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CLIMATE RESILIENT AGRICULTURE: INNOVATIONS AND EXPERIENCES IN KANDI REGION OF PUNJAB

(NICRA 2011-12 to 2016-17)

Vijay Kumar, Vivek Sharma,
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All India Coordinated Research Project for Dryland Agriculture
Regional Research Station
Punjab Agricultural University
Ballowal Saunkhri, District Shaheed Bhagat Singh Nagar, Punjab – 144521

2019

Climate Resilient Agriculture: Innovations and Experiences in Kandi Region of Punjab

(NICRA 2011-16)

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(2019)

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ACKNOWLEDGEMENT

Weather plays animmense role in Indian agriculture. Timely onset and good distribution of rainfall are critical for achieving optimum crop yields by farmers, particularly during Kharif season along with other factors like inputs,labour and technology. The sub-montane North Eastern part of Punjab which falls under agro-climatic zone AESR 9.1 of India is known as *Kandi* Region. Out of the total rainfall in this region, 80 % of it is received during the monsoon season which determines the success of rainfed crops. Any deviation from normal monsoon pattern affects crop production. To develop mitigation strategies for changing climatic scenario the "National Innovation on Climate Resilient Agriculture (NICRA)project" was started at AICRPDA Centre-Ballowal Saunkhri with the financial assistance from CRIDA, Hyderabad during the year 2011-12. The project was started at AICRPDA centre (On-station) for development of technologies and Village Achalpur&Nainwan, Block Garhshankar, District Hoshiarpur for simultaneous testing and dissemination of the technologies developed at AICRPDA centre.During the last five years a number of technologies have been developed and successfully adopted by the farmers in the adopted villages. The overall impact of NICRA during the last five years has been documented in this report.

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Finally, we sincerely thank scientists & supporting staff of Regional Research Station, Ballowal Saunkhri for providing assistance in planning and execution of experiments since inception of this project. We are also thankful to the farmers of the adopted villages for their support.

January, 2019 EDITORS

Ballowal Saunkhri

Contents

1. Background

Climate change impacts on agriculture are being witnessed all over the world, but countries like India are more vulnerable in view of the huge population dependent on agriculture, excessive pressure on natural resources and poor coping mechanisms. The warming trend in India over the past 100 years has indicated on increase of 0.60°C. The projected impacts are likely to further aggravate field fluctuations of many crops thus impacting food security. There are already evidences of negative impacts on yield of wheat and paddy in parts of India due to increased temperature, water stress and reduction in number of rainy days. In India, significant negative impacts have been implied with medium-term (2010-2039) climate change, predicted to reduce yields by 4.5 to 9 percent, depending on the magnitude and distribution of warming. Since agriculture makes up roughly 16 percent of India's GDP, a 4.5 to 9% negative impact on production implies a cost of climate change to be roughly up to 1.5 percent of GDP per year. The Government of India has accorded high priority on research and development to cope with climate change in agriculture sector. The Prime Minister's National Action Plan on climate change has identified Agriculture as one of the eight national missions.

With this background, the ICAR launched a major Project entitled, **National Initiative on Climate Resilient Agriculture (NICRA)** during 2010-11 with PC unit at CRIDA, Hyderabad. The project was initiated with the following objectives:

- To enhance the resilience of Indian agriculture covering crops, livestock and fisheries to climatic variability and climate change through development and application of improved production and risk management technologies
- To demonstrate site specific technology packages on farmers' fields for adapting to current climate risks
- To enhance the capacity building of scientists and other stakeholders in climate resilient agricultural research and its application.

The project along with other centres was also started at AICRPDA centre, Ballowal Saunkhri both at On-station (for development of climate resilient technologies) and On-farm (for testing, refinement as well as popularization of the successful technologies. The technologies developed, tested and refined by AICRPDA centre, Ballowal Saunkhri during the period 2011-2016 has been complied in this technical report.

National Initiative on Climate Resilient Agriculture (NICRA)

1.1 General Information

i.	**Project Code**		**AICRPDA/NICRA/TD/2010**
ii.	**Name of the Centre**	**:**	**Ballowal Saunkhri**
iii.	Name & Address of Centre	:	Regional Research Station (PAU), Ballowal Saunkhri, P.O. Takarla, Tehsil Balachaur, District: SBS Nagar – 144 521 (Punjab)
iv.	Name of ZARS/RRS/RARS/ZRS		Regional Research Station (PAU), Ballowal Saunkhri
v.	Agro-climatic Zone	:	Agro-climatic Zone – I
vi.	Name of SAU	:	Punjab Agricultural University, Ludhiana
vii.	Location of village and address of the operation of the Project	:	
	On-station	:	RRSKA, AICRPDA, Ballowal Saunkhri
	On-farm (Name of village(s), tehsils/blocks/District)	:	Villages – Nainwan & Achalpur Tehsil/block – Garhshankar District - Hoshiarpur
viii.	Project title	**:**	**National Innovations for Climate Resilient Agriculture: Technology Demonstrations in a Participatory Action Research mode**

