Fig 6.3. Performance of crops under different production systems

Different production systems had no significant on soil pH, available N and Mn. Plots under organic management had lower bulk density (1.23 Mg/m^3) than other treatments. However, plots under organic management recorded significantly higher soil organic C (0.65%), compared to inorganic and integrated production systems. Plots under organic management being on par with integrated production systems also recorded significantly higher available K (259.8 kg/ha), Cu (2.23 ppm), Fe (7.34 ppm), Zn (0.54 ppm), dehydrogenase (3.13 µg TPF/g soil/h) and microbial biomass carbon (236.6 µg/g soil) compared to inorganic production system. However, integrated production system recorded significantly higher available P (27.8 kg/ha) compared to other production systems. The soil moisture content in different plots ranged between 3.7-15.1% during the crop season depending on the amount of rainfall received prior to soil sampling. On average, the soil moisture content was 0.6-1.0% higher in the plots under organic management during the crop season compared to integrated and inorganic treatments. Similarly, the soil temperature was lower under organic management by 0.9^0C compared to other treatments.

7. NICRA - Other Activities

7.1. Village Institutions

7.1.1. Village Climate Risk Management Committee (VCRMC)

VCRMCs have been established in each NICRA village and actively involved in various activities of the project. During 2016-17 in NICRA villages, the VCRMCs participated in 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	Outcome of VCRMC meetings
Nagla Dulhe Khan village, Agra district, Uttar Pradesh (Agra)	18.06.2016	Selection of high yielding and drought tolerant varieties, rainwater harvesting and organic farming.
	16.09.2016	Summer ploughing, compartmental bunding and intercropping systems
Warkhed village, Akola district, Maharashtra (Akola)	20.07.2016	Opening of furrows in soybean and cotton for moisture conservation
	26.10.2016	Foliar spray @ 2% Urea and 2% DAP at the time of flowering and boll development stage in Cotton Crop.
Naiwan & Achalpur villages, Hoshiarpur district, Punjab (Ballowal Saunkhri)	21.06.2016	Revised the rates of custom hiring
	25.10.2016	Supplementary irrigations from harvested rain water
Vannedoddipally village, Ananthapu-ramu district, Andhra Pradesh (Ananthapuramu)	12.06.2016	Collection of soil samples in farmers fields
	01.09.2016	Formation of conservation furrows
	24.09.2016	Spraying of carbendizm and mancozed in groundnut
Chikkamaranahalli village, Bengaluru rural district, Karnataka (Bengaluru)	15.07.2016	Opening of moisture conservation furrow between paired rows of pigeonpea crop
	05.08.2016	Diploma agriculture students interaction with the farmers
	29.08.2016	Weeding and intercultivation in finger millet. Opening of conservation furrow between paired row in pigeonpea
	30.09.2016	Plant protection measures in pigeonpea
	04.10.2016	
Kalimati/Dholia and Chandanki villages, Banaskantha/ Mehasana districts, Gujarat (SK Nagar)	21.06.2016	Planning of interventions for different crops and selection of farmers for various interventions
	02.07.2016	Distribution of inputs
	22.07.2016	
	15.07.2016	Application of fertilizers at the time of sowing
	07.08.2016	Urea applied as per treatments
	18.08.2016	Foliar application of nutrients
	16.09.2016	
Kavalagi village, Vijayapura district, Karnataka (Vijayapura)	14.06.2016	Seed treatment before sowing of pigeonpea and greengram
	21.06.2016	Sowing of greengram, pigeonpea and pearl millet
	05.07. 2016	Thinning in pigeonpea has been taken up.
	12.07.2016	Moisture conservation practices (repeated intercultivation and thinning) has been followed and compartmental bunding was done in fallow land.
	19.07.2016	Plant protection in greengram with Imidachloprid (0.5ml/lit) has sprayed

