

National Innovations in Climate Resilient Agriculture
Managing Weather Aberrations
through Real Time contingency Planning

Annual Report
2016-17

AICRPDA - NICRA



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, IGFR 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 and cropping systems for higher yield and income, contingency crop planning, integrated nutrient management, bullock/tractor drawn farm implements for efficient tillage/seeding/fertilizer application/ intercropping and other operations with cost effectiveness and timeliness, alternate land use systems for diversification, higher income and resource use efficiency.

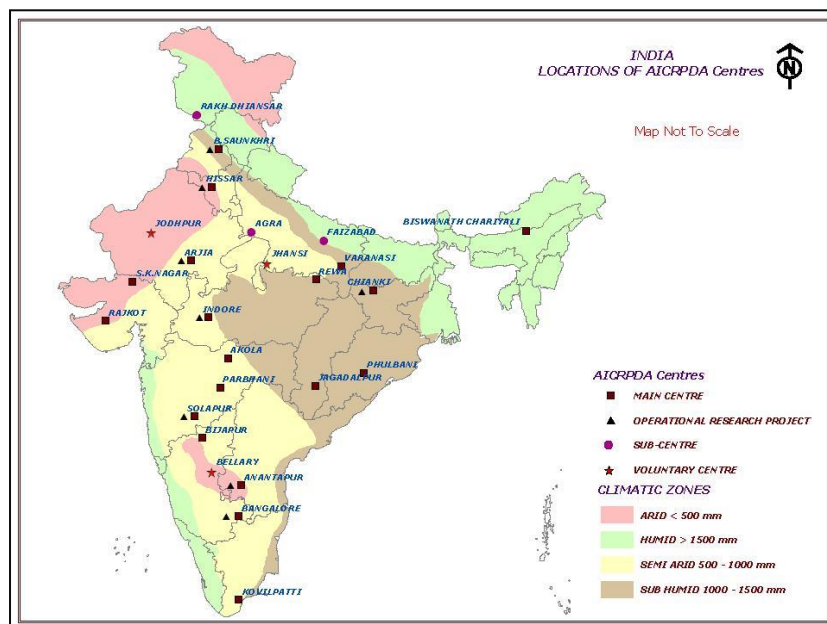


Fig 1: Location Map of AICRPDA Network Centres

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 (Ravalaseema) 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 | <i>Rabi</i> 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 | <i>Kharif</i> |
| 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 | <i>Rabi</i> 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 | <i>Rabi</i> 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 | <i>Rabi</i> |

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**.

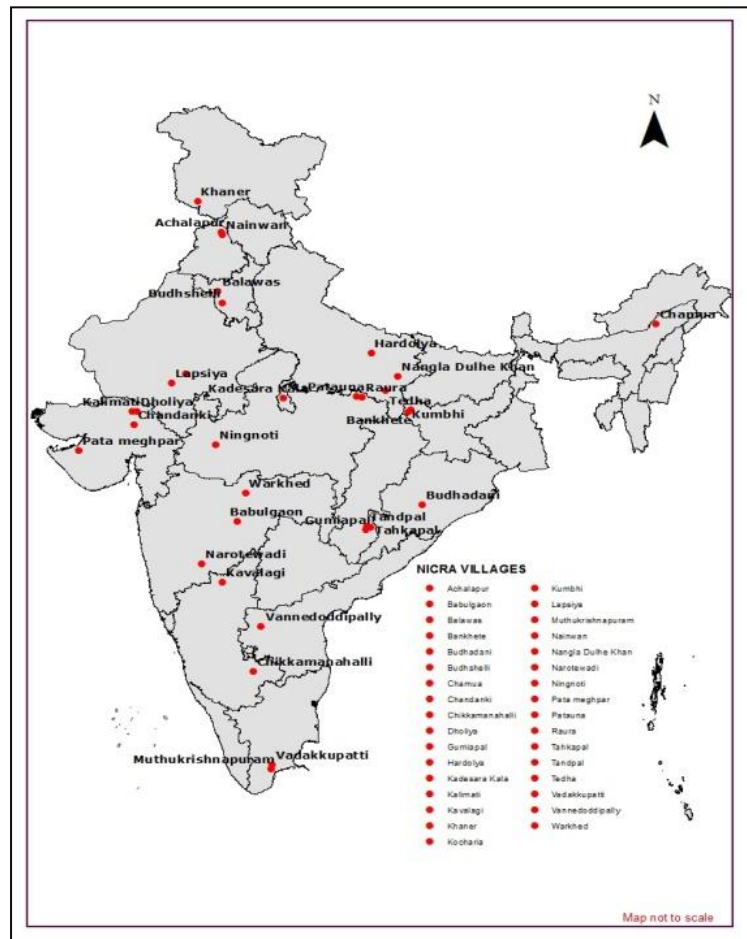


Fig 2: Location map of AICRPDA-NICRA adopted villages

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 RTCs, 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 |
| Jagdapur | 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 pearl millet, cluster bean, sesame under normal and 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 *khariif* 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, intercultural 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% KNO₃ 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/fruitletting 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% KNO₃ 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 | 2 nd July | 6 th July | 4 |
| Warkhed (Akola) | Western Vidarbha Zone in Maharashtra | 10 th June | 7 th June | - |
| Vannedoddipally (Ananthapuramu) | Scarce rainfall zone (Rayalaseema) in Andhra Pradesh | 7 th June | 6 th June | - |
| Kochariya (Bhilwara) | Southern zone in Rajasthan | 1 st July | 28 th June | - |
| Lapsiya (Rajsamand) | Southern zone in Rajasthan | 2 nd July | 29 th June | - |
| Achalpur & Nainwan. (Hoshiarpur) | Kandi region in Punjab | 1 st July | 27 th June | - |
| Chikkamaranahalli (Bangalorerural) | Central, eastern and southern dry zone in Karnataka | 2 nd June | 1 st June | - |
| Kavalagi (Vijayapur) | Northern dry zone in Karnataka | 7 th June | 19 th June | 12 |
| Chamua (Lakhimpur) | North Bank plain zone in Assam | 1 st July | 1 st July | - |
| Kumbhi & Bankheta (Garhwa) | Western plateau zone of Jharkhand | 10 th June | 22 nd June | 12 |
| Hardoiya (Faizabad) | Eastern plain zone in Uttar Pradesh | 21 st June | 8 th June | - |
| Balawas & Budhshelly (Bhiwani) | South-western dry zone in Haryana | 1 st July | 3 rd July | 2 |
| Nignoti (Indore) | Malwa plateau in Madhya Pradesh | 12 th June | 11 th June | - |
| Tahkapal (Bastar) | Basthar Plateau zone in Chattisgarh | 15 th June | 8 th June | - |
| Kadesara Kala(Lalitpur) | Bundhelkhand zone in Uttar Pradesh | 25 th June | 25 th 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 | 20 th June | 18 th June | - |
| Budhani (Kandhamal) | Eastern Ghat Zone in Orissa | 10 th June | 24 th June | 14 |
| Patameghpar (Jamnagar) | North Saurashtra zones in Gujarat | 16 th June | 12 th June | - |
| Khaner (Samba) | Low altitude subtropical zone in Jammu and Kashmir | 27 th June | 6 th July | 9 |
| Patuana & Raura (Rewa) | Keymore plateau and Satpura Hill zone in Madhya Pradesh | 23 rd June | - | - |
| Kalimati (Banaskantha) | Northern Gujarat in Gujarat | 25 th June | 12 th July | 17 |
| Narotewadi (Solapur) | Scarcity zone in Maharashtra | 7 th June | 10 th June | 3 |
| Tedha Pahadi (Mirzapur) | Eastern Plain and Vindhyan Zone in Uttar Pradesh | 22 nd June | 21 st June | - |

In general, the total rainfall during *khariif* 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), Bhabulgaon (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), Bhabulgaon (Parbhani), Patameghpar (Jamnagar) and Kalamati (Banaskantha). During the period (2016), no rainfall was received in 3 NICRA villages, in *khariif* 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, Garwaha, 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**).

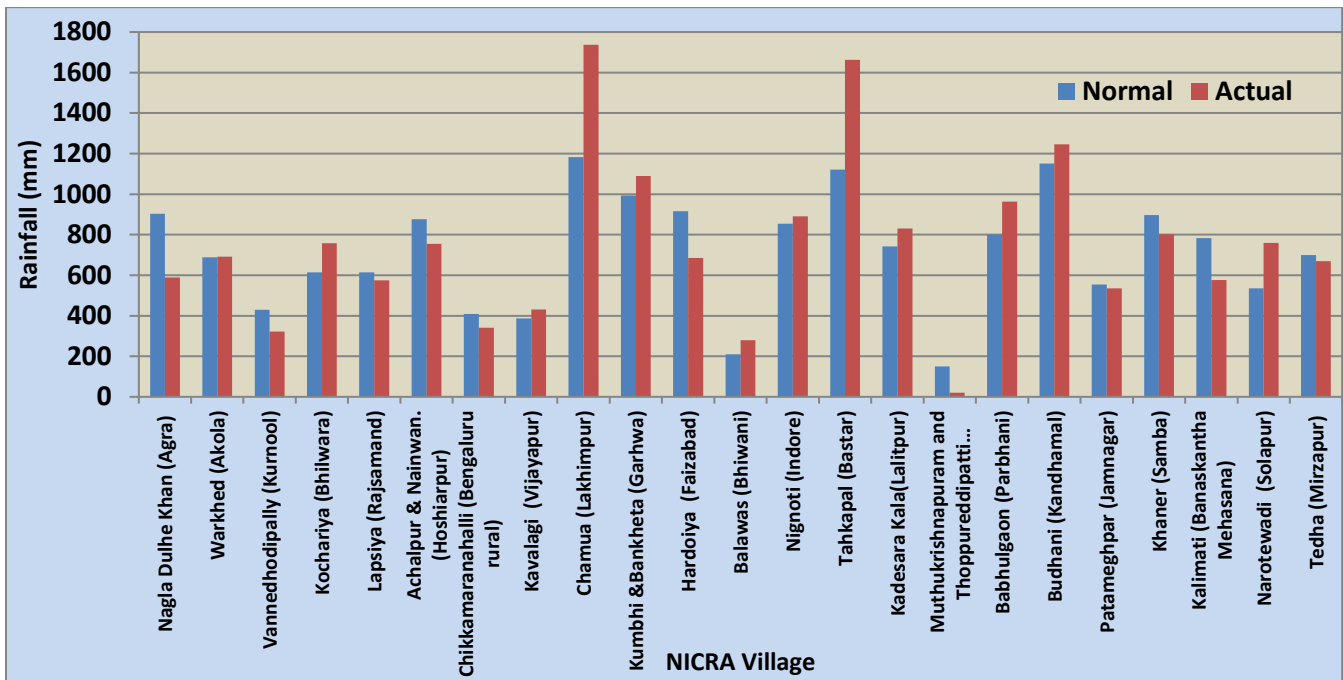


Fig 3: Normal and actual (2016) rainfall in AICRPDA-NICRA villages (June – September)

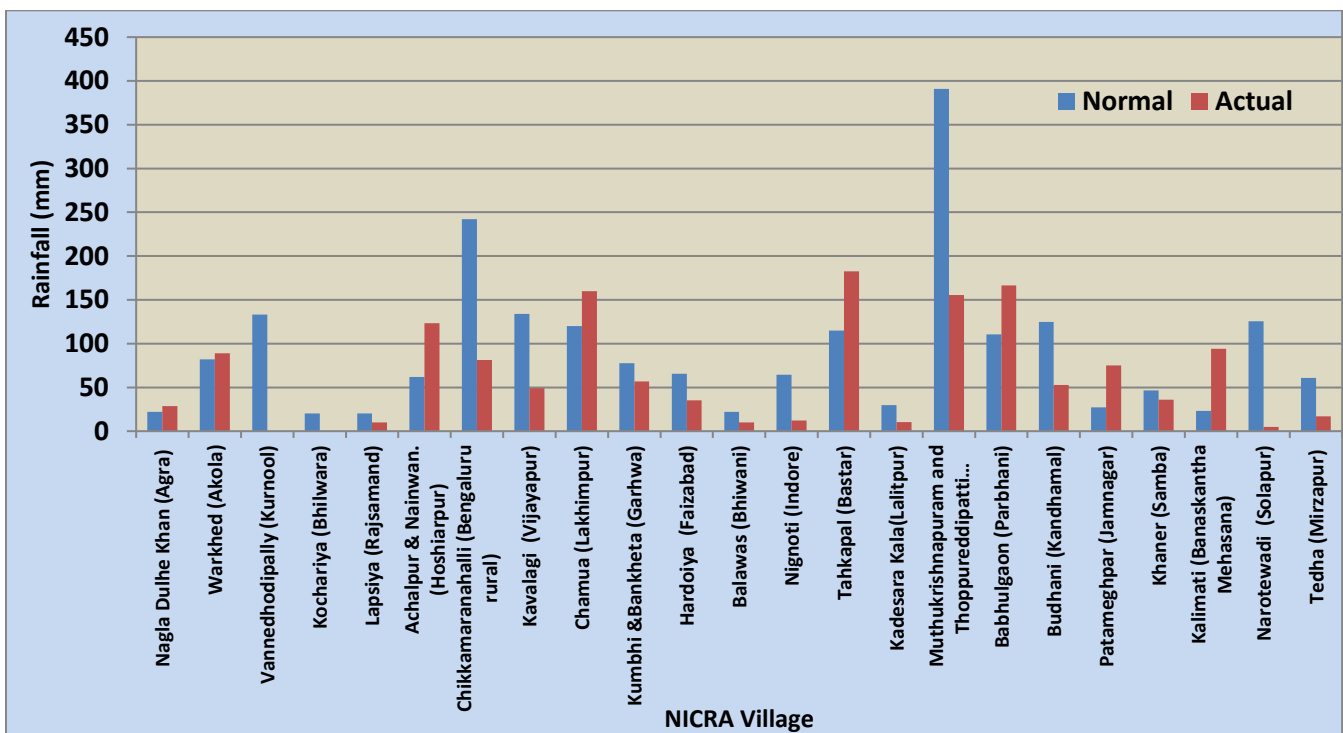


Fig 4: Normal and actual (2016) rainfall in AICRPDA-NICRA villages (October – December)