2. Introduction of Domain area

2.1 Agro-climatic zone

The domain area falls in ACZ-1 of North Eastern Punjab state and AESR 9.1 of India, known as the *Kandi* Region. The area is characterized by erratic distribution of rainfall, delayed onset and an early withdrawal of monsoons with uncertain crop yields. Crop failures are quite common due to moisture stress caused by dry spells. Frequency of extreme weather events has increased in the region and there has been unpredictability in onset, amount, intensity and duration of monsoon rains resulting in considerable effect on crop cycle, disease incidence, maturity time and ultimately yields. The requirement of water for *rabi* and *kharif* crops cannot be met because most of the rainfall occurs in 2½ months only and 40% of this water also gets wasted and rather causes floods. Rain is the ultimate source of soil moisture needed by the crops and it is most unpredictable with regard to onset, intensity and distribution. The major characteristics of the region are sloppy lands with small and fragmented land holdings and uncertain & erratic rainfall. The water table is very deep. The land holding of the farmers are very small and they do not have the economic capacity to install deep tubewells, which result in low productivity of crops grown under these conditions. Average agriculture yield has been only 700 Kg/Hectare against State's 4500 Kg/Hectare. The soils are loamy sand to sandy loam having low moisture retention capacity resulting in un-assured and un-predictable dry farming agriculture.

Soil and water are two most important natural resources and their over-exploitation is continuously degrading the quality of these resources, which have been responsible for poverty and misery of the people of *Kandi* area. Conservation of water resources through adoption of various on-farm water saving technologies can improve water use efficiency thus leading to higher productivity. Efforts are being made to increase the productivity in *Kandi* region through efficient management of all available water resources including harvesting of rain water and its judicious utilization along with integrated nutrient management through combination of organic and inorganic sources of fertilizers, tillage practices, crop residue management, crop diversification, contingency crop planning, intercropping, participatory varietal selection, energy management and farming system research.

2.2 Climate

The climate of the region varies between semi-arid to sub-humid. The average maximum temperature (41 °C) is recorded in first fortnight of June; whereas the minimum temperature (6 °C) is recorded in the month of January. Rainwater constitutes the major water source for crops that becomes scarce due to ill distribution in time and space. The region receives average annual rainfall of 800-1500 mm with a very high coefficient of variation. The highest rainfall is recorded in the Dhar block of the region. About 80% rain occurs in *Kharif* season (July-September) and rest 20% occurs in *rabi* season. A major portion (30-40%) of rain goes as runoff. The frequency of drought in the zone is 1/2 in 5/10 years.

2.3 Soils

Majority of the soils range from loamy sand to sandy loam and have low to medium moisture retention capacity and are highly erodible having gentle to moderate slope. Arable lands generally belong to class II and class III of land use capability classification. The inherent fertility of the soils of this area is very low. The and hence is highly dispersible and erodible. These are low in organic carbon (<0.04%) & nitrogen, low (5-10 kg P_2O_5 ha^{-1}) to medium (11-20 kg P_2O_5 ha^{-1}) in available phosphorus and medium in K (118-280 kg K_2O ha^{-1}).

The region is characterized by small and scattered land holdings, deforestation because of heavy biotic pressure, crop failure and uncertain yields, poor quality of livestock, shortage of fuel and fodder, poverty, backwardness, drudgery of women and lack of infrastructure facilities. However, the region comprises of natural forests rich in floral & faunal biodiversity. The region is popularly known as *Kandi* area and draws great attention of the different agencies for its sustainable development.

2.4 Crops and cropping systems

Maize is the principal crop of *Kandi* area and occupies about 46 thousand ha. Pearl millet, green gram, black gram and sesame are the other important *kharif* crops. In addition to these crops rice and groundnut are also sown in the region in some pockets. Wheat, raya, taramira, lentil and gram are major *Rabi* crops. The other emerging *rabi* crops in the region are gobhi sarson, toria, African sarson, linseed, arhar. Maize-wheat and maize-wheat + raya/gram are the predominant cropping systems but maize-raya, black gram - raya, pearl millet-wheat cropping systems are also in practice.

Amla, ber, guava, mango and galgal are the major fruits of the region. The minor fruits of area are: bael, harad, bahera, jamun, kathal and karonda. The *kandi* area dominates in natural forest area in the entire Punjab and is rich in floral and faunal biodiversity. The animal husbandry is the main allied enterprise, buffalo is dominant livestock. In some areas sericulture, apiculture and pisciculture.

The major pest and disease incidence in the region include: i) blister beetle during Aug-Sept in greengram, pearlmillet, maize and blackgram; ii) borer in maize; iii) termite during *rabi* season, especially in wheat; iv) yellow rust in wheat v) wilt in chickpea; vi) citrus psylla in citrus; vii) phyllody in sesame.

Animal and bird damage, e.g. wild pigs at sowing and maturity, parrot attack in late sown maize and peacock, rabbits, *seh* damages wheat, barley, triticale and chickpea crops just after emergence. Throughout the year damage by stray cattle and wild animals is common in the region.

2.5 Socio economic characteristics

People of the area are generally poor, illiterate and tradition bound. They are little conversant with the improved technologies. The land holdings are small, fragmented and are generally degraded and poor in productivity. Majority of the farmers in this region are having holding of <2 ha which exist in small fragmented pieces. The farmers' capacity to invest is very limited. The farmers generally do not use inputs needed for high production viz., fertilizer, insecticides, pesticides and weedicides and improved seeds because of (i) uncertainty about the return due to crop failure (erratic rainfall), (ii) poor economic condition and (iii) lack of awareness about improved technology (extension gaps). In the *Kandi* area almost equal numbers to land holders are landless people and landless people work as daily paid labourers. Farming as profession even with land holders is a subsidiary occupation, about 40% of them work at their farms and others go to cities for earning their livelihood. In addition to this, the inhabitants of the area depend for their livelihood on subsidiary occupations viz., bee-keeping, basket and rope making, pisciculture, poultry and piggery, etc. However these cottage industries units are not scientifically managed