	26.07.2016	Weed control and intercultivation operations under normal rainfall
	02.08.2016	Hand weeding operation under normal rainfall
	16.08.2016	Repeated intercultivation for moisture conservation with dust mulching.
	04.10.2016	Immamectinbenzoate was sprayed to control the pod borer of pigeonpea and sowing of chickpea, sorghum and safflower.
	18.10.2016	Inter cultivation and foliar spray of KNO_3 @ 0.5% in *rabi* crops during the period of dry spell.
Babhulgaon village, Parbhani district, Maharashtra (Parbhani)	21.06.2016	Timely sowing with drought tolerant improved varieties.
	12.07.2016	Hoeing and weeding operations to prevent soil evaporation during dry spells. Straw mulching and spraying of KNO3, opening of furrow after every 4 rows in soybean and 2 rows in pigeonpea and cotton. (30 days after sowing) was followed using **Ridger**
	15.10.2016	Farmers applied protective irrigation to cotton and pigeon pea crop from harvested rain water from borewells / open wells/ farm ponds.
Tahakapal, Tandpal and Gumiyapal villages, Bastar district, Chattishgarh (Jagdalpur)	07.07.2016	Early heavy down pour situation and remedy measures were discussion
	05.08.2016	Diversion and water management into fields
	26.08.2016	Sowing of mid season upland crops
	27.09.2016	Mid season drought review with farmers
	17.10.2016	Supplemental irrigation to paddy
	25.11.2016	Terminal drought situation
Khaner village, Samba district, Jammu & Kashmir (Rakh Dhiansar)	19.05.2016	Sowing was performed across the slope along with compartmental bunding for moisture conservation.
	21.11.216	Sowing of wheat crop was done on receding moisture due to the prolonged dry spell in the wake of non-receipt of winter rains.
Nignoti and Bishkhedi villages, Indore district, Madhya Pradesh (Indore)	30.04.2016	De silting and deepening of irrigation tank ; Common drain
	04.06.2016	Soil sampling in farmers fields for issue of soil health cards. New varieties of soybean and pigeon pea and modification in seed drill with BBF sowing.
	20.07.2016	Plantation of guava as field crop in agri-horti system and procurement of THAI guava variety.
	01.09.2016	New variety of chick pea and wheat
	09.03.2017	Green gram sowing as summer crop
	15.03.2017	Vermi compost pits
Budhadani village, Kandhamal district, Odisha (Phulbani)	03.06.2016	Planning for kharif crop sowings in NICRA Villages
	20.06.2016	Beneficiary selection and interventions of NICRA activities
	15.07.2016	Regarding custom hiring center maintenance
	10.08.2016	Regarding pest and disease surveillance
Peta meghapar village, Jamnagar district, Gujarat (Targhadia)	27.05.2016	Awareness of control measures for pink boll in cotton
	10.06.2016	Contingency crop planning for kharif 2016
	18.10.2016	Contingency crop planning for rabi crop

7.1.2 Custom Hiring Center (CHC)

Custom Hiring Centre (CHC) was established in each NICRA village and need based implements were made available for farmers for hiring as per the rates approved by custom hiring management committee (CHMC). The money incurred from CHC maintained and used for repair of the implements. Implements availability for various agricultural operations on custom hiring during 2016-17 in adopted NICRA villages, are given below:

Improved implements used for various agricultural operations on custom hiring

NICRA village	Implement used	Farm operation	Usage/ unit (days)	Area covered (ha)	Labour saving (hr /ha)	Cost saving (Rs/ ha)
Nagla Dulhe Khan village, Agra district, Uttar Pradesh (Agra)	Seed cum ferti drill	Sowing and fertilizer application	18.0	-	-	400
	Rotavator	Seedbed preparation and weed removal	14.0	-	600	8400
	Ridger Seeder	Opening of furrow for *in-situ* moisture conservation	22	-	-	-
Warkhed village, Akola district, Maharashtra (Akola)	Multipurpose Thresher	Threshing	-	27.20	11	1170
	Rotavator	Land preparation	-	3.6	5	900
Vannedoddipally village, Ananthapu-ramu district, Andhra Pradesh (Ananthapuramu)	Duck foot 5 row cultivator	Preparatory cultivation	-	3.0	2	-
Kochariya and Mandpiya villages in Bhilwara district and Lapsiya and Tara ka kheda villages in Rajsamanad district, Rajasthan (Arjia)	Reversible Disc plough	Primary tillage	-	2.0	-	-
	M B Plough	Primary tillage	-	4	-	-
	Intercropping seed drill	Sowing	-	8	-	-
	Two row seed drill	Sowing	-	2	-	-
	Arjia wheel hoe	Interculture	-	38	-	-
	Single row power weeder	Interculture	-	10	-	-
	Single row power weeder	Interculture	-	8	-	-
	Battery operated power sprayer	Spraying	-	15	-	-
Naiwan & Achalpur villages, Hoshiarpur district, Punjab (Ballowal Saunkhri)	Rotavator	Field preparation	-	5	-	-
	Bund Maker	Field preparation	-	0.72	-	-
	Diesel Pump	Supplementary irrigation	-	10	-	-
	Maize planter	Sowing of maize	-	3.55	-	-
	Ridger	Field preparation	-	0.55	-	-
	Wheat seed drill	Sowing of wheat crops	-	3.55	-	-