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 <i>kharif</i> and <i>rabi</i> | : 614.5 and 20.2 mm, respectively |
| Crop seasonal rainfall during 2016-17 (<i>kharif</i> and <i>rabi</i>) | : 964.1 and 13 mm, respectively |

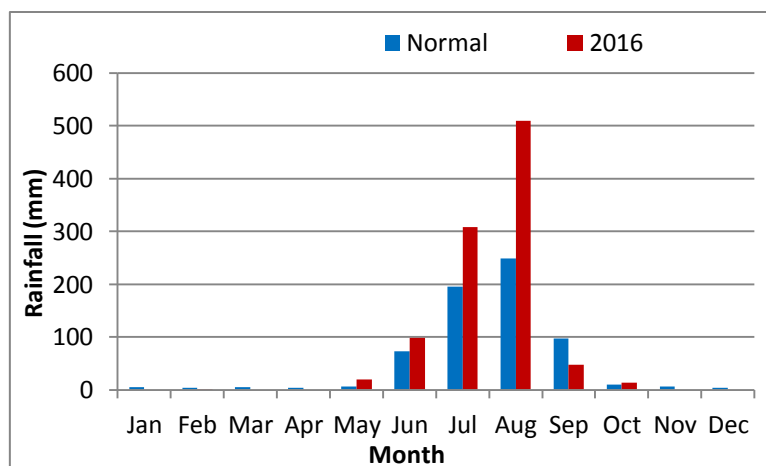


Fig. 1.1.1: Normal and actual (2016) monthly rainfall at Arjia

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 $\text{KNO}_3 + \text{ZnSO}_4$ 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 1 st 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 |
| Greengram | 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°C 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 (<i>kharif</i> and <i>rabi</i>) | : 614.5 mm and 20.2 mm during <i>kharif</i> and <i>rabi</i> , respectively |
| Crop seasonal rainfall during 2016-17 | : 584.0mm (Lapsiya) & 758.0 mm (Kochariya) during <i>kharif</i> |

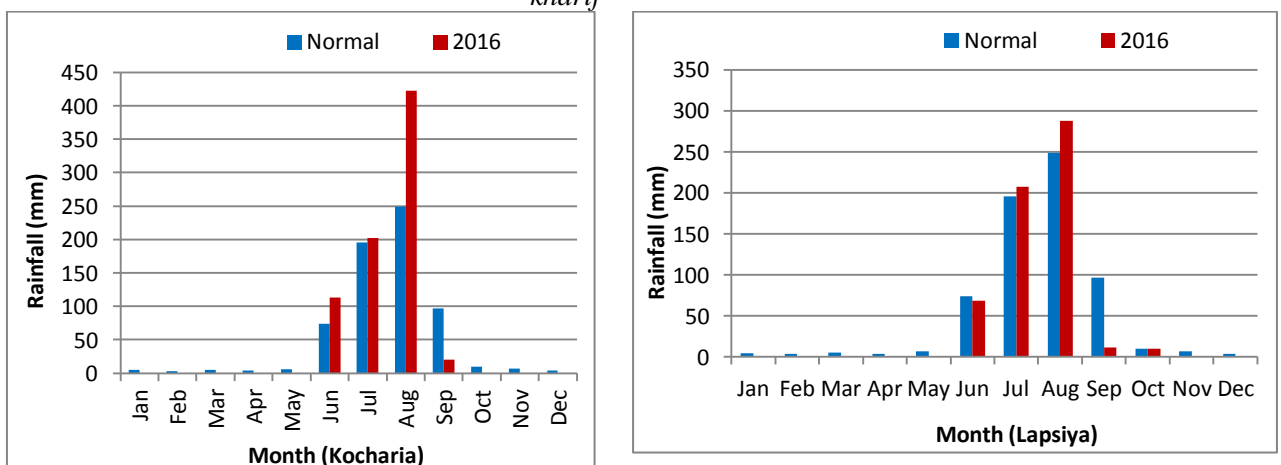


Fig. 1.1.2: Normal and actual (2016) monthly rainfall at Kocharia & Lapsiya

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% KNO₃ 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 KNO₃ 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 <i>in-situ</i> practices | 2708 | 2600 | 4013 | 22.79 | 4.20 | 30086 | 2.69 |
| | Without <i>in-situ</i> practices | 2205 | 2126 | 3250 | - | 3.42 | 21945 | 2.29 |
| Lapsiya | | | | | | | | |

| | | | | | | | | |
|---------|----------------------------------|------|------|------|-------|------|-------|------|
| | With <i>in-situ</i> practices | 2595 | 1766 | 3563 | 26.12 | 5.03 | 27736 | 2.58 |
| | Without <i>in-situ</i> practices | 2058 | 1451 | 2948 | - | 3.99 | 19474 | 2.17 |
| Sorghum | Kochariya | | | | | | | |
| | With <i>in-situ</i> practices | 2747 | 2747 | 5183 | 25.99 | 4.26 | 29718 | 2.83 |
| | Without <i>in-situ</i> practices | 2180 | 2180 | 3740 | - | 3.38 | 20360 | 2.34 |
| | Lapsiya | | | | | | | |
| | With <i>in-situ</i> practices | 2817 | 2817 | 5267 | 27.84 | 5.46 | 30567 | 2.86 |
| | Without <i>in-situ</i> 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 ZnSO₄/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 setigerus* – 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 (<i>Cenchrus setigerus</i>) | 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 <i>kharif</i> and <i>rabi</i> | : 352 & 144 mm, respectively |
| Crop seasonal rainfall during 2015-16 (<i>kharif</i> and <i>rabi</i>) | : 405.7 & 10.0, respectively |

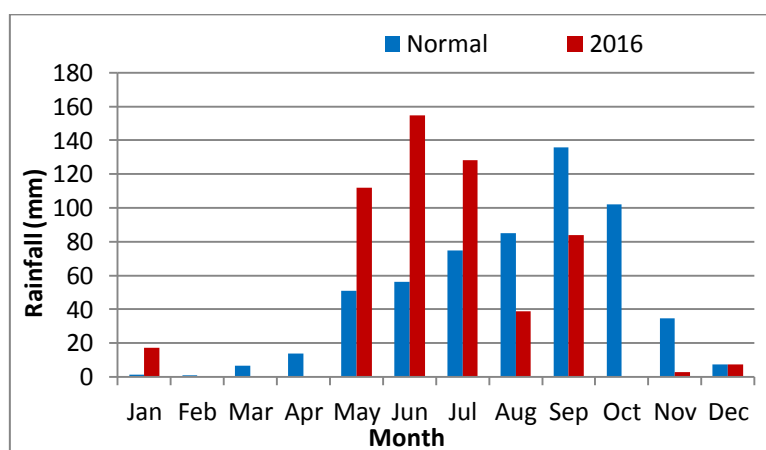


Fig. 1.2.1: Normal and actual (2016) monthly rainfall at Anantapuramu

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, pearl millet, castor, 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 4th 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 <i>kharif</i> and <i>rabi</i> | : 430 and 133 mm, respectively |
| Crop seasonal rainfall during 2016 during <i>kharif</i> and <i>rabi</i> | : 332.1 mm and 0 mm, respectively |

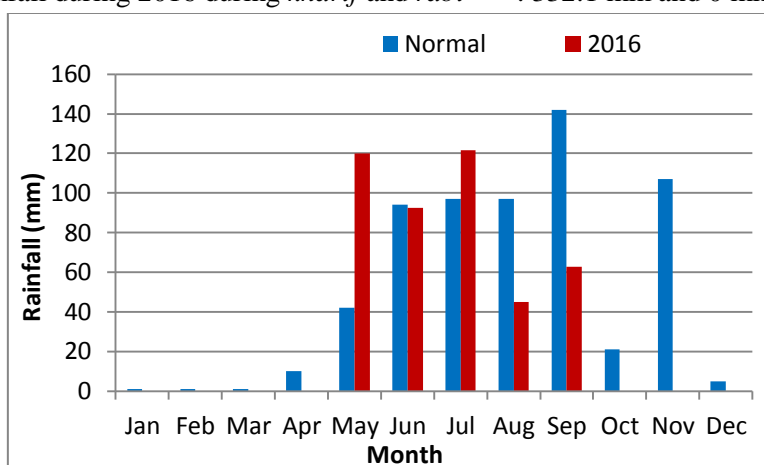


Fig. 1.2.2: Normal and actual (2016) monthly rainfall at Vannedoddi village

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 carbendazim 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 groundnut (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 <i>kharif</i> and <i>rabi</i> , respectively |
| Crop seasonal rainfall during 2016-17 | : 991.2 mm and 19.3 mm <i>kharif</i> and <i>rabi</i> , respectively |

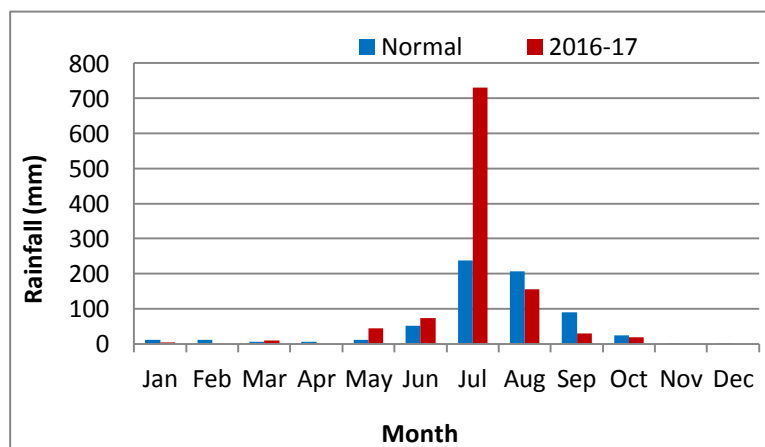


Fig. 1.3.1: Normal and actual (2016) monthly rainfall at Agra

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 to 18 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-ago 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 pearl millet produced 75.8% higher grain yield of pearl millet (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-67 and 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 pearl millet 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 | | |
| 4 th Week of September (D1) | 1508 | 4129 | 46699 | 3.55 |
| 1 st week of October (D2) | 2252 | 5624 | 77957 | 5.26 |
| 2 nd week of October (D3) | 2485 | 6240 | 87968 | 5.81 |
| 3 rd week of October (D4) | 1951 | 5254 | 65663 | 4.59 |
| 4 th week of October (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 pearlmillet with clusterbean and sesame, highest pearlmillet equivalent yield of 2900 kg/ha was recorded with pearlmillet + 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 returns 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 pearl millet, 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°C in June and as low as up to 1.0°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 <i>kharif</i> and <i>rabi</i> | : 587.1 and 28.5 mm, respectively |
| Crop seasonal rainfall during 2016-17 <i>kharif</i> and <i>rabi</i> | : 902.9 mm and 22.0 mm, respectively |

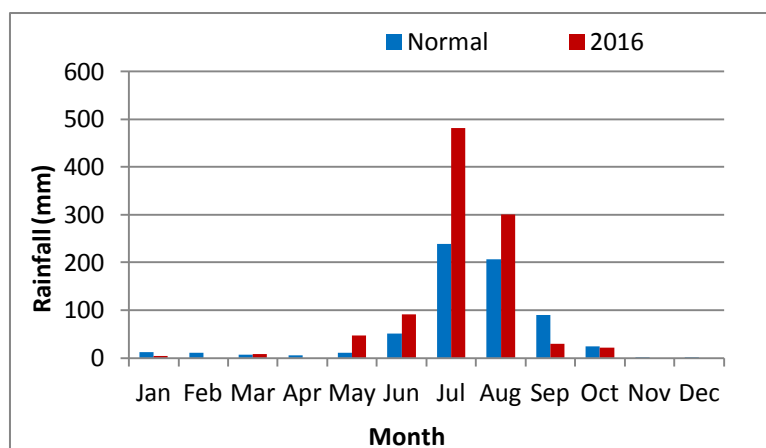


Fig.1.3.2: Normal and actual (2016) monthly rainfall in Nagla Dulhe Khan Village

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 pearl millet (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 pearl millet



Pearlmillet - broadcasting

Similarly, the highest pearl millet 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 pearl millet 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 pearl millet 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 |

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 pearl millet in association with clusterbean (4:4) gave maximum pearl millet equivalent yield of 1880 kg/ha, which was 15.3% higher than pearl millet 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+ | 1213+ | 1880 | 2907 | | 17883 | 2.14 |
| Sole pearl millet | 242 | 282 | 1630 | 1549 | 4.11 | 14288 | 1.89 |

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

Similarly, pearl millet + sesame strip cropping system (4:4) gave highest pearl millet equivalent yield of 2542 kg/ha compared to sole pearl millet (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 pearl millet 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) | | | |
| Pearl millet + sesame strip cropping | 1465+237 | 1235+238 | 2542 | 3153 | 2.87 | 28516 | 2.87 |
| Sole pearl millet | 1630 | 1659 | 1630 | 1659 | 1.89 | 14285 | 1.89 |

PMEY- Pearl millet 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 pearl millet, 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 pearl millet 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 (1/3 rd 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 ₂ O (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, North Gujarat Plain and South-western Punjab plain (AESR 2.3) and South-western dry zone in Haryana. The climate is hot arid. Annual rainfall is 411 mm. 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 20.8 mm excess than normal (9.2 mm).