2.6 Problems/constraints in rainfed agriculture in the doamin districts:

2.6.1 Erratic rainfall with long rainless days

The area receives average annual rainfall of 800-1500 mm with a very high coefficient of variation. About 80% rain occurs in *Kharif* season (July-September) and rest 20% occurs in *rabi* season. These rains are more uncertain at the time of sowing and drought occurs frequently, even during rainy season. The probability of expecting at least one dry spell of >6 days during individual months varies between 55 to 98%. The rainfall in June (pre-monsoon showers) is quite uncertain and often delays the *Kharif* sowing, resulting in decreased yields. Early withdrawal of monsoon is common in this region, resulting in severe drought during late part of the *Kharif* season. It also affects the stand establishment of the next *Rabi* crop as the upper soil layer dries up by the sowing time. Sometimes, it becomes impossible to sow a *Rabi* crop on residual moisture due to inadequate soil water in seed zone.

2.6.2 Soil and water erosion

The land in the area is undulating and has three distinct physiographic unts viz., hilly, choes (seasonal streams) and the area lying between the two and is usually cultivated. Gullies and rills are commonly found in the area. The organic carbon (<0.04%) is low and hence soil is highly dispersible and erodible. A major portion (30-40%) of rain goes as runoff resulting in water erosion.

2.6.3 Poor inherent fertility of the soils along with inadequate supply of nutrients

The inherent fertility of the soils of this area is very low. The organic carbon (<0.04%) is low. These are deficient in nitrogen, low to medium in available phosphorus and medium in K. Farmers do not use adequate amount of nutrients to the crops because of uncertainly of rainfall and their poor buying capacity.

2.6.4 Small and fragmented land holdings

The land holdings are small, fragmented and are generally degraded and poor in productivity. Majority of the farmers in this region are having holding of less than 2 ha.

2.6.5 Low and unstable crop yields

Due to erratic rains, poor fertility of soil, soil and water erosion and damage to crops by wild animals, the productivity of the crops is low and unstable.

2.6.6 Poor mechanization of farming

The farmers are still dependent on the bullocks for different field operations. Their farm machinery status is poor mainly due to their poor economic status and unstable returns from the crops. Also the implements required for small land holdings and smaller fields are not available.

2.6.7 Insect-pest problem

The major insect-pests of the area are: stem borer in maize, termite in wheat, aphids in mustard and hairy caterpillars in moong and mash.

2.6.8 Wild life damage

Monkey, wild and stray cattle menace is becoming a major threat to crops in the region. Wild and stray animals particularly in the area adjoining the forests and barren lands from sowing to harvesting of crops cause severe damage. Even farmers are not cultivating the fields which are adjacent to the forest area. The net returns are sometimes negligible or even sometimes negative in case crop is completely damaged by the animals.

2.6.9 Lack of adequate infrastructure

Means of transport are much less than in the developed area and the people largely depend upon their own inputs like seeds and manures and use very less improved seed, fertilizers, chemicals and insecticides.

2.6.10 Poor dairy animal breeds and nutritional status

Dairy and crop framing is the principal occupation of 28.9% of landless and 41.4% of marginal farmers. Dairy farming has been recognized as a viable option for improving economic condition of human population of Kandi area. Optimal general health, nutrition and reproduction are three corner stones for achieving optimal production potential. Often, reasons quoted by dairy farmers for not increasing herd size were fodder scarcity, low production and losses due mortality and poor health. Surveys show that Infectious, non-infectious and poisonings were the common cause of mortality. Isolated studies show mineral deficiencies and malnutrition were prevalent in dairy animals of the region. The breeds of the dairy animals are also not good in this region as the animals of the good breeds are costly and due to low income and risk bearing capacity of the farmers of the region they are not able to procure these animals which results in less milk production and ultimately affects the net returns.

3. AICRPDA Centre, Ballowal Saunkhri

Regional Research Station, Ballowal Saunkhri (Shahid Bhagat Singh Nagar) is a constituent unit of Punjab Agricultural University, Ludhiana (Punjab). In order to address the problems of rainfed agriculture production system, the All India Coordinated Research Project for Dryland Agriculture (AICRPDA) was initiated in 1970 at PAU, Ludhiana campus and shifted to Ballowal Saunkhri in1990 along with an Operational Research Project on watershed approach. This centre represents one of the 25 AICRPDA centres spread over the rainfed regions of the country with headquarter at Hyderabad. The project has mandate to generate location specific technologies through on-station research focusing rainwater management, soil & water conservation, integrated nutrient management (INM), cropping systems, crop improvement, energy management, alternate land use and farming systems under rainfed maize-based production system of *Kandi* region of Punjab. Under the State plan/Non-plan Research, the station has lead function to work on land and water management, arable cropping systems, horticulture & agro-horticulture, agro-forestry, livestock management; testing and verification functions and special function including trainings and technology dissemination.

3.1 Mandates of the Centre

i. Develop and promote technologies towards minimizing soil & water loss, degradation of environment and optimize use of natural resources.

ii. Develop technologies to substantially increase crop productivity and viability.

iii. Increase stability of crop production over years by improved crop management and alternate crop production technologies matching weather aberrations.

iv. Evaluation of traditional farming systems and study transferability of improved dryland technologies to farmer's field.