Chikkamaranahalli village, Bengaluru Rural district, Karnataka (Bengaluru)	Improved sickles	Harvesting	12.0	12.5	40.0	1320
	Hand weeders	Weeding and earthing up	3.0	19.2	260.0	290
	Knapsack sprayer	Plant protection	7.0	7.4	-	-
	Bullock drawn modified seed drill	Sowing fingermillet	7.0	23.3	20.0	160
	Tractor drawn post hole digger	Digging holes	1.0	0.5	-	1800
	Tractor drawn spike tooth harrow	Secondary tillage	7.0	28.3	18.0	400
Thoppureddipatti village, Thoothukudi district, Tamil Nadu (Kovilpatti)	Rotavator	*In-situ* soil mulching	3.0	3.0	4.0	2400
Nignoti and Bishkhedi villages, Indore district, Madhya Pradesh (Indore)	Reversible Mould board plough	Summer tillage	12	-		1500
	Sprayers	Plant protection	10	-	-	-
	Spiral seed grader	Seed grading	12	-		-
	BBFAttachments	Sowing	07	-	-	-
Tahakapal, Tandapal and Gumiyapal villages, Bastar district, Chattishgarh (Jagdalpur)	Cultivator	Ploughing	05	4	300.00	5000
	Seed cum fertilizer	Sowing	03	1	250.00	1350
	Rotavator	Fining soil	04	2	300.00	1800
	Tractor Trolley	Transport	03	3	200.00	900
Kadesara Kalan village, Lalitpur district, Uttar Pradesh (Jhansi)	Seed drill	Sowing	2.4	-	-	300
	Sprayer	Spraying	6	-	-	150
	Leveler	Field Leveling	0.4	-	-	30
	Rotavator	Field preparation	2.0	-	-	400
Kalimati/Dholia, Chandanki villages, Banaskantha/Mehasana districts, Gujarat (SK Nagar)	Disc harrow	Ploughing	20	12.0	--	-
	Rotavator	Seed bed preparation	45	30.0	2.5	600
	Roto till drill	Sowing	13	9.0	3.5	1500
	Multi crop seed cum fertilizer drill	Sowing	25	26.0	5.0	1200
	Power weeder	Weeding / interculture	36	17.0	6.0	1200
	Improved sickle	Harvesting	70	24.0	3.0	250