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

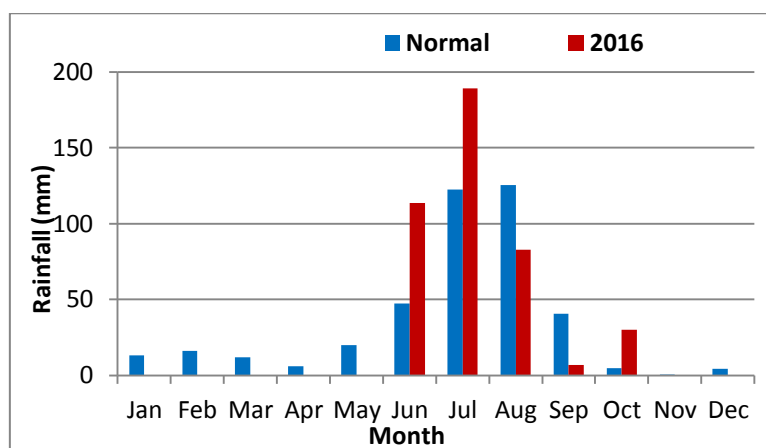


Fig. 1.4.1: Normal and actual (2016) monthly rainfall at Hisar

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 | Pearl millet Cluster bean Greengram | Seed/grain filling | Mechanical weeding/ hoeing by <i>kasola</i> and wheel hand hoe. Harvest of every 3 rd 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 *khari* season, there was long dry spell of 21 days (29th July to 18th August) 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 pearlmillet, clusterbean and greengram (4.04, 7.5 and 13.3%, respectively). Similarly, net returns, 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* | 24632* | 1.4* |
| | | | | | 8.4 | 23674 | 1.4 |
| Clusterbean | HG-870 | 1280 | 1190 | 7.5 | 6.1* | 39680* | 2.1* |
| | | | | | 5.2 | 36890 | 2.2 |
| Greengram | MH-421 | 680 | 600 | 13.3 | 3.2* | 35496* | 2.1* |
| | | | | | 2.8 | 31350 | 2.0 |

* Intervention

All high yielding varieties need 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* | 25602* | 1.4* |
| | | | | | 8.5 | 24006 | 1.4 |
| Clusterbean | HG-870 | 1305 | 1205 | 4.6 | 6.1* | 40455* | 2.1* |
| | | | | | 5.6 | 37355 | 2.2 |
| Mungbean | MH-421 | 710 | 675 | 5.2 | 3.3* | 37062* | 2.2* |
| | | | | | 3.1 | 35235 | 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 pearl millet, 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 ($-0.112/-0.071^{\circ}\text{C}$) 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.*, pearl millet, 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 by 11.0 mm (3.8%) 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 | : 1 st week of July |
| Onset of monsoon during 2016-17 | : 1 st July |
| Normal annual mean rainfall | : 300 mm |
| Actual annual rainfall during 2016-17 | : 289 mm |
| Mean crop seasonal rainfall during <i>kharif</i> & <i>rabi</i> | : 210.7 and 22 mm, respectively |
| Crop seasonal rainfall during 2016-17 (<i>kharif</i> and <i>rabi</i>) | : 279 and 10 mm, respectively |

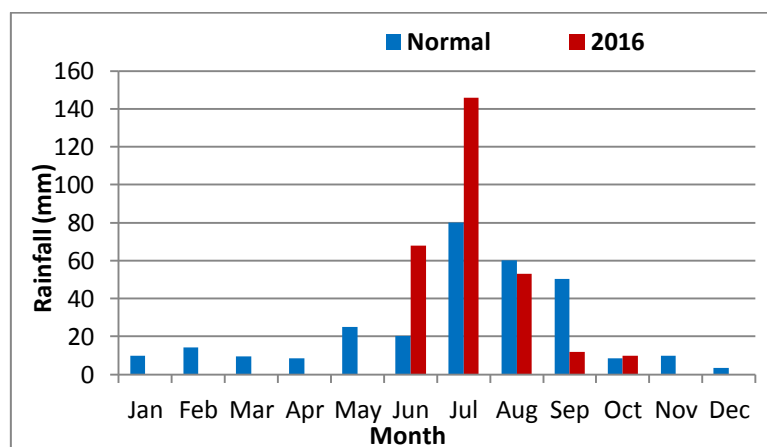


Fig.1.4.2: Normal and actual monthly rainfall (2016) at Balawas

Dry spells during crop growing season (2016)

| Dry spell | | Crop | Stage of the crop |
|-----------|---------------------------|--|---|
| Duration | Dates & Months | | |
| 24 days | 31 July to 23 August | 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 (31st July to 23rd August) was coincided with 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 pearl millet was implemented resulting in pearl millet 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 (pearl millet + clusterbean(8:4) gave pearl millet 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 3 rd 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 pearl millet, 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 pearl millet, clusterbean and greengram, 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* | 17024* | 0.9* |
| | | | | 8.4 | 15295 | 0.9 |
| Greengram | Satya | 620 | 600 | 4.5* | 32364* | 1.9* |
| | | | | 4.4 | 31350 | 2.0 |

* Intervention

High yielding varieties need optimum nutrition for good harvests; adoption of recommended package of practice increased the yield of pearl millet 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 pearl millet 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* | 17622* | 0.9 |
| | | | | | 8.8 | 16026 | 0.9 |
| Clusterbean | HG-870 | 1395 | 1280 | 8.89 | 10.2* | 43245* | 2.2* |
| | | | | | | | 9.4 |

* 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

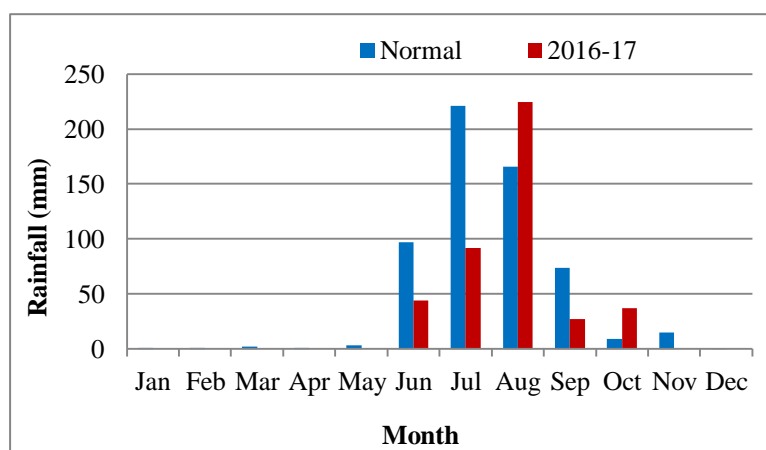


Fig 1.6.1: Normal and actual (2016) monthly rainfall at Rajkot

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

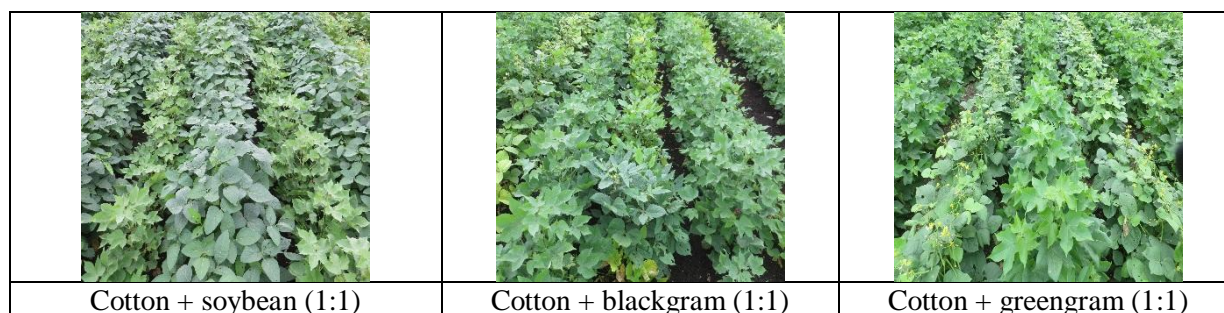
Cropping system

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



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 and 11.9% 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 *khari* 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 Meghpar 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 (24 th SMW) |
| Onset of monsoon during 2016-17 | : 12 July (28 th SMW) |
| Annual mean rainfall | : 541 mm |
| Annual rainfall during 2016-17 | : 611 mm |
| Mean crop seasonal rainfall during <i>Khari</i> and <i>rabi</i> | : 555 and 27.3 mm, respectively |
| Crop seasonal rainfall during 2016-17 <i>khari</i> and <i>rabi</i> | : 536 and 75 mm, respectively |

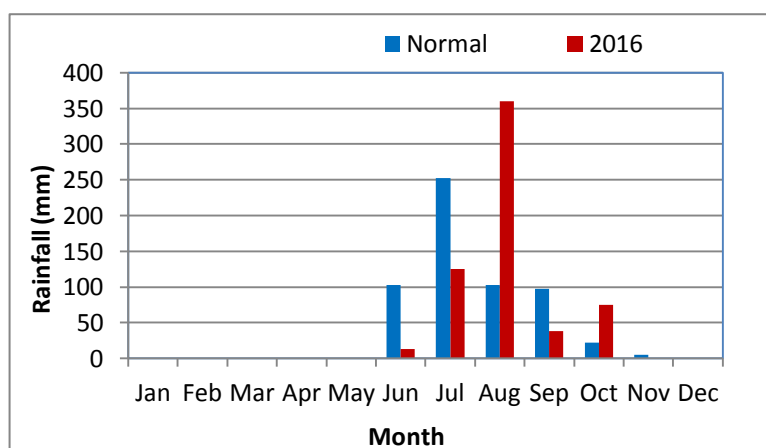


Fig 1.6.2: Normal and actual (2016) monthly rainfall at Pata Meghpar

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 | <i>In-situ</i> 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 KNO₃ 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 *murrum* @ 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 |
|-------------------------|---------------|------------------------|--------------------|------------------------|--------------|
| <i>Murrum</i> @ 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 (Table 1.6.21).

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 <i>kharif</i> & <i>rabi</i> |
| Crop seasonal rainfall during 2016-17 | : 495 and 90.4 mm, respectively (<i>kharif</i> & <i>rabi</i>) |

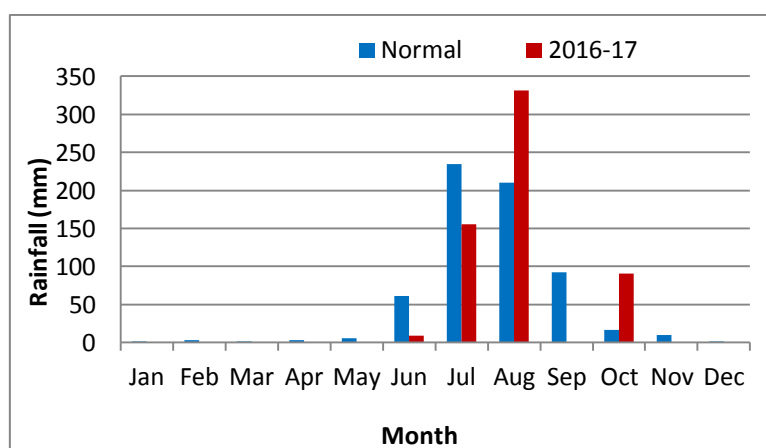


Fig.1.7.1: Normal and actual (2016) monthly rainfall at SK Nagar

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 |
| | | 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 pearl millet 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 pearl millet 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 (*khariif*), 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 pearl millet. 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 pearl millet 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 pearl millet 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) | | | | CEY | RWUE (kg/ha-mm) | Net returns (Rs/ha) | B-C ratio |
|-----------------------------------|----------------|-------|-----------|--------|------|-----------------|---------------------|-----------|
| | Castor | | Greengram | | | | | |
| | 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 pearl millet, green gram, castor, cotton, black gram, sorghum, cluster bean, 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 pearl millet, green gram, sorghum, cluster bean, maize, castor, cotton etc.

Experienced weather conditions during 2016-17

During 2016, in Kalimati village, onset of monsoon was delayed by 17 days (12th July). A total rainfall of 670 mm was received which was deficit by 203 mm 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* 94 mm was received which was excess by 70.9 mm compared to normal of 23.1 mm 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 <i>kharif</i> and <i>rabi</i> , respectively |
| Crop seasonal rainfall during 2016-17 | : 670 & 94 mm during <i>kharif</i> and <i>rabi</i> , respectively |

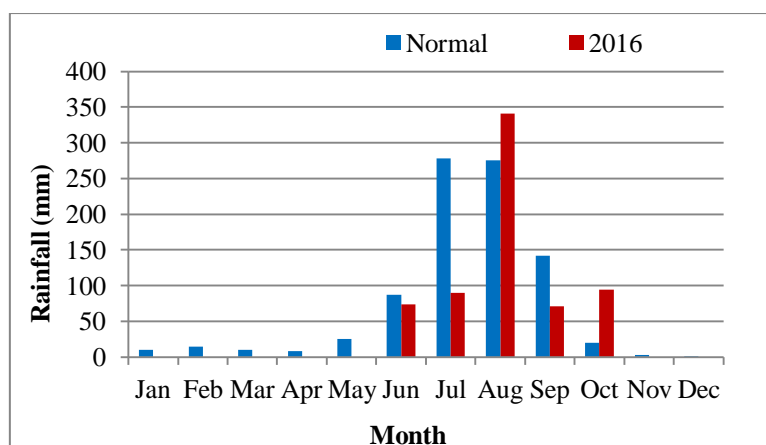


Fig.1.7.2: Normal and actual (2016) monthly rainfall in Kalimati village

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 monsoon

| 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 pearl millet 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 pearl millet 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 pearl millet

| 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 <i>kharif</i> and <i>rabi</i> , respectively |
| Crop seasonal rainfall during 2016-17 | : 684.5 and 67.4 mm during <i>kharif</i> and <i>rabi</i> , respectively |

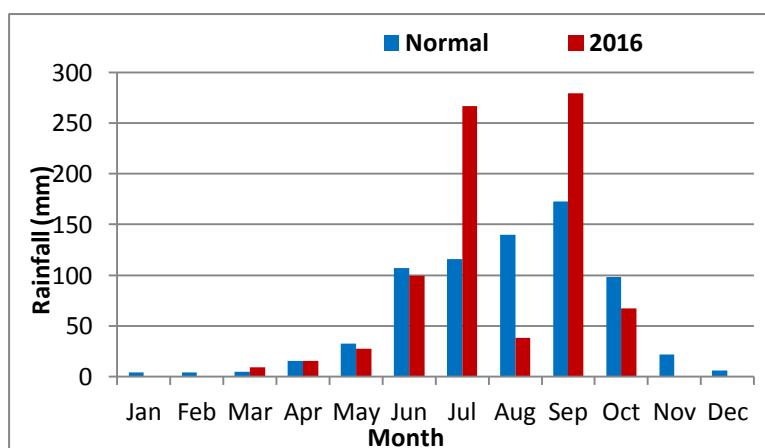


Fig.1.8.1: Normal and actual (2016) monthly rainfall at Solapur

Dry spells during crop growing season (2016-17)