3.2 Operational area of NICRA project

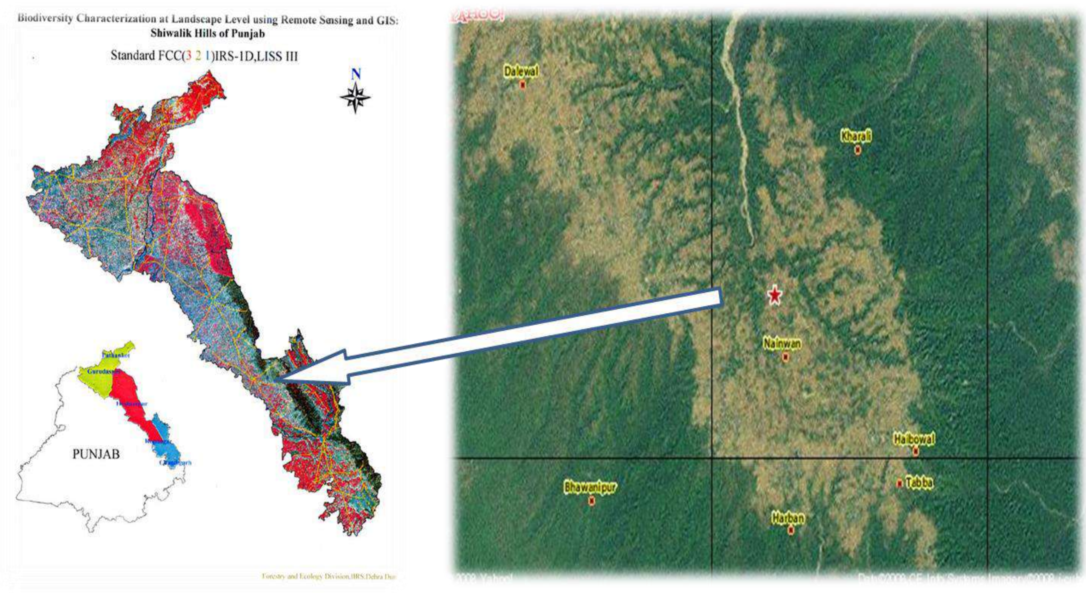
A team of scientists ICAR, ORP and RRS, Ballowal Saunkhri visited the villages and collected the basic information. Based on this information, interaction with farming community and secondary source data, the villages undertaken in this project are: Nainwan & Achalpur (Hoshiarpur) due to following reasons:

- The livelihood of the villagers depends mainly on crop production under rainfed condition due to meagre water resources.
- Majority of farmers are not following the recommended packages of practices.
- Maize-Wheat is the main cropping system while, area under oilseed and pulses is less. The productivity of crops and cropping systems is below the expected potential.
- There is need to evolve short duration drought tolerant varieties under aberrant weather condition and seed of these varieties should be made available to farmers well in time.
- Little awareness regarding moisture conservation and rainwater harvesting including production technologies of rainfed crops
- Lack of awareness regarding contingent crop planning.
- Limited knowledge regarding balance nutrition to milch animals and not improved livestock.
- Scarcity of green fodder during *rabi* season and there is need to introduce high biomass producing multicut fodder grasses.
- Economically farmers are not in a position to have farm machinery therefore there is need to establish custom hiring system having farm tools which are required for farming operations.
- Crops are damaged by wild/stray animals, hence there is need to introduce such crops / varieties which are least damaged by animals.
- Sustainable alternate land use / farming system is viable for the climatic change.
- Inadequate knowledge of pest control measures.
- Regular agro advisories to protect the crops/ trees from adverse climatic conditions.

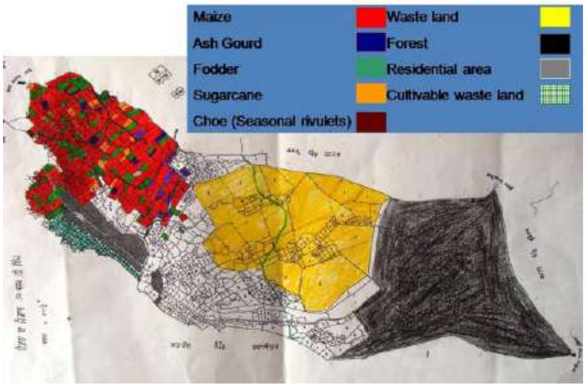
3.2.1 Brief description of NICRA village

The program is being implemented at the villages Achalpur and Nainwan in Tehsil Garhshankar of district Hoshiarpur, Punjab, which is approximately 35 km from RRS, Ballowal Saunkhri. The total cultivated area in Achalpur is 145.2 hectares out of which 102.2 are rainfed similarly, in Nainwan out of 320.0 hectares cultivated ares 288.5 hectares is rainfed. 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) in texture. The major crops in *kharif* season under rainfed area are Maize and sorghum and in *rabi* season wheat, raya and taramira. The small, marginal, medium and large farmers are 86, 11, 3 and 0 per cent in Achalpur and 76, 13, 6 and 5 per cent in Nainwan, respectively. Only one tube well is available in each village as a source of irrigation, which is covering approximately 10 per cent of cultivated area.