	Castor decorticator	Seed decorating	27	18.0	5.0	750
	Maize sheller	Threshing	12	4.0	4.0	400
	Winnowing fan	Seed cleaning	33	19.0	5.0	800
Kavalagi village, Vijayapura district, Karnataka (Vijayapura)	Power sprayer	Plant protection	6.0	8.0	2.0	100
	Cycle operated fertilizer drill	Fertilizer application	2.0	1.0	2.0	400
	Cycle weeder	Weeding	1.0	1.0	-	650
	Tractor drawn Seed cum fertilizer drill	Sowing and fertilizer application	9.0	16.0	8.0	800
	Phule sheti yantra	Seedling and fertilizer application	30.0	19.0	-	2000
	Cycle hoe	Hoeing	14.0	8.0	0.1	700
Babhulgaon village, Parbhani district, Maharashtra (Parbhani)	Seed cum ferti drill	Sowing and fertilizer application	-	4.0	-	400
	Stubble collector	Collection of stubbles	-	8.0	-	600
	Ridger	Opening of conservation furrow	-	8.0	-	-
Khaner village, Samba district, Jammu & Kashmir (Rakh Dhiansar)	Maize planter	Sowing	11.0	0.8	-	1110
	Maize sheller	Shelling of maize cobs	27.0	-	-	3060
Budhadani village, Kandhamal district, Odisha (Phulbani)	Power tiller	Land preparation	10.0	2.5	-	-
	Reaper	Harvesting	12.0	2	-	-
	Winnower	Threshing	12.0	2	-	-
	Water Pump	Irrigation	6.0	1	-	-
	Sprayer	Plant protection	5.0	1.5	-	-
Narotewadi village, Solapur district, Maharastra (Solapur)	Phule sheti yantr	Seedling and fertilizing application	1.0	19.0	2000	1425
	Cycle hoe	Hoeing purpose	0.5	8.0	700	1200
Peta meghapar village, Jamnagar district, Gujarat (Targhadia)	Cultivator	Primary tillage	-	19	1.5	187
	Reversible plough	Deep ploughing	-	16	1.0	555
	Mobile Slicer	Incorporation of cotton stalks	-	24	2.5	834
	Rotavator	Ploughing	-	16	2.5	518

7.1.3 Village Seed Bank

Efforts were made to provide the sources of alternative crop seed and varieties to address the problem of seed unavailability. The farmers of Budhadani village, Kandhamal district, maintained seed of Vandana, Sahabhagi and ODR 1-2 of rice. In Pata meghapar, Jamnagar district farmers produced seed of recent varieties of groundnut, sesame; wheat and gram were stored for sowing in next season. In Naiwan and Achalpur villages in Hoshiarpur district the farmers are maintaining the seed material of recently developed wheat varieties and sesame are maintaining for their own use also exchanging the seed.

Seed availability in NICRA villages

NICRA village	Crop	Variety/hybrid	Quantity (kg)
Nignoti village (Indore)	Soybean	RVS 2001-4	4000
	Wheat	HD 2987	10000
		MPO 1215	8000
Tahakapal village (Jagdalpur)	Paddy	-	200
	Blackgram	-	50
	Pigeonpea	-	23
	Sorghum	-	42
	Finger millet	-	123
	Kodo millet	-	140
	Horsegram	-	30
	Little millet	-	45
	Niger	-	10
Kalimati and Chandanki villages (SK Nagar)	Pearlmillet	GHB 558	90
	Maize	GM 2	350
	Greengram	GM 4	320
	Blackgram	GU 1	200
	Clusterbean	GG 2	150
	Sorghum (Fodder)	CSV 21	2800
Chikkamaranahalli village (Bengaluru)	Fingermillet	MR-1	320
		GPU-28	20
		GPU-48	30
	Pigeonpea	BRG-1	200
		BRG-2	255
	Field bean	HA-4	55
	Cowpea	IT-38956-1	55
Babhulgaon village (Parbhani)	Soybean	MAUS 71 & MAUS 81	3200
	Pigeonpea	BDN 711	900
		Total (kgs)	31608
Kadesara Kalan village (Jhansi)	BN Hybrid, TSH and Guinea grass	Hybrid-live rooted slips	5.5 lakh No's
Hardoiya (Faizabad)	Pigeonpea	NDA-1	60
	Pigeonpea	NDA-2	60
	Maize	Naveen	50
	Chickpea	PUSA-362	150
	Chickpea	Udai	200
	Lentil	HUL-57	50
	Mustard	NDA1	25
	Mustard	Varuna	25
	Linseed	Garima	20

7.1.4 Fodder Bank

To strengthen the availability of the green fodder in the NICRA villages (Naiwan and Achalpur), seed of improved variety of pearl millet (FBC 16) was provided as well as Napier Hybrids cutting on the field bunds of the farmers were planted at Ballowal Saunkhri. At Bengaluru 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. Subsequently, fodder maize (South African Tall) was grown in an area of 34.0 ha in 120 farmers' field for realizing better fodder supply to milch animals in the cluster. The live fodder bank at Jhansi centre is having more than 3500q fresh fodder available for feeding and marketing.