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

Salient achievements of on-station experiments

Preparedness

Crops and cropping systems

Improved varieties of pearl millet, 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) + pearl millet (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 | : 7 th June |
| Onset of monsoon during 2016-17 | : 10 th 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 <i>kharif</i> and <i>rabi</i> , respectively |
| Crop seasonal rainfall during 2016-17 | : 760 and 5 mm during <i>kharif</i> and <i>rabi</i> , respectively |

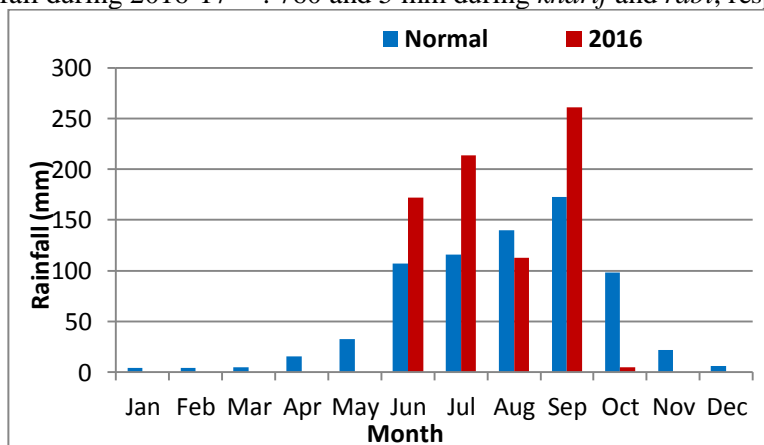


Fig.1.8.2: Normal and actual (2016) monthly rainfall at Narotiwadi

Dry spells during crop growing season (2016)

| Dry spell | | Crop & Stage |
|-----------------|---|---|
| Duration (days) | Dates & months | |
| 17 | 7 th August to 24 th August | Pigeonpea- early growth stage Pearlmillet- vegetative growth stage |
| 14 | 31 st August to 13 th September | Sunflower- button growth stage Blackgram- flowering stage |
| 120 | 28 th 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 3 rd , 5 th , 8 th week after sowing Protective irrigation at 42 nd day Removal of 1/3 rd plant population. |
| | Gram | Improved variety |
| | | 1) One weeding within 30 days after sowing. 2) Hoeing at 3 rd week after sowing. 3) Protective irrigation at 42 nd 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, pearl millet, 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 evapotranspiration 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 | : 7 th June |
| Onset of monsoon during 2016 | : 19 th June |
| Annual mean rainfall | : 594.4 mm |
| Annual rainfall during 2016 | : 481.3 mm |
| Mean crop seasonal rainfall during <i>kharif</i> and <i>rabi</i> | : <i>kharif</i> 388.6 mm and <i>rabi</i> 134.2 mm |
| Crop seasonal rainfall during 2016 (<i>kharif</i> & <i>rabi</i>) | : <i>kharif</i> 402.9 mm and <i>rabi</i> 12.0 mm |

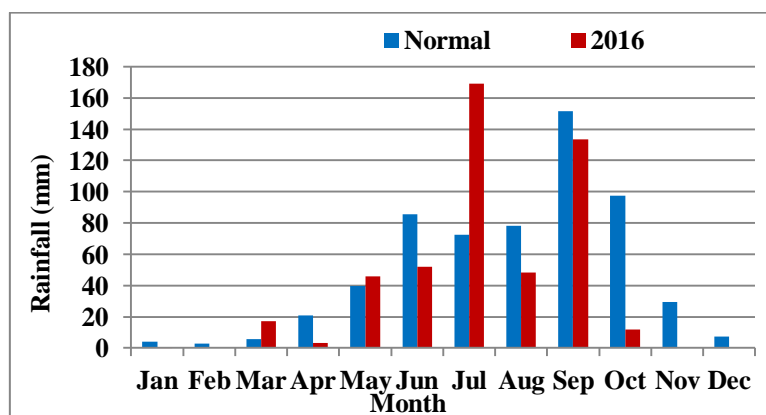


Fig 1.9.1: Normal and actual (2016) monthly rainfall at Vijayapura

Dry spells during crop growing season (2016)

| Dry spell | | Crops | Stage of the crop |
|---|---|-------------|------------------------------|
| Duration | Dates & Months | | |
| 16 Days | 13 th August 28 th August | Pearlmillet | Ear head emerging stage |
| | | Pigeonpea | Vegetative growth stage |
| | | Groundnut | Peg initiation stage |
| | | Greengram | Physiological maturity stage |
| There was no rainfall since 9 th 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 pearl millet 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, pearl millet 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, pearl millet + groundnut intercropping system gave significantly higher pearl millet 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 pearl millet + 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 pearl millet and groundnut

| Treatment | Seed (kg/ha) | | PEY (kg/ha) | RWUE (kg/ha-mm) | | Gross return (Rs/ha) | Net returns (Rs/ha) |
|---|--------------|-----------|-------------|-----------------|-----------|-------------------------|-------------------------|
| | Pearl millet | Groundnut | | Pearl millet | Groundnut | Pearlmillet + groundnut | Pearlmillet + groundnut |
| Set furrow + residue + Glycicidia incorporation | 675 | 367 | 1859 | 2.11 | 1.15 | 33455 | 18955 |
| Set furrow + silt + residue + glycidia 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, pearl millet 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 pearl millet

| 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 CaCl₂ 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 pearl millet, 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 borewells 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 <i>kharif</i> and <i>rabi</i> | : <i>kharif</i> 387.5 mm and <i>rabi</i> 134.0 mm |
| Crop seasonal rainfall during 2015-16 | : <i>kharif</i> 430.4 mm and <i>rabi</i> 49.1 mm |

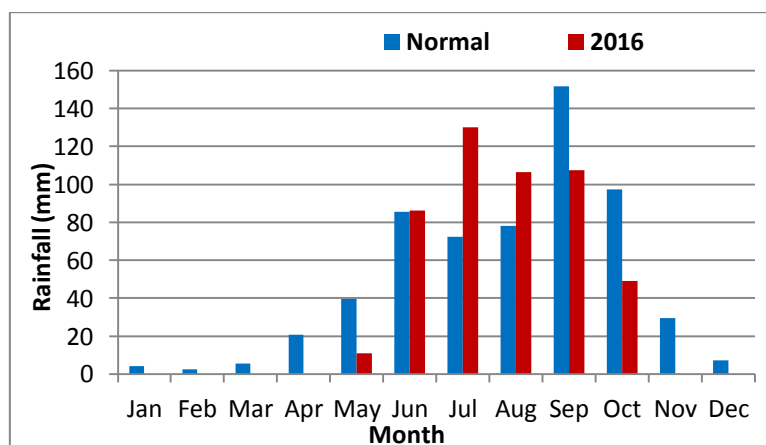


Fig.1.9.2: Normal and actual (2016) monthly rainfall at Kavalagi

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, pearl millet | Vegetative growth stage |
| | | Greengram | Pod development stage |
| 13 days | 30-08-2016 to 12-09-2016 | Pigeonpea, pearl millet | vegetative growth stage |
| | | Greengram | Grain filling stage |
| There was no rainfall since 9 th 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 pearl millet 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 KNO₃ @ 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.96725/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

| Intercropping 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 (24 th 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 <i>kharif</i> and <i>rabi</i> | : 666.3 and 66.8 mm respectively |
| Crop seasonal rainfall during 2016-17 | : 741.8 in <i>kharif</i> and 90.5 mm in <i>rabi</i> |

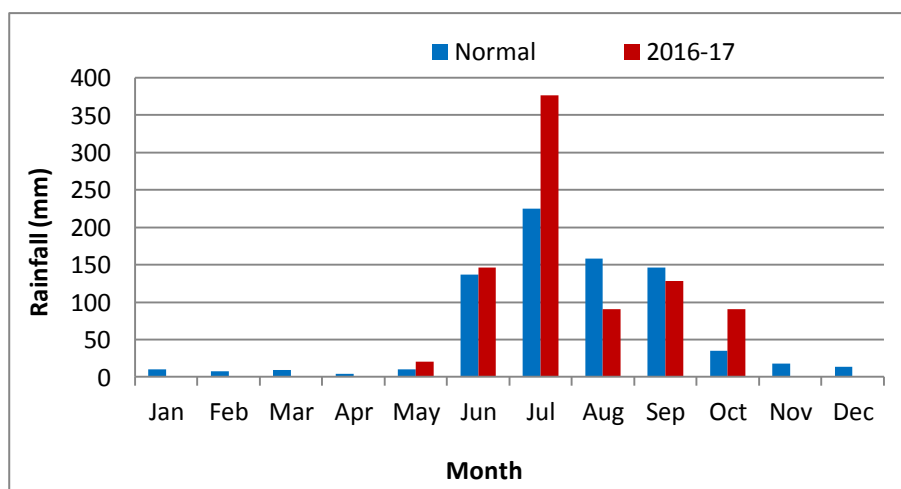


Fig.2.1.1: Normal and actual (2016) monthly rainfall at Akola

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 | |
| 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-081 under 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 |
| <i>Bt.</i> 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 with 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 sprays 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 <i>kharif</i> and <i>rabi</i> | : 688 mm and 82 mm, respectively |
| Crop seasonal rainfall during 2016-17 | : 692mm and 89 mm, respectively |
| <i>Kharif</i> and <i>rabi</i> | |

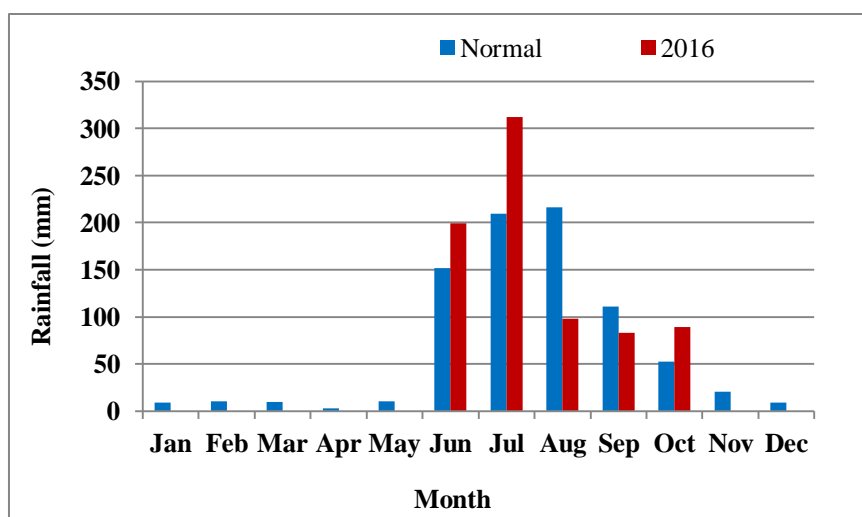


Fig : Normal and actual (2016) monthly rainfall at Barshi Takali

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 23 August | 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 varieties 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 |
|-------------------------------------|-------------|------------------|-----------------|---------------------|-----------|
| <i>Bt.</i> cotton + greengram (1:1) | 2365 | 35.6 | 3.36 | 54761 | 2.11 |
| Sole <i>Bt.</i> 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 | : 2 nd June |
| Onset of monsoon during 2016-17 | : 1 st June |
| Annual mean rainfall | : 920.4 mm |
| Annual rainfall during 2016-17 | : 694.9 mm |
| Mean crop seasonal rainfall during <i>kharif</i> & <i>rabi</i> | : 508.3 & 253.9 mm |
| Crop seasonal rainfall during 2016-17 <i>kharif</i> & <i>rabi</i> | : 480.8 & 93.7 mm |

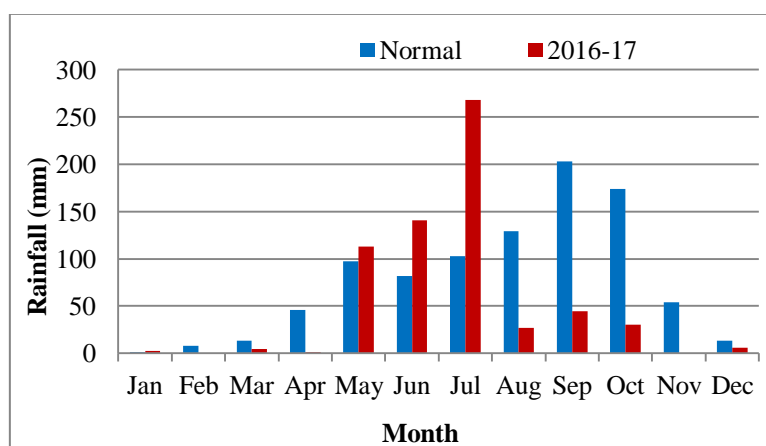


Fig.2.2.1: Normal and actual (2016) monthly rainfall at Bengaluru

Dry spells during crop growing season (2016-17)

| Dry spell | | Crop | Stage of the crop |
|-----------------|--|--------------------|------------------------------|
| Duration (Days) | Dates and months | | |
| 18 | 18 th August to 04 th September | Fingermillet | Germination to establishment |
| | | Pigeonpea, cowpea | Vegetative |
| | | Groundnut | Flowering |
| | | Field bean, castor | Pod filling |
| 13 | 16 th September to 28 th 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 | 30 th September to 9 th 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 | 14 th October to 2 nd December | Finger millet | 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 | Finger millet and pigeonpea | Sowing | Transplanting of finger millet and pigeonpea |
| Mid season drought | Finger millet | 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 |
| | Finger millet, 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, finger millet can be established through dry sowing, drill sowing and transplanting. Among different methods of finger millet 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 finger millet

| 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 finger millet. 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 finger millet 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 (591 and 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 finger millet, 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: Finger millet 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 + <i>akkadi</i> | - | 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 finger millet, 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 + finger millet | 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 + finger millet | 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 |
| Finger millet | - | - | - | -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 + finger millet | 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 |
| Finger millet | - | - | - | -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 finger millet (GPU- 48 with 105-110 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-1 with 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 finger millet 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 finger millet, 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 | : 2 nd June |
| Onset of monsoon during 2016 -17 | : 1 st June |
| Annual mean rainfall | : 753.4 mm |
| Annual mean rainfall during 2016-17 | : 554.9 mm |
| Mean crop seasonal rainfall during <i>kharif</i> and <i>rabi</i> | : 415.1 & 241.6 mm |
| Crop seasonal rainfall during 2016-17 (<i>kharif</i> and <i>rabi</i>) | : 340.3 & 81.2mm |