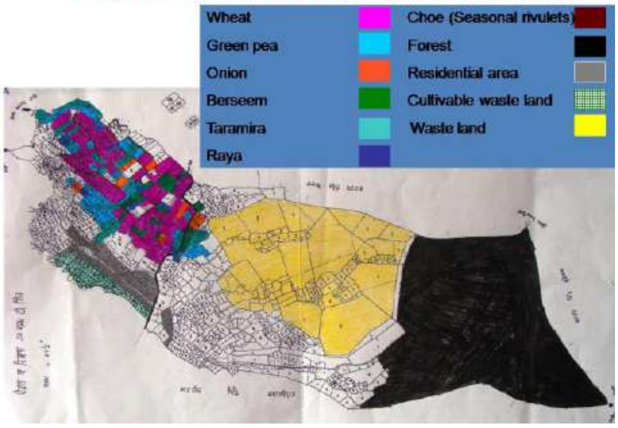
Village : Nainwan and Achalpur Tehsil Garh shankar Distt Hoshiarpur Punjab			
Location	Altitude	Agroclimatic Zone	Agro-ecological sub region AESR 9.1
N 31^{o} 14.55’ E 76^{o} 18.16’	493 m	Zone-I	Sub-mountain (Shiwalik hills)

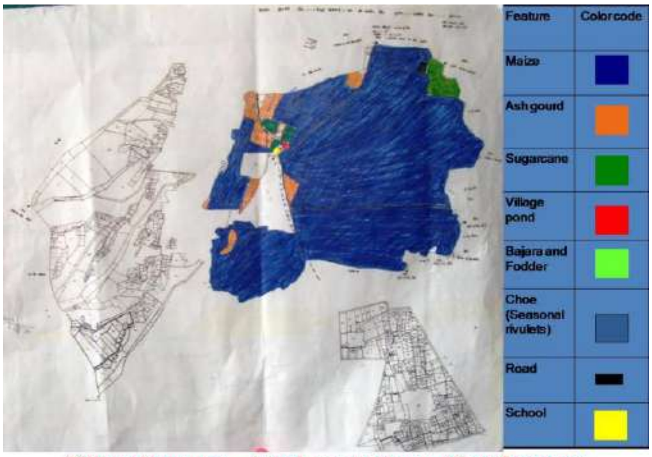


Village Achalpur – Land use pattern - Kharif season



Village Achalpur – Land use pattern – Rabi season





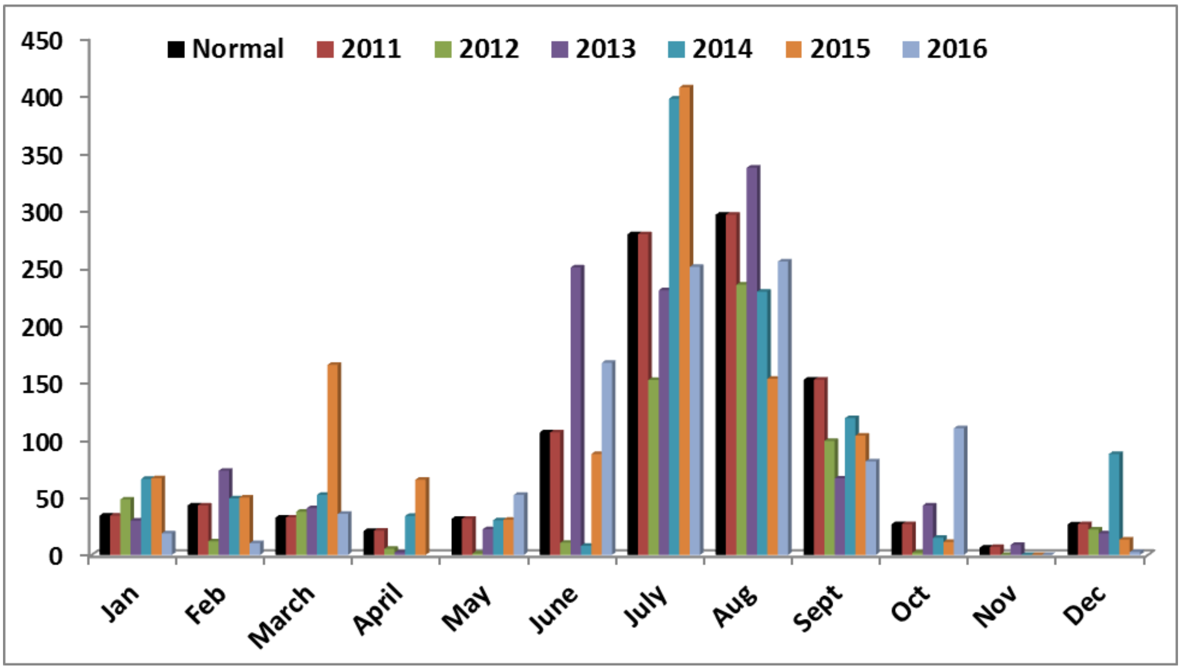
Village Nainwan – Land use pattern - Kharif season

Detail of the villages covered under NICRA projects i.e. Achalpur and Nainwan

Name of the village	Total area of the village (ha)**	No of farmers/ land holdings*	Rainfed Area (ha)**	Cultivated area (ha)**	Waste land Area (ha)**	Soil Type
Nainwan	576.4	397 Land less:149 <1 ha: 146 1-2 ha:55 2-4 ha: 28 >4 ha: 19	288.5	320	256.4	Silt loam (sub soil silty clay loam)/ Typic Haplustept
Achalpur	348	230 Land less: 75 <1 ha: 122 1-2 ha: 23 2-4 ha: 10	102.2	145.2	202.8	Silt loam (sub soil silty clay loam)