In NICRA village at Parbhani centre, 30 farmers raised *kharif* sorghum for fodder and grain purpose and 15 farmers raised perennial grasses for fodder purpose, 15 farmers grown *rabi* sorghum and 10 farmers grown Bajra for dual purpose. At Targhadia centre fodder sorghum was grown by farmers for their animals and harvest at maturity and dry fodder stored and used for cattle. Haulm of ground nut and straw of wheat was also stored for own cattle's during drought condition. Farmers (75) in NICRA village, Parbhani produced more than 2750 q fresh fodder by growing *kharif* and *rabi* sorghum and bajra for grain as well as fodder whereas perennial grasses for fodder purpose during current year. At Jagdalpur centre in NICRA village, farmers produced 78 kgs of fodder seed of Stylosanthes, Napier bazra hybrid, Fodder sorghum and Beseem.

7.2 Training / Field days etc., organized

7.2.1 Trainings

AICRPDA centre	Training programme	Beneficiaries (No.)	Date
SK Nagar	Sowing methods of different crops	240	21.06.2016
	Foliar and soil application of fertilizers	305	15.08.2016
Bengaluru	*Kharif* planning on different themes for NICRA at Chikkaputtayyanapalya, Nelamangala (Taluk)	61	20.05.2016
Parbhani	*Kharif* crop management	69	22.06.2016
	Crop management	64	26.07.2016
	Rabi crop management	45	05.10.2016
	Bore well recharge technology	70	01.06.2016
	Stress management practices in different crops	55	28.08.2016
	Cotton crop management	62	28.09.2016
	Rabi crop management	95	24.10.2016
Solapur	Soil and water testing training Programme	73	17-21.03.2016
	Jaljagruti Saptah/ Jalsakshrta Abhiyan	53	19.03.2016
	Kharif pre-seasonal training programme	55	01.07.2016
	Rabi pre-seasonal training and seed distribution	50	09.10.2016
Vijayapura	Soil moisture conservation and contingency crop planning at Kavalagi village	120	22.11.2016
Hisar	Timely sowing and weed management in *kharif* crops	21	22.07.2016
	Insect pest and disease management in clusterbean and mungbean	16	03.08.2016

	Weeding and pest management in pearlmillet clusterbean and mungbean	20	12.08.2016
	BLB control in clusterbean	17	19.08.2016
	Yellow mosaic virus control in mungbean	16	01.09.2016
	Field preparation for *rabi* crop sowing	20	21.09.2016
	Seed treatments in *rabi* crops	16	04.10.2016
Rakh Dhiansar	Pre-seasonal training programme for *kharif* crops	30	19.05.2016
	Pre-seasonal Training programme for *rabi* crops	30	21.11.2016
Ananthapuramu	Improved dryland technologies	23	12.07.2016
	Demonstration on Ananta bullock drawn seed drill	30	17.07.2016
	Mechanization in groundnut	23	22.07.2016
	Demonstration of chisel plough in Pigeonpea	24	24.07.2016
	Crops and cropping systems in rainfed agriculture	23	13.08.2016
	Contingent crops in rainfed agriculture	23	22.08.2016
	Pre-sowing training programme conducted at Agricultural Research Station, Ananthapuramu	50	26.08.2016
	Training programme on late leaf spot in groundnut	20	24.09.2016
	Symptoms and management practices in castor botrytis	32	13.10.2016
	Soil Test based fertilizer application for Rabi crops	21	27.11.2016
Indore	Management of kharif crops	20	20.07.2016
	Post harvest operations in kharif crops	25	27.10.2016
	Nutrient management in crops	18	04.11.2016
	Irrigation scheduling	22	02.12.2016
	Soil health and residues management	40	24.03.2017
Targhadia	Crop Contingency Planning for *Kharif* season	53	01.06.2016
	Pest management of pink boll worm in cotton crop	20	20.07.2016
	Supplementary fertilizers in *Kharif* crops	35	09.08.2016
	Supplementary fertilizer and pest management in Kharif crops	40	09.09.2016
	Selling price of agricultural produce	38	20.01.2017
	Total No. of beneficiaries	**2183**	