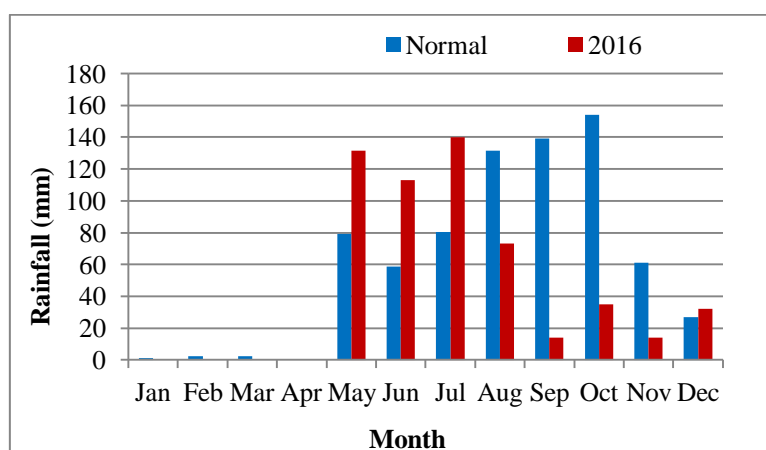


Fig.2.2.2: Normal and actual (2016) monthly rainfall at Chikkamaranahalli

Dry spells during crop growing season (2016-17)

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

| | | | |
|----|---|---------------------------------|---------------------------|
| | 1 st November | Pigeonpea | Grain filling |
| | | Castor | Tertiary spike initiation |
| 39 | 3 rd November to 12 th 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 | 25 th August | 87 | 1350 | 4250 | 4 | 13.10 | 25097 | 2.15 |
| Direct sown | 21 st 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 ZnSO₄ (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 ZnSO₄ 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 <i>kharif</i> and <i>rabi</i> | : 854.5 mm and 64.5 mm, respectively |
| Crop seasonal rainfall during 2016-17 (<i>kharif</i> and <i>rabi</i>) | : 1062.8 mm and 17.1 mm, respectively |

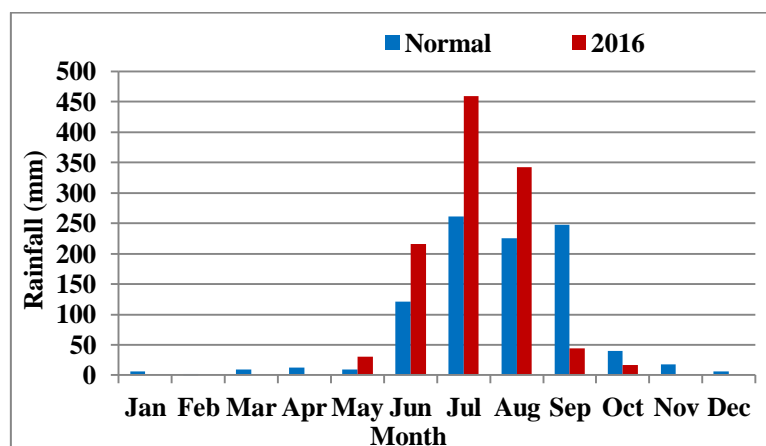


Fig.2.3.1: Normal and actual (2016) monthly rainfall at Indore

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 sowing 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% KNO₃ (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 <i>kharif</i> and <i>rabi</i> | : 854.5 and 64.5 mm, respectively |
| Crop seasonal rainfall during 2016-17 (<i>kharif</i> and <i>rabi</i>) | : 890.2 mm and 12.3 mm, respectively |

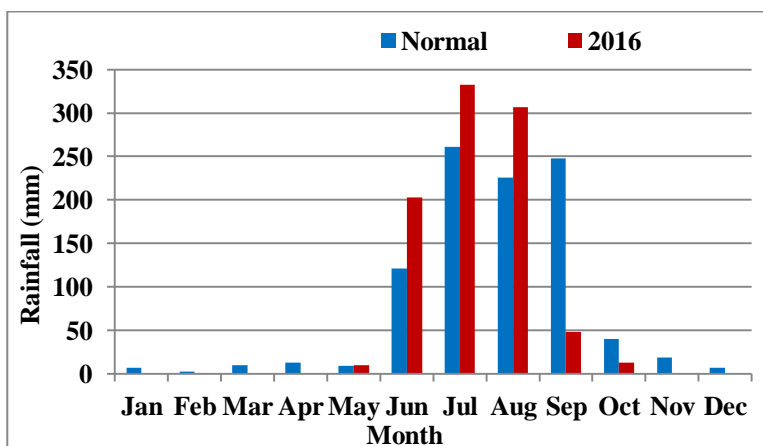


Fig.2.3.2: Normal and actual (2016) monthly rainfall at Nignoti village

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 | : 20 th June |
| Onset of monsoon during 2016 -17 | : 18 th June |
| Annual mean rainfall | : 963 mm |
| Annual mean rainfall during 2016-17 | : 1175.1mm |
| Mean crop seasonal rainfall during <i>kharif</i> and <i>rabi</i> | : 800.5 & 110.5 mm, respectively |
| Crop seasonal rainfall during 2016-17 | : 963.7 mm in <i>kharif</i> and 166.4 mm in <i>rabi</i> |

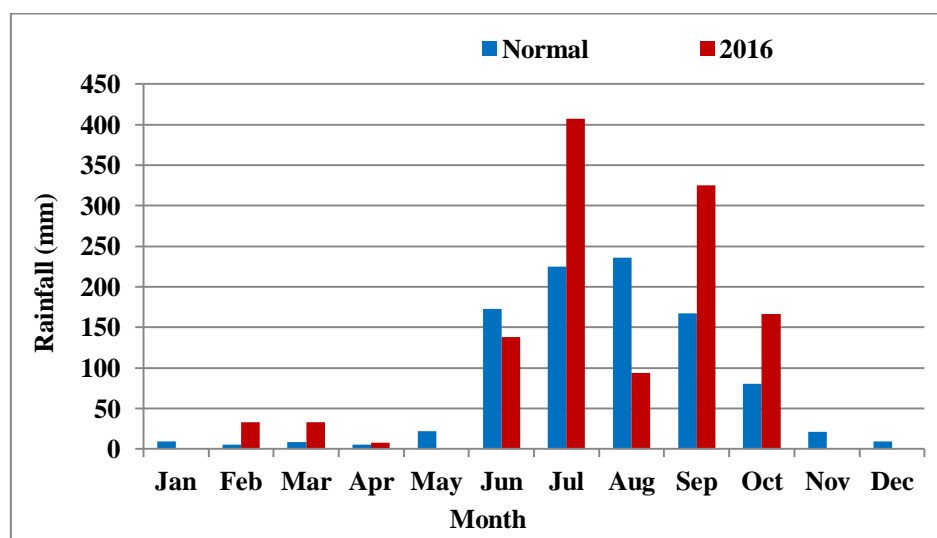


Fig.2.4.1: Normal and actual (2016) monthly rainfall at Parbhani

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 |
| <i>Bt</i> 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 <i>Bt</i> | 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 KNO₃ (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 KNO₃ (1% and 2%), water sprays and Kaoline (7%) were applied at vegetative and square formation stage (35 DAS) during midseason drought. Foliar spray of KNO₃ (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 (2.11 and 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 of 1899 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 <i>Bt</i> | 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^oC, 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 |
| | Soybean, pigeonpea | Mulching |
| | | 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 *khariif* 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 | 11.35 | 1.55 | 24872 | 2.17 |
| | JS-9560 | 1517 | 1354 | 12.09 | 1.51 | 22727 | 2.06 |
| Cotton <i>Bt</i> | 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 KNO₃ (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 KNO₃ (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 during 2016-17 | : 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 <i>kharif</i> and <i>rabi</i> respectively |
| Crop seasonal rainfall during 2016-17 | : 779.8 and 25.8 mm in <i>kharif</i> and <i>rabi</i> , respectively |

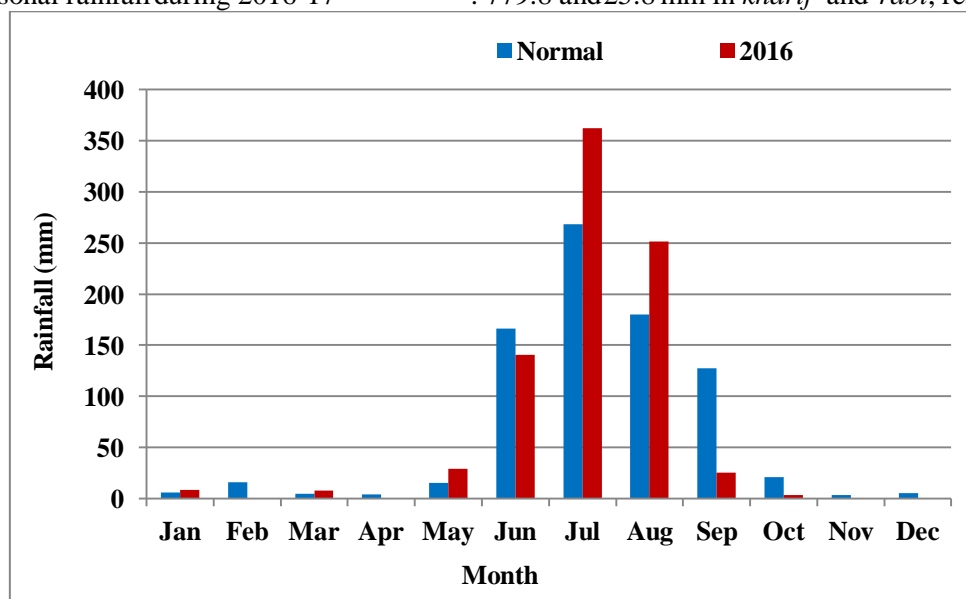


Fig. 2.5.1: Normal and actual (2016) monthly rainfall at Jhansi

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 returns 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 | <i>C. ciliaris</i> | <i>S. ebrana</i> | 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 (27th SMW) in July. The soil moisture status was deficit during pod filling in *kharif* crops, germination to harvesting in *rabi* crops depending on rainfall. The extreme events like unusual and high intensity rainfall in short span were increasing during *kharif* and *rabi* seasons. The region is also experiencing other extreme events like cold waves. There has been a considerable shift in rainfall pattern and amount has been decreasing at the rate of 2.0 mm/year during *kharif* season.

Experienced weather conditions during 2016-17

The onset of monsoon was on 25 June (26th 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 <i>kharif</i> and <i>rabi</i> | : 742.3 and 29.8 mm, respectively |
| Crop seasonal rainfall during 2016-17 <i>kharif</i> and <i>rabi</i> | : 387 and 10.5 mm, respectively |

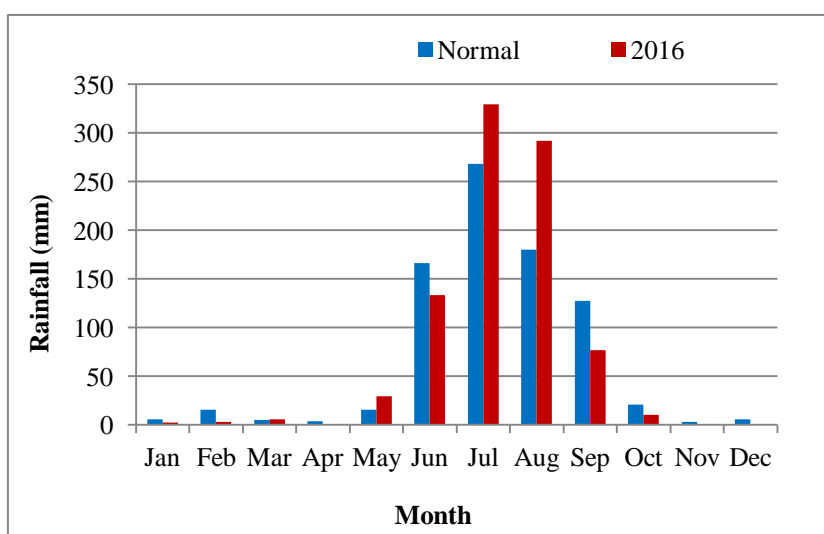


Fig 2.5.2: Normal and actual (2016) monthly rainfall at Kadesara Kalan village

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: <i>kharif</i> | : 885.8 mm |
| <i>rabi</i> | : 47.6 mm |
| Crop seasonal rainfall during 2016-17: <i>kharif</i> | : 757.9 mm |
| <i>rabi</i> | : 69.6 mm |

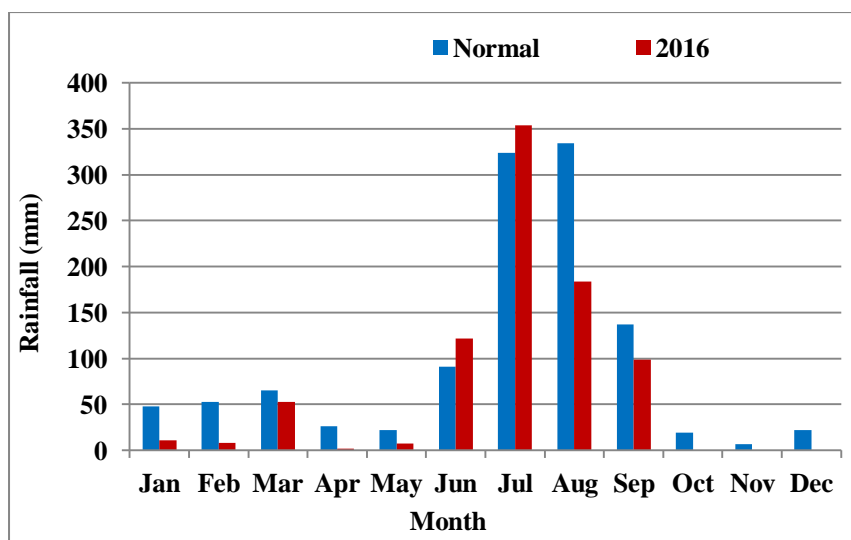


Fig.2.6.1: Normal and actual (2016) monthly rainfall at Rakh Dhiansar

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

| Dry spell | | Crop | Stage of the crop |
|-----------------|----------------|-------------------------------------|-------------------|
| Duration (days) | Dates & Months | | |
| 10 days | 2-11 September | 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.31977/ha 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 2.59 and 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 | |
| | | | | | | | | | |
| 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 pearl millet, fodder sorghum and during *rabi* season are wheat, chickpea and mustard. The number of small, marginal and medium farmers is 40, 18 and 32, respectively. The ground water table is 150-200 meters. There is no source of irrigation in the village.