* Based on PRA of Village ** Based on Revenue record, October 2011

3.2.2 Weather experienced during 2010-16 in NICRA village



4. Broad Objectives of AICRPDA - NICRA Project at Ballowal Saunkhri

4.1 Real time Contingency Plan implementation both on- station and on-farm in a Participatory mode

The *Kandi* area is characterized by erratic distribution of rainfall, delayed onset and an early withdrawal of monsoon, light and medium textured soils with poor water retention capacity, uncertain crop yields. Crop failures are common due to moisture stress caused by dry spells. Frequency of extreme weather events has increased in the region and there has been unpredictability in the onset, amount, intensity and duration of monsoon rain resulting in considerable effect on crop cycle, disease incidence, maturity time and ultimately yields. Keeping in view of above situations, sub-project is planned to find out suitable seasonal crops/varieties which can tolerate early or late season drought and ensure crop productivity thus improving the economic conditions of Kandi farmers.

Objectives

1. To evaluate adaptation of drought tolerant short duration varieties
2. To evaluate adaptation of the efficient crop and cropping systems with best bet practices (i*n situ* moisture conservation practices , INM, IPM, IWM etc) which provide resilience to climate variabilities.

3. To develop and disseminate Agro-advisories through ICTs (information kiosks) combining the village level weather data linked to district advisory issued by the IMD/SAU

4.2 Rainwater harvesting *(in situ and ex situ)* and efficient use

Kandi region receives more than 1000 mm annual rainfall. About 80 % of this is received during monsoon season of which 30-40 % goes off as runoff. It has been observed that even under good conservation management, about 20% of summer rains will essentially go as runoff. One way of dealing with this situation is to direct the runoff from upper area to lower valley land or dug out pond and allow harvesting rain water. Runoff water retention proved to be a promising way to change temporarily the moisture status of the soil and to cause a large change in grass and vegetative characteristics and productivity. Therefore, runoff harvesting has potential in improving production in rainfed areas. The harvested rain water to be used efficiently (drip or sprinkler) to provide life saving irrigation to combat with adverse climatic conditions.

Objectives

1. To find out catchment-storage-command relationships of farm ponds
2. To demonstrate efficient *in situ* moisture conservation practices to overcome short dry spells
3. To recycle the silt from tanks and near check dams to crop lands for enhancing water productivity and soil health
4. Efficient use of harvested water by supplemental irrigation to rainfed crops through micro-irrigation systems (MISs)
5. Adoption of ground water recharge (open and wells) and sharing practices at whole village level

4.3 Efficient Energy use and Management

The land holdings in this region are small, fragmented and are generally degraded and poor in productivity. Majority of the farmers in this region are having holding of less than 2 ha. There is poor mechanization of farming as the farmers are still dependent on the bullocks for different field operations. Their farm machinery status is poor mainly due to their poor economic status and unstable returns from the crops. Therefore, concentration of agricultural operations coincides for all farmers during the field preparation, sowing, weeding and harvesting period or for any contingent situation. This leads to shortage of labour, farm implements, bullock pairs and other farm resources which adversely affect crop production. Also the topography of the region does not support mechanization to the extent prevalent in other regions of the state. This debars the local farmers from availing the benefits of mechanization available for cultivation, sowing, harvesting, threshing etc. This problem can be solved to some extent by the practice of custom hiring. Many implements and machines are available at affordable rates for use, procuring for which otherwise at an individual farmer level is not feasible. Also these implements, machines etc. can be bought at village level by forming cooperatives and promoting custom hiring system at nominal charges.

The various implements and machines those can be made timely available on custom hiring are: tractor, tiller, disc harrow, rotavator, laser leveler, thresher, seed drill, ridger, tractor operated plant hole digger etc.

Objective

1. Popularizing of suitable manual tools and implements, bullock/ tractor drawn implements for various operations through Custom hiring

4.4 Alternate Land Use / Farming systems for carbon sequestration and ecosystem services

The erratic rains results in frequent crop failures thus threatening the economy of the stakeholders of the region. Thus a system is needed that can provide economic security to the farmers. The farmers are already in the practice of traditional agro-forestry. *Acacia nilotica* (Kikar) a native tree is associated with crops in the region. However, the fast growing trees (*Melia composita*, *Leucaena leucocephala* etc.) those are draught tolerant and well adaptive to the area can be associated with recommended crops. These trees ensure economic returns to the farmers in spite of frequent crop failures. Besides the benefit of biomass productivity this will provide opportunity of carbon trading in near future to the growers. In addition to this trees can be associated with the fast growing grass (*Pennisetum purpureum, Eulaliopsus binata, Panicum maxicum, Sachharum munja, etc.*) with high productivity for developing silvipastoral model for marginal lands. *Leucaena leucocephala* has high potential to produce biomass for energy in the region besides rehabilitating the denuded and degraded lands and bringing good returns to the farming community.

Objectives

1. Use of CPRs (common pool resources) and PPR (private property resources) for fodder and other commodity and service needs
2. To strengthen the traditional farming systems and demonstrate the efficient farming systems

5. Brief details of onset of monsoon, annual/seasonal rainfall, dryspells at different stages of crops, excess rainfall events etc.