7.2.2 Field days

AICRPDA centre	Intervention	NICRA village	Date	Beneficiaries (No's)
Agra	Rainwater management	Nagla Dule Khan	29.12.2016	40
Akola	Technology demonstration to farmers	Warkhed	24.07.2016	27
	Field visit and Scientists- farmers interaction meeting	Warkhed	20.01.2017	109
Targhadia	Animal health camp	Patameghapar	27.01.2017	44
Arjia	Development of community pasture land	Bagatpura	26.09.2016	480
	Maize+ blackgram (2:2) intercropping system	Kocharia	28.09.2016	95
Ballowal Saunkhri	Seminar on organic farming	Ballowal Saunkhri	27.07.2016	65
	Training of farm women for making cleaning agents	Achalpur	17.08.2016	25
	Camp on silage making	Achalpur	23.08.2016	45
	Kisan Mela	Ballowal Saunkhri	09.09.2016	4000
	Promotion of kitchen gardening	Achalpur	26.09.2016	65
	Improved production technologies of rabi crops	Achalpur	27.10.2016	48
	Demonstration on Ash gourd processing to farm women	Ballowal Saunkhri	27.12.2016	30
Bengaluru	Performance of Chickpea variety (JG-11)	Kavalagi	02.01.2017	120
Hisar	Sowing and Weed management *kharif* crops	Balawas	22.07.2017	21
	Field preparation for *rabi* crop sowing		21.09.2017	20
	Seed treatments in *rabi* crops		04.10.2016	16
Indore	Kharif crops performance in adopting full package of cultivation	Nignoti	26.08.2016	25
	Field preparations for rabi crops.	Nignoti and Bishkhedi	04.11.2016	15
	Summer ploughing and residues management	Bishkhedi	24.03.2017	30
Jagdalpur	Krishi Panchayath	Jhartarai & Bastar	13.01.2016	65
Jhansi	Farmers Scientist Interface meeting on Climate Resilience Fodder Production	Kadesara Kalan	04.02.2016	68
	Farmer scientist Interface meeting		30.08.2016	90
	Low tunnel making and all information provide growing vegetables nursery		19.11.2016	26
Parbhani	Cotton crop Management	Babhulgaon	28.09.2016	62
	Rabi crop management		4.10.2016	95
Solapur	Krishi Darshani	Narotewadi	24.08.2016	30
	Total No. of beneficiaries			5756

7.3. Agro-advisories

Centre	Agro-advisories	
	Mode	Frequency
Agra	SMS in collaboration with IAAS	Twice in a week
Bengaluru	In collaboration with AICRPAM and IMD. Messages were written on display board in NICRA villages	Twice a week (Tuesday and Friday)
Vijayapura	Agro advisory about weather, improved package of practices of crops	Once in a week (Tuesday)
Kovilpatti	SMS, All India Radio and The bulletins were displayed in the village notice board.	Weekly

7.4 Soil health cards

Distribution of soil health cards in NICRA villages across the centres

Centre	NICRA village	Soil health cards issued (No. of farmers)
SK Nagar	Kalimati and Dholiya	32
Hisar	Balawas and Budhshelly	71
Kovilpatti	Muthukrishnapuram and Thoppurediapatti	23
Phulbani	Budhadani	38
Indore	Bishkhedi	183
Faizabad	Hardoiya	15

7.5 Publications

a) Research Papers

- Sharma **RK**, Sharma S**K** and Balyan **JK.**2017. Productivity and profitability of mustard under different organic nutrient management practices in Semi-arid region. *Journal of Oilseeds Brassicca*, 8 (1):89-94
- Sharma **R**K, Sharma SK and **Dangi** NL. 2016**.** Influence of different Organic Nutrient Sources on Productivity and Profitability of Groundnut in Southern Rajasthan. *Indian Journal of Agricultural Research* 50 (6):623-626
- Ramachandrappa BK, Thimmegowda MN, Sathish A, Jagadeesh BN, Devaraja K, Srikanth Babu PN, and Savitha MS 2016. Real time contingency measures to cope with rainfall variability in Southern Karnataka. *Indian J. Dryland Agric. Res. & Dev.*, **31** (1): 37- 43.

b) Popular articles

- Thangapandian RN, Anandaraj S, Elamathi S. 2016. Agricultural technological adaption in black soils. *Uzhavarin Valarum Velanmai* 7(11) : 13 - 17.