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^oC per year while during *rabi* season the mean temperature had also gone up by 0.04^oC per year. The day temperature decreased by 0.7^oC from the last two decades and the night temperature had gone up by 0.6^o 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 <i>kharif</i> , 2016 -17 | : 3 July |
| Annual mean rainfall | : 150.9 mm |
| Annual rainfall during 2016-17 | : 1297.6 mm |
| Mean crop seasonal rainfall during <i>kharif</i> and <i>rabi</i> | : 896.9 mm : 46.6 mm |
| Crop seasonal rainfall during 2016-17 <i>Kharif</i> and <i>rabi</i> | : 1170.8 mm : 0.0 mm |

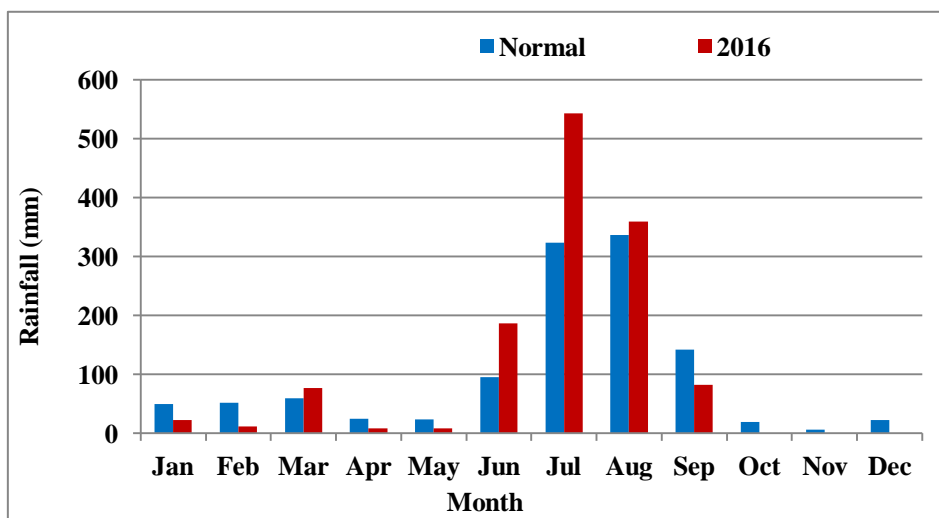


Fig. 2.6.2: Normal and actual (2016) monthly rainfall at Khaner village

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 + pearl millet 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 was 182.3 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 <i>kharif</i> and <i>rabi</i> | : 862 and 190.5 mm, respectively |
| Crop seasonal rainfall during 2016-17: <i>kharif</i> and <i>rabi</i> | : 673.8 and 8.2 mm, respectively |

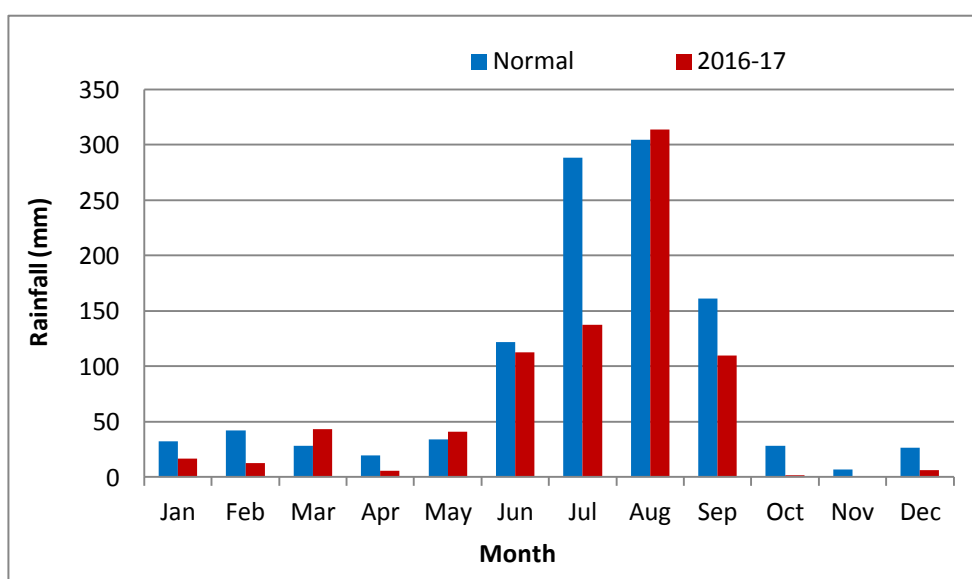


Fig 3.1.1: Normal and actual (2016) monthly rainfall at Ballawal Saunkhri

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% KNO₃ 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% KNO₃****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 | 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 greengram 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-rya | 6166 | -9.6 | 54528 | 2.12 |
| Maize-chickpea | 8444 | 19.9 | 86731 | 2.61 |
| Greengram-wheat | 6896 | 2.0 | 80647 | 2.63 |
| Greengram-rya | 6186 | -9.3 | 59701 | 2.50 |
| Greengram-chickpea | 9058 | 25.4 | 100941 | 3.24 |
| Sesame-wheat | 6141 | -10.1 | 63760 | 2.45 |
| Sesame-rya | 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 <i>pora</i> | 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) | | | | | | | |
|-------------|--------------------|--------------------|-------------------|---------------------|------------------|--------------------|------------------|--------------------|
| | <i>Kharif</i> | Guava + black gram | black gram | Galgal + black gram | black gram | Mango + black gram | black gram | Lemon + black gram |
| | 580 | 620 | 540 | 608 | 570 | 598 | 564 | 586 |
| <i>Rabi</i> | 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 40.8⁰C and 21.4 to 26.2⁰C, whereas during *rabi* season it varied from 16.0 to 38.9⁰C and 2.3 to 20.4⁰C, 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 by 107.9 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 : 862 and 61.9 mm, respectively
 during *kharif* and *rabi*
 Crop seasonal rainfall : 754.1 and 123.4 mm, respectively
 during 2016-17 *kharif* and *rabi*

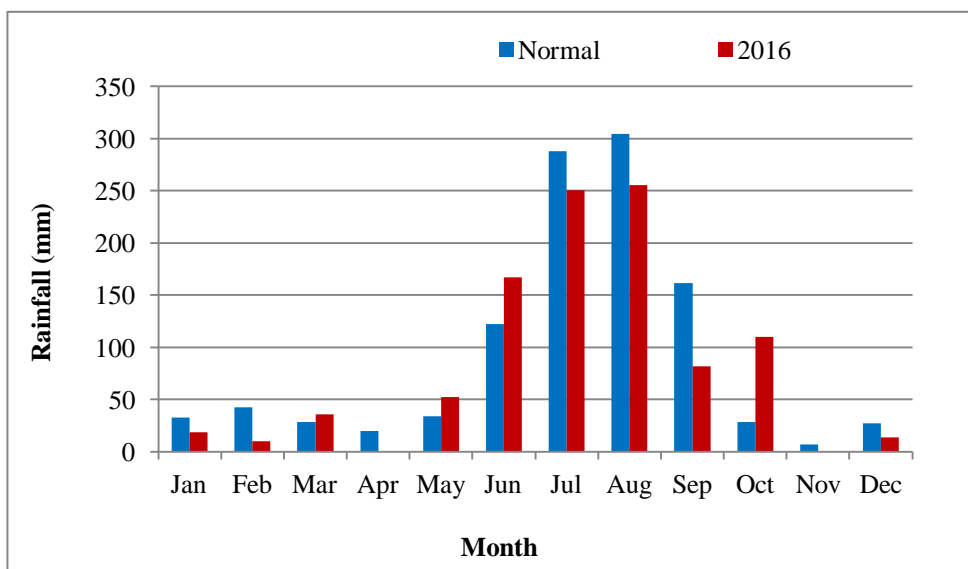


Fig 3.1.2: Normal and actual (2016) monthly rainfall at Ballawal Saunkhri

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 Rs.36678/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, pearl millet 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 intercropping in 1:1 ratio were conducted in both the adopted villages. Wheat +

chickpea intercropping system gave highest WEY than sole 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 | Drill Sowing | 2862 | 2410 | 22.9 | 15.4 | 31427 | 2.13 |
| Taramira | | 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 <i>kharif</i> and <i>rabi</i> | : 1038 and 65.9 mm, respectively |
| Crop seasonal rainfall during 2016-17 (<i>kharif</i> and <i>rabi</i>) | : 1224.6 & 84.2 mm, respectively |

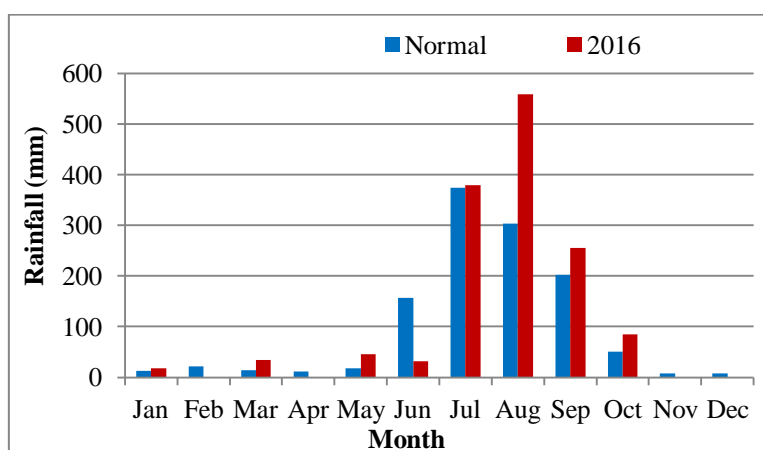


Fig.3.2.1: Normal and actual (2016) monthly rainfall at Chianki

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 | - | <ul style="list-style-type: none"> • 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 <i>kharif</i> and <i>rabi</i> | : 993 and 77.6 mm, respectively |
| Crop seasonal rainfall during 2016-17 (<i>kharif</i> and <i>rabi</i>) | : 1089 and 56.8 mm, respectively |

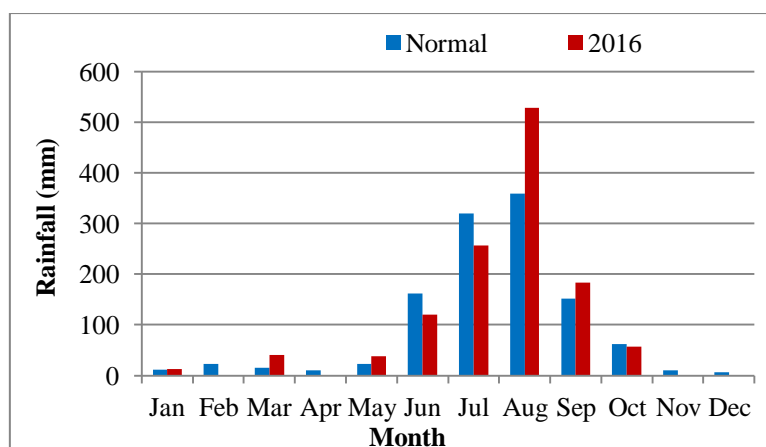


Fig.3.2.2: Normal and actual (2016) monthly rainfall at Garhwa (Kumbhi Bankheta)

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 finger millet 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 | - | - | - | - |
| Finger millet | | | | | |
| 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 (*khariif*), 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 (<i>khariif</i>) & 65.6 mm (<i>rabi</i>) |
| Crop seasonal rainfall during 2016 | : 684.6 mm (<i>khariif</i>) & 35.1 mm (<i>rabi</i>) |

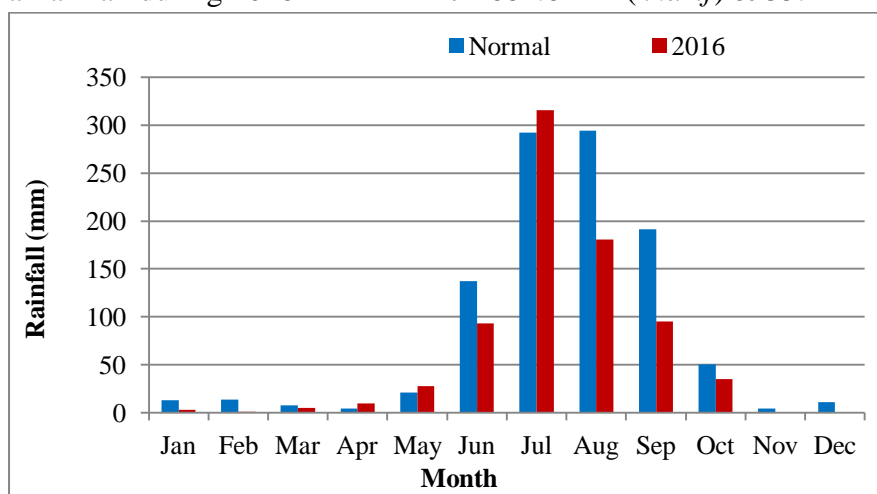


Fig 3.3.1. Normal and actual (2016) monthly rainfall at Faizabad

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 <i>in-situ</i> 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 | 3.24 | 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 + 1 harrowing | 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 pearl millet 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 <i>in-situ</i> 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 weeding 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 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 | 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 + 1 Harrowing | 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, pearl millet, 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 | : 25 th 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 <i>kharif</i> and <i>rabi</i> | : 699.5 & 60.9 mm, respectively |
| Crop seasonal rainfall during 2016-17 (<i>kharif</i> & <i>rabi</i>) | : 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 onset of monsoon (21 June), maize, rice and pearl millet 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 pearl millet 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 pearl millet | 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