Year	Onset of monsoon (normal/delay by how many days)	No. of rainy days		Excess rainfall events/floods	
		Normal	Actual	Duration, dates and month	Crop(s) & stage(s)
2011	28th June (Normal)	51	51	12th August	Vegetative growth
2012	6th July (Normal)	51	42	No event occurred	
2013	25th June (Normal)	51	58	8th August	Maize: vegetative growth
2014	1st July (Normal)	51	54	16th July	Maize: vegetative growth
2015	29th June (Normal)	51	60	24thAug -15th Sept.	Maize (silking)
2016	27th June (Normal)	51	45	6th July – 14th July	Germination

Dry spells during crop growing season

(2011-12)

Dry spell		Crop	Stage of the crop
Duration	Dates & Months		
12 days	19th July to 31th July	Maize	Vegetative growth
79 days	17th Sept to 5th Dec.	Maize Rabi crops	Dough/Maturity Sowing & Germination

* Early Season drought was experienced in kharif crops

(2012-13)

Dry spell		Crop	Stage of the crop
Duration	Dates & Months		
83 days	18th Sept. to 10th Dec.	Maize Rabi crops	Dough/Maturity Sowing & Germination

* Terminal drought was experienced in kharif crops

(2013-14)

Dry spell		Crop	Stage of the crop
Duration	Dates & Months		
15 days	05/10/2013 to 29/10/2013	Maize	Maturity
32 days	08/11/2013 to 20/10/2013	Rabi crops	Sowing & Germination

* No drought was experienced in kharif crops

(2014-15)

Dry spell		Crop	Stage of the crop
Duration	Dates & Months		
15 days	16/08/2014 to 29/08/2014	Maize	Vegetative growth
13 days	07/09/2014 to 20/09/2014	Maize	Silking
60 days	14 /10/2014 to 12/12/2014	Rabi crops	Sowing & Germination

* Mid Season drought was experienced in kharif crops

(2015-16)

Dry spell		**Crop**	**Stage of the crop**
Duration	**Dates & Months**		
23 days	23 Aug -16 Sept	Maize	Silking / Dough
		Mash/moong	Flowering/pod formation
		Sesame	Flowering/pod formation
47 days	26 Oct. – 11 Dec	rabi crops	Sowing & Germination
32 days	12 Dec – 12 Jan	rabi crops	Sowing & Germination

* Mid Season drought was experienced in kharif crops

(2016-17)

Dry spells		**Crop**	**Stage of the crop**
Duration (Days)	**Dates & months**		
9 days	6th July – 14th July	Maize	Germination

In order to meet out the above set objectives and different weather abberrations annual technical programme were formulated and implemented both at On-station and On-farm from 2011-12 to 2016-17. This technical programme was implemented by the team of scientists from AICRPDA centre, Ballowal Saunkhri alongwith the scientists from RRS, Ballowal Saunkhri. The detail of the technical programmes implemented at On-station from 2011-17 is given below:

6.0 Technical Programme On-Station from 2011-12 to 2016-17

2011-12

Theme	Programme Title (Technology) and Objectives
Real time Contingency Plan Implementation	**Programme 1:** Demonstration of drought management practices under climate change situation **Technology :** Contingent crop plan for maize/pearlmillet/sorghum/ Ash gourd-wheat/oilseeds **Objectives:** • To demonstrate the performance of crops under contingent situation.
	Programme 2: The most efficient intercropping systems which provides resilience to climate variability **Technology :** The most efficient intercropping systems Wheat/Lentil/Chikpea + Raya rows **Objective**: • To demonstrate the performance of potential intercropping systems for stability under varied rainfall situation.
Rain water harvesting (*in situ and ex situ*) and efficient use	**Programme 1:** Catchment – storage – command relationship of farm ponds/ WHS **Technology :** Supplemental irrigation to rainfed crops from harvested water **Objective:** • To demonstrate usefulness of WHS/farm pond and it's lining for *ex situ* runoff collection and efficient use.
	Programme 2: In-situ rain water harvesting **Technology:** Summer ploughing, Compartmental bunding, sowing across the slope followed by earthing-up 25-30 DAS. **Objectives:** • To demonstrate effect of proven in-situ rainwater conservation technology in dryland crops
	Programme 3: Rain water harvesting **Technology:** Harvesting rain water from roof top. **Objectives:** • To demonstrate effect of roof top rain water harvesting on groundwater recharge
Efficient energy use and Management	**Programme 1** : Popularization of improved farm implements (tractor/ bullock drawn/manual) **Technology :** To make availability of farm implements to the farmers by developing custom hiring service. **Objectives :**

	• To minimize climatic risk through efficient use of machinery for enhanced resource conservation and use efficiency. • To increase energy use efficiency in crop production through mechanization. • To ensure timely agriculture operations for effective management of weather situations.
	Programme 2 : Reduced tillage crop productivity in maize-wheat cropping sequence under dryland conditions **Technology :** Reduced tillage (50%) will be compared with that of conventional tillage. **Objectives :** • To study the effect of tillage on productivity of rainfed maize and wheat • To study the long-term effect of tillage on the physico-chemical properties of soil and carbon sequestration
Alternate land use for carbon sequestration and ecosystem services	**Programme 1:** Agri-horticulture system **Technology :** • Recommended fruit tress • Seasonal crops **Objectives :** • Rehabitation of land to meet needs of local inhabitants for fruit, fodder, fuel & timber • Carbon sequestration and carbon crediting benefits to poor farmers
	Programme 2: Silvi-pastoral system **Technology :** • Multi-purpose trees • Grasses **Objectives :** • To make available fodder & fuel besides rehabilitating marginal land • To enhance income of farmers and make base lands more productive
	Programme 3: Farm forestry **Technology:** Boundary plantation of recommended forest trees **Objectives:** • To enhance income of farmers by using bunds
	Programme 4: Integrated farming system **Technology:** 1) Efficient utilization of harvested rainwater through pumping. 2) Minimizing the percolating water by lining of the farm pond. **Objectives :** • To recycle the harvested water for life saving irrigation of different crops, trees and biomass production.