- Jawahar DR, Thangapandian, Elamathi S, Anandaraj N, JosephM., Malini N, Anandhi P, Sanjivkumar V and Gopalakrishnamoorthi S. 2016. K 12 - A high yielding dual purpose sorghum variety suitable for rainfed vertisol tracts of southern zone of Tamil Nadu

c) Research/ Extension bulletins

- Surakod VS , Devaranavadgi SB, Shirahatti MS, Ravindra Chary G, Hundekar ST, Vijayakumar AG and Maktumsab MT 2016. Resilient intercropping system for Northern Dry zone of Karnataka. AICRPDA, RARS Vijayapura.
- Shirahatti MS, Surakod VS, DevaranavadgiSB, Ravindra Chary G, Hundeka,ST And Maktumsab MT. 2016. Compartmental bunding; A drought coping practice AICRPDA, RARS Vijayapura.
- Surakod VS, Shirahatti MS, Maktumsab MT and Devaranavadgi S B. 2016. Dimension of Farm pond and its water use. AICRPDA, RARS Vijayapura.
- Agrawal R K, Singh JB, Das MM, Sunil Kumar, Satyapriya, Ghosh PK, Satendra Kumar and Ravi Pratap Singh. 2017. Mobilizing National Resources for Bringing Prosperity through Climate Resilience in Agriculture of Bundelkhand Region. pp.18. IGFRI, Jhansi.

- Umamageswari C, Joseph M, Jawahar D. 2016. Weed management in dryland crops.

d) Books

- Ramachandrappa BK, Krishnamurthy R, Thimmegowda MN, Savitha MS, Srikanth Babu PN, Manjunatha, BN, Bhavitha NC, Ravindra Chary G, Gopinath KA and Srinivasarao Ch. 2017. Long term integrated nutrient management- Soil and crop. All India Co-ordinated Research Project for Dryland Agriculture, Directorate of Research, University of Agricultural Sciences, Bangalore, Karnataka, p. 117.
- Jawahar D, Rajeswari M, Elamathi S, Sanjivkumar V, Joseph RM,. Thangapandian N,. Anandaraj, J. Sundersingh Rajapandian, A. Solaimalai G. Ravindra Chary and Ch. Srinivasa Rao (2016). Four Decades of Dryland Agricultural Research in Southern Zone of Tamil Nadu - 1971 to 2011. Agricultural Research Station, Kovilpatti, Tamil Nadu. 243 p.
- Jawahar D, Rajeswari M, Elamathi S, Sanjivkumar V, Umamageswari C, Maruthi Sankar GR , Ravindra Chary G and Srinivasa Rao Ch. 2016. Contingency crop planning for southern agroclimatic zone of Tamil Nau. Agricultural Research Station, Kovilpatti, Tamil Nadu. 46 p.

e) Book chapters

- ElamathiS and Jawahar D. 2016. Fertilizer and Moisture conservation practices in High density planting system in Cotton under dryland conditions. In **:** Possible by Tamil. Agriculture-Veterinary- Fisheries- Crop Management. Agricultural Scientific Tamil Society. New Delhi.166-172
- Elamathi S, Jawahar D, RangarajT, Rajeswari M and Sanjivkumar V. 2016. Improved Agronomic practices for rainfed crops in southern zone of Tamilnadu In: Improved Agronomic practices for rainfed crops in India edited by Ravindrachary *et al.* **2016**. AICRPDA. CRIDA. Hyderabad .P 240-247.

7.6 Linkages developed

The AICRPDA, centres are developed linkages with ICAR institutes, Central government schemes/ State Government programmes for implementation of NICRA programmes, state line department, KVKs, ATMA, KSDA, NGOs, State and capacity building of various stake holders.

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