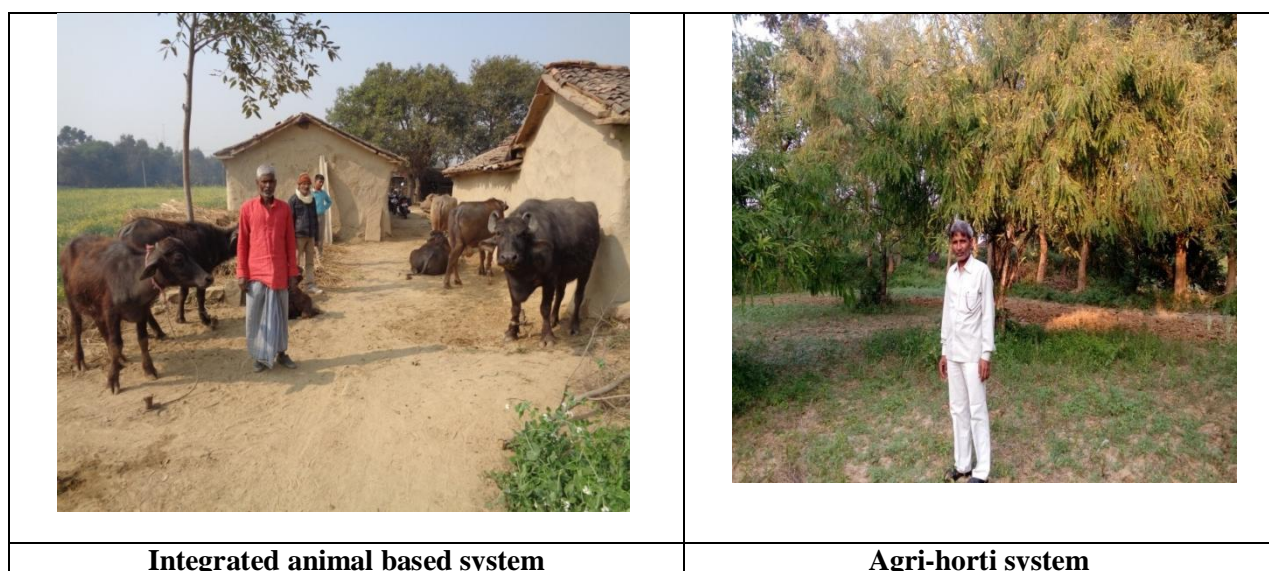
| Treatment | Yield (kg/ha) | | Cost of cultivation (Rs/ha) | Net returns (Rs/ha) | B:C ratio | RWUE (kg/ha-mm) |
|----------------------------------|---------------|-------|-----------------------------|---------------------|-----------|-----------------|
| | grain | Straw | | | | |
| Improved practice (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 net returns of Rs. 168640/ha, B:C ratio of 1.36 and employment generation of 160 man day/ha/yr whereas agrihorti system gave net 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 |



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 <i>kharif</i> and <i>rabi</i> | : 1122 and 115 mm, respectively |
| Crop seasonal rainfall during 2016-17 (<i>kharif</i> & <i>rabi</i>) | : 1718.1 and 182.6 mm, respectively |

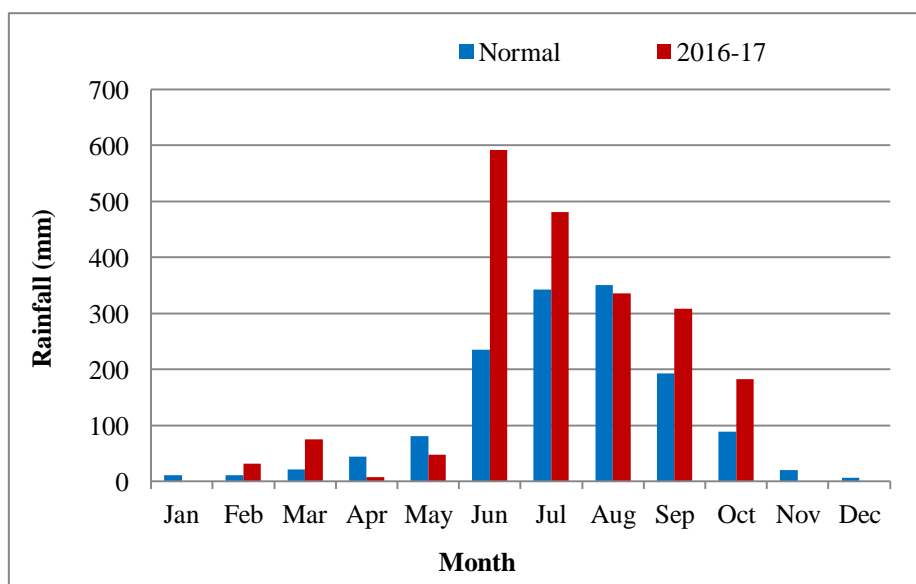


Fig. 4.1.1: Normal and actual (2016) monthly rainfall at Jagdalpur

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 7 th 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 T₅ may be due to maximum height (223.6cm) and biomass (16.91 kg/tree). Further, trench at base + cowpea intercrop (T₄) resulted in higher collar diameter (12.9 cm) and trench at base + bhindi intercrop (T₆) 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 |

T₁: Spading out at base on trees for restoring rainwater + cowpea intercrop; T₂: Spading out at base on trees for restoring rainwater + colocasia intercrop; T₃: Spading out at base on trees for restoring rainwater + bhindi intercrop; T₄: Trench at base on trees for restoring rainwater + cowpea intercrop; T₅: Trench at base on trees for restoring rainwater + colocasia intercrop; T₆: 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 Gumiyaal 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, chickpea, 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 <i>kharif</i> and <i>rabi</i> | : 1122 and 115 mm, respectively |
| Crop seasonal rainfall during 2016-17 (<i>kharif</i> & <i>rabi</i>) | : 1662.99 and 182.66 mm, respectively |

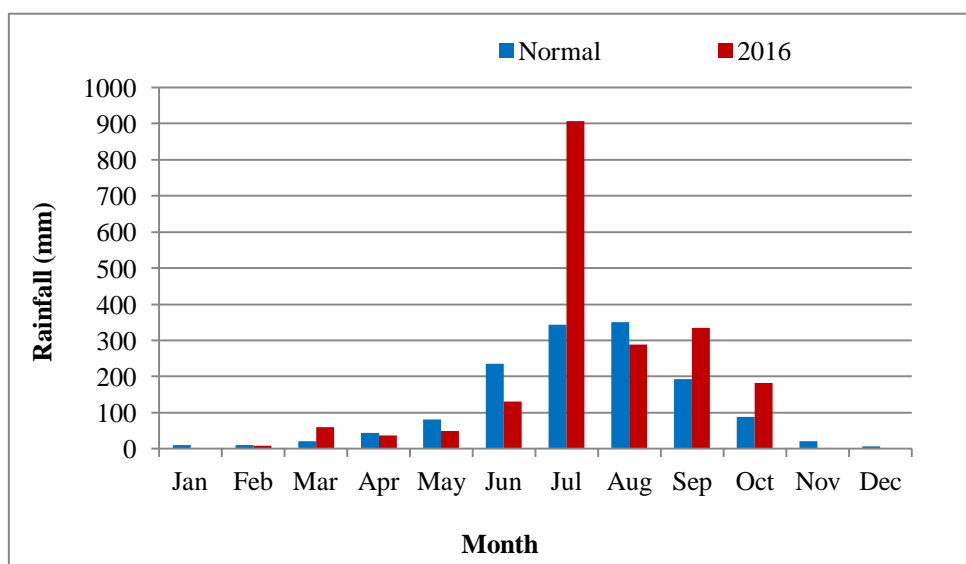


Fig.4.1.2 : Normal and actual (2016) monthly rainfall at Tahkapal village

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 |
| Finger millet | 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, finger millet + 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 finger millet + 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 finger millet (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 | : 10 th June |
| Onset of monsoon during 2016-17 | : 24 th June |
| Annual mean rainfall | : 1407.3 mm |
| Annual rainfall during 2016-17 | : 1248.8 mm |
| Mean crop seasonal rainfall during <i>kharif</i> and <i>rabi</i> | : 1150 & 124.7 mm, respectively |
| Crop seasonal rainfall during 2016-17 (<i>kharif</i> & <i>rabi</i>) | : 1159.8 & 51.6 mm, respectively |

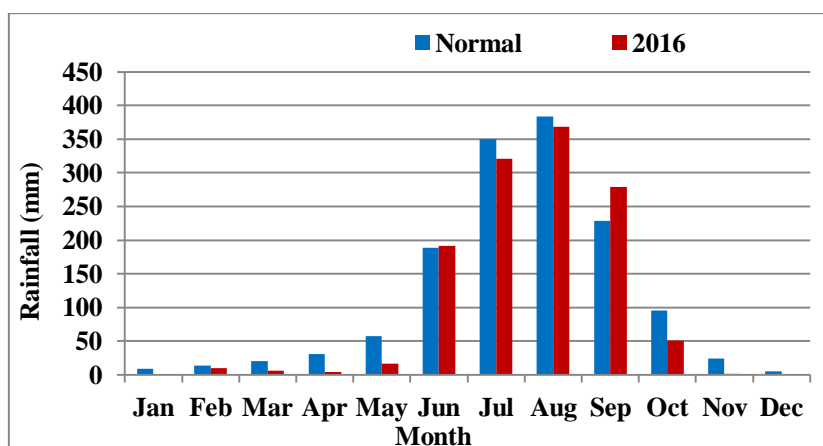


Fig.4.2.1: Normal and actual (2016) monthly rainfall at Phulbani

Dry spells during crop growing season, 2016-17

| Dry spells | | Crop | Stage of the crop |
|-----------------|---|---|--|
| Duration (days) | Dates & Months | | |
| 9 | 19 th to 27 th July | Rice, maize, cowpea, pigeonpea, tomato, brinjal | Germination / seedling |
| 14 | 19 th August to 1 st September | Rice, maize, cowpea, pigeonpea, greengram, blackgram | Panicle initiation, flowering, cob and pod development, veg. and flowering stage of vegetables |
| 18 | 18 th September to 5 th 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 varieties |
| Early season drought | Rice | Germination / Seedling | Gap filling |
| | Maize, pigeonpea, cowpea, radish | Early veg. stage | <i>In-situ</i> 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 <i>in-situ</i> moisture conservation practice | No <i>in-situ</i> moisture conservation practice | | | | |
| Rice | Sahabhagi, | 2450 | 1980 | 28.07 | 1.95 | 10736 | 1.48 |
| | ZHU 11-26 | 2340 | 1860 | | | | |
| | Yogesh | 2380 | 1730 | | | | |
| | Lalitgiri | 2280 | 1810 | | | | |
| 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 *khariif* 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 | 19 th to 27 th July | Rice, maize, cowpea, pigeonpea | Germination / seedling |
| 14 | 19 th August to 1 st September | -do- | Panicle initiation, flowering, cob and pod development |
| 18 | 18 th September to 5 th 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 | <i>In-situ</i> moisture conservation, gap filling, hoeing & weeding |
| | Pigeonpea | <i>In-situ</i> moisture conservation, gap filling, hoeing and weeding |
| | Cowpea | <i>In-situ</i> 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 |
|----------------------------|---------------------------------|---------------------------------------|-------------------|-----------------|---------------------|-----------|
| | | <i>In-situ</i> 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 | : 1 st week of June |
| Onset of monsoon during 2016-17 | : 1 st 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 <i>kharif</i> and <i>rabi</i> , respectively |
| Crop seasonal rainfall during 2016-17 | : 1210.8 and 101.2 mm during <i>kharif</i> and <i>rabi</i> , respectively |

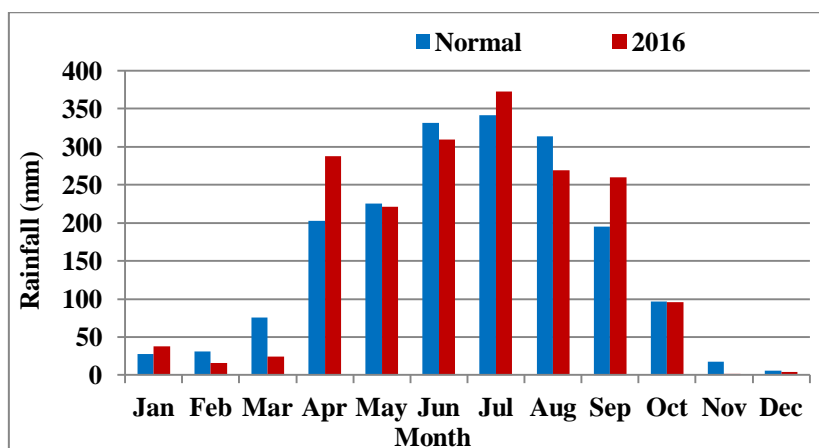


Fig 5.1.1: Normal and actual (2016) monthly rainfall at Biswanath Chariali

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°C/year and minimum by 0.0194°C/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 | : 1 st week of June |
| Onset of monsoon during 2016-17 | : 1 st week of June |
| Normal annual rainfall | : 1978.6 mm |
| Annual rainfall during 2016-17 | : 2658.9 mm |
| Normal crop seasonal rainfall respectively | : 1280.1 and 161.0 mm during <i>kharif</i> and <i>rabi</i> , |
| Crop seasonal rainfall during 2016-17 respectively | : 1737.4 and 160.0 mm during <i>kharif</i> and <i>rabi</i> , |