2012-13

<table>
<tr><th>Theme</th><th>Programme Title (Technology)
and Objectives</th></tr>
<tr><td>Real time Contingency Plan Implementation</td><td>Programme 1:
Demonstration of real time crop contingency under aberrant weather conditions
Technology :
• Crop substitution under aberrant weather conditions as per crop contingency plan
Objectives:
• Intervention of technologies to improve the performance of crops under aberrant weather conditions.</td></tr>
<tr><td></td><td>Programme 2:
The most efficient intercropping systems/cropping sequence which provides resilience to climate variability
Technology :
1. Intercropping:
Kharif: maize + blackgram/ greengram
Rabi: Toria + gobhi sarson
Wheat/chickpea/lentil + raya
2. Cropping sequence:
i) Traditional (maize-wheat)
ii) Blackgram-raya
iii) Blackgram-chickpea
iv) Maize-raya
v) Ashgourd-taramira
Objective:
• To demonstrate the performance of potential intercropping systems/cropping sequence for stability under varied rainfall situation.</td></tr>
<tr><td></td><td>Programme3:
Evaluation of drought tolerant varieties
Technology:
Maize: Local, PMH-2, JH-3459, Parkash,
Mash: Mash-338, local
Moong: ML-613, local
Wheat: PBW-175, PBW-644, local
Raya: RLM-619, PBR-97, local
Taramira: TLMC-2, local
Chickpea: PBG-1, PBG-5, local
Lentil; LL-699</td></tr>
<tr><td>Rain water harvesting (in situ and ex situ) and efficient use</td><td>Programme 1:
Catchment – storage – command relationship of farm ponds/WHS
Technology :
Life saving/supplemental irrigation to rainfed crops from harvested water
Objective:
• To demonstrate usefulness of farm pond/WHS and it's lining for ex situ runoff collection and efficient use.</td></tr>
<tr><td></td><td>Programme 2:
In-situ rain water harvesting Technology:
Summer ploughing, Compartmental bunding,
sowing across the slope, earthing-up/Haloding in maize 25-30 DAS.
Objectives:</td></tr>
</table>

	• To demonstrate effect of proven in-situ rainwater conservation technology in dryland crops
	Programme 3: Rain water harvesting **Technology:** Harvesting rain water from roof top. **Objectives:** • To demonstrate effect of roof top rain water harvesting on groundwater recharge
Efficient energy use and Management	**Programme 1** : Popularization of improved farm implements (tractor/ bullock drawn/manual) **Technology :** To make availability of farm implements to the farmers by developing custom hiring service. **Objectives :** • To minimize climatic risk through efficient use of machinery to enhanced resource conservation and use efficiency. • To increase energy use efficiency in crop production through mechanization. • To ensure timely agriculture operations for effective management of weather situations.
	Programme 2 : Effect of Reduced tillage on crop productivity in maize-wheat cropping sequence under dryland conditions **Technology :** 1. Conventional Tillage (CT) 2. Reduced tillage (50% of CT) **Objectives :** • To study the effect of tillage on productivity of rainfed maize and wheat • To study the long-term effect of tillage on the physico-chemical properties of soil and carbon sequestration
Alternate land use for carbon sequestration and ecosystem services	**Programme 1:** Agro-horticulture system **Technology :** • Recommended fruit trees (guava and amla) • Seasonal crops (blackgram, sesame, lentil, taramira, raya) **Objectives :** • Rehabilitation of land to meet needs of local inhabitants for fruit, fodder, fuel & timber • Carbon sequestration and carbon crediting benefits to poor farmers
	Programme 2: Silvi-pastoral system **Technology :** • Multi-purpose trees • Fodder Grasses (Guinea grass, *Cenchrus sp. Napier Bajra Hybrid*) **Objectives :** • To make available fodder & fuel besides rehabilitating marginal land • To enhance income of farmers and make base lands more productive
	Programme 3: Integrated farming system **Technology:** 3) Efficient utilization of harvested rainwater through pumping in farming system. 4) Minimizing the percolation losses by lining of the farm pond. **Objectives :** • To recycle the harvested water for life saving irrigation of different crops, trees and biomass production.

2013-14

Sl. No	Code	Interventions	Crops/Treatments
A. **ON-STATION**			
Theme 1 : Real time contingency planning			
1	BALO/N/OS/RTC/2013	Evaluation of improved varieties of *kharif* crops	<u>Crops</u> <u>Varieties</u> Maize: Prakash, JH 3459, Local Blackgram: Mash 338, Mash 114 Local
2	BALO/N/OS/RTC/2013	Evaluation of improved varieties of *rabi* crops	<u>Crops</u> <u>Varieties</u> Wheat PBW-175, PWB- 644, Local Raya PBR-97, RLM-619, Local Chickpea PBG-1, PBG-5, Local Taramira LMC-2, Local Lentil LL-699, Local
4	BALO/N/OS/RTC/2013	Evaluation of improved intercropping systems	*Kharif* : • Maize sole • Maize + Blackgram • Maize + Greengram *Rabi* : • Wheat sole • Wheat + Raya • Wheat + Chickpea
5	BALO/N/OS/RTC/2013	Evaluation of maize based double cropping system