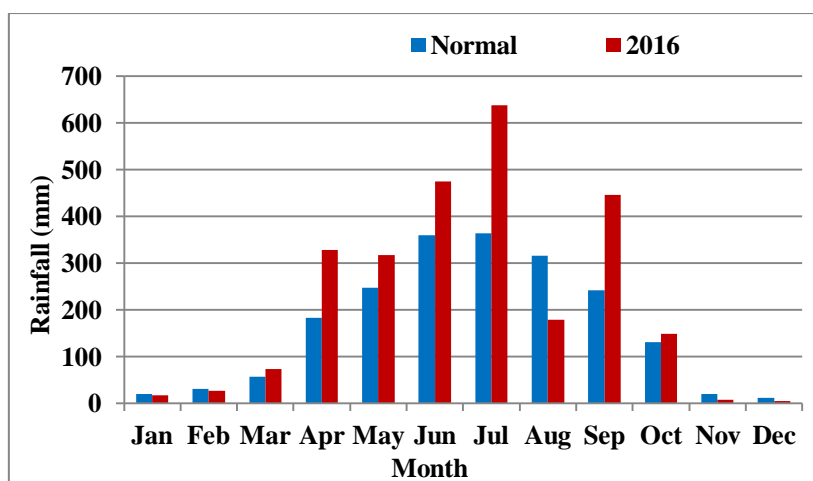


Fig 5.1.2: Normal and actual (2016) monthly rainfall at Chamua village

Dry spells during crop growing season (2016)

| Dry spell | | Crop | Stage of the crop |
|-----------------------|---------------------------------------|-------------------------------------|---|
| Duration (days) | Dates & Months | | |
| 7 | 8 to 14 August | <i>Sali</i> 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 (<i>rabi</i>) | 14 October, 2016 to 19 February, 2017 | Rapeseed, potato, winter vegetables | Flowering/grain filling /tuber formation stages of potato |

Real time contingency practices (RTCP) implemented

| Weather aberration | Crop | Stage of crop | Real time contingency measure implemented |
|----------------------|--|-----------------------------|---|
| Early season drought | <i>Sali</i> rice | Early tillering, vegetative | Supplemental irrigation |
| Mid season drought | <i>Sali</i> rice, turmeric, ginger, potato, rapeseed | Grain filling, vegetative | Supplemental irrigation |

Salient achievements

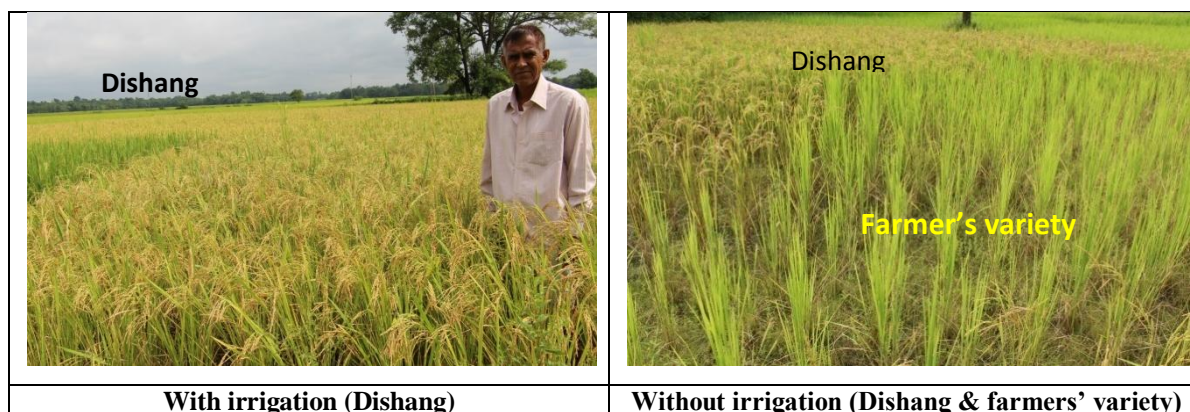
Real time contingency planning

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 | |
| <i>Sali</i> Rice | Dishang | 2380 | 3400 | 42.85 |

**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 Dishang 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

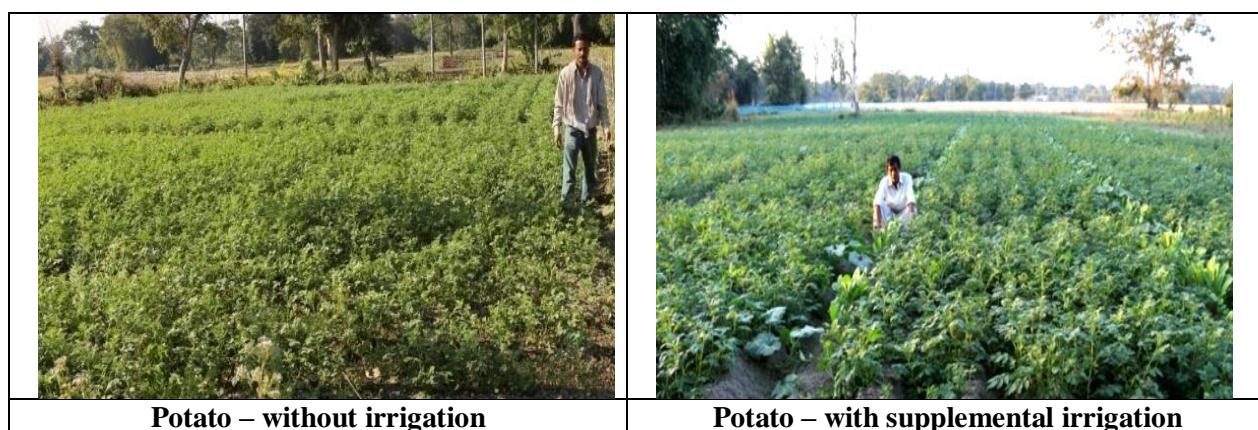
| Crop | Duration (days) | Variety | Yield (kg/ha) | | % increase in yield | Net returns (Rs/ha) | B:C ratio |
|------------------|----------------------|--------------|-------------------------|--------------------------|---------------------|---------------------|-----------|
| | | | With improved practice* | With farmers' practice** | | | |
| <i>Sali</i> 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 from 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* varieties (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 existing 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) | % increase in yield | Net returns (Rs/ha) | B:C ratio |
|----------------|-----------------------|---------------|---------------------|---------------------|-----------|
| | | Direct seeded | | | |
| Direct seeding | <i>Bakul bora</i> | 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

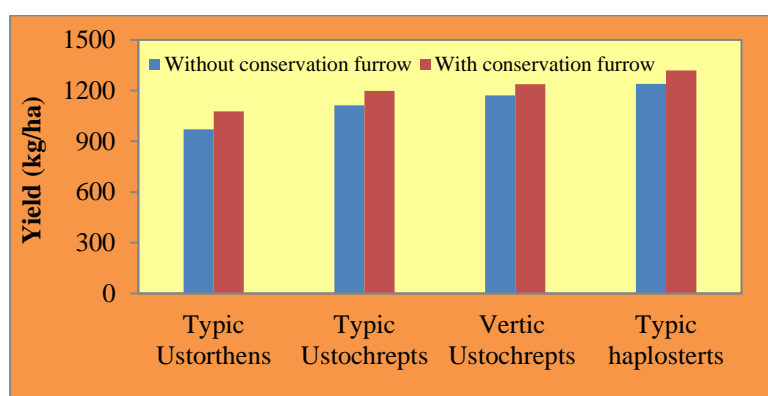


Fig 6.1. Performance of soybean under *in-situ* moisture conservation in various soil types

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).

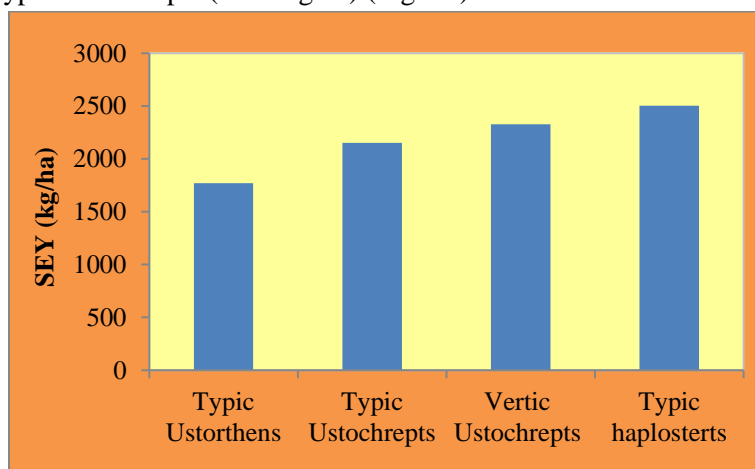


Fig 6.2. Performance of soybean + pigeonpea intercropping system (4:2) in different soil types

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.

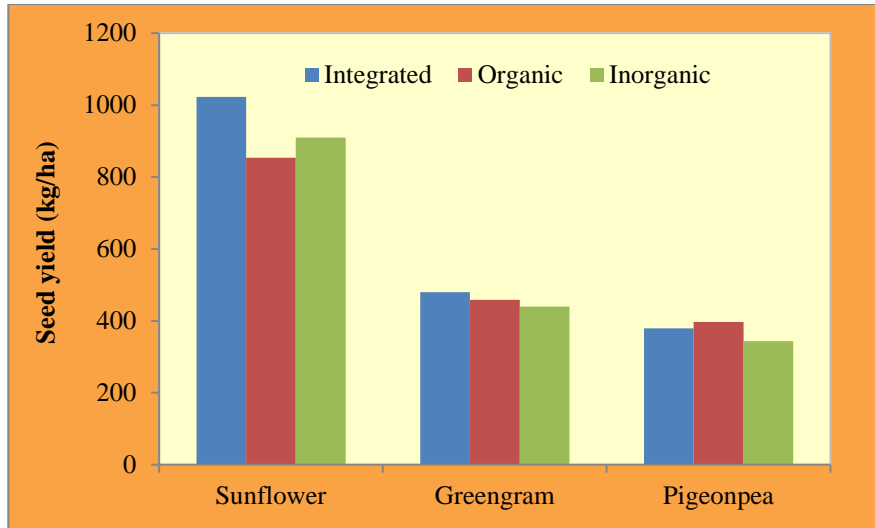


Fig 6.3. Performance of crops under different production systems

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 ($3.13 \mu\text{g TPF/g soil/h}$) and microbial biomass carbon ($236.6 \mu\text{g/g soil}$) 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°C 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 (Ballawal 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 carbendizim 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 Imidachlopid (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 <i>rabi</i> 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 KNO ₃ , 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. |
| | 21.11.2016 | 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 <i>in-situ</i> 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 finger millet | 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 | <i>In-situ</i> 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 | - | - | - |
| | BBF Attachments | Sowing | 07 | - | - | - |
| Tahakapal, Tandapal and Guniyapal 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 decortating | 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 | Hoing | 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, Maharashtra (Solapur) | Phule sheti yantr | Seedling and fertilizing application | 1.0 | 19.0 | 2000 | 1425 |
| | Cycle hoe | Hoing 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 (Jagdapur) | 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 Ballawal 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 | <i>Kharif</i> planning on different themes for NICRA at Chikkaputtayyanapalya, Nelamangala (Taluk) | 61 | 20.05.2016 |
| Parbhani | <i>Kharif</i> crop management | 69 | 22.06.2016 |
| | Crop management | 64 | 26.07.2016 |
| | <i>Rabi</i> 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 |
| | <i>Rabi</i> 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 |
| | <i>Kharif</i> pre-seasonal training programme | 55 | 01.07.2016 |
| | <i>Rabi</i> 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 <i>kharif</i> crops | 21 | 22.07.2016 |
| | Insect pest and disease management in clusterbean and mungbean | 16 | 03.08.2016 |

| | | | |
|---------------|---|-------------|------------|
| | Weeding and pest management in pearl millet 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 <i>rabi</i> crop sowing | 20 | 21.09.2016 |
| | Seed treatments in <i>rabi</i> crops | 16 | 04.10.2016 |
| Rakh Dhiansar | Pre-seasonal training programme for <i>kharif</i> crops | 30 | 19.05.2016 |
| | Pre-seasonal Training programme for <i>rabi</i> 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 <i>Rabi</i> crops | 21 | 27.11.2016 |
| Indore | Management of <i>kharif</i> crops | 20 | 20.07.2016 |
| | Post harvest operations in <i>kharif</i> 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 <i>Kharif</i> season | 53 | 01.06.2016 |
| | Pest management of pink boll worm in cotton crop | 20 | 20.07.2016 |
| | Supplementary fertilizers in <i>Kharif</i> crops | 35 | 09.08.2016 |
| | Supplementary fertilizer and pest management in <i>Kharif</i> 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 |
| Ballawal Saunkhri | Seminar on organic farming | Ballawal 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 | Ballawal 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 | Ballawal Saunkhri | 27.12.2016 | 30 |
| Bengaluru | Performance of Chickpea variety (JG-11) | Kavalagi | 02.01.2017 | 120 |
| Hisar | Sowing and Weed management <i>kharif</i> crops | Balawas | 22.07.2017 | 21 |
| | Field preparation for <i>rabi</i> crop sowing | | 21.09.2017 | 20 |
| | Seed treatments in <i>rabi</i> 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 |
| Jagdapur | 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 **SK** and Balyan **JK**. 2017. Productivity and profitability of mustard under different organic nutrient management practices in Semi-arid region. *Journal of Oilseeds Brassica*, 8 (1):89-94
- Sharma **RK**, 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, Joseph M., 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, Devaranavadgi SB, 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 Nadu. Agricultural Research Station, Kovilpatti, Tamil Nadu. 46 p.
- e) **Book chapters**
- Elamathi S 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, Rangaraj T, Rajeswari M and Sanjivkumar V. 2016. Improved Agronomic practices for rainfed crops in southern zone of Tamil Nadu 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.

8. Project Team of AICRPDA-NICRA

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B. AICRPDA – NICRA Centres

| Production system/centre/PI/Co-PI/ Address | Production system/centre/PI/Co-PI/ Address |
|--|---|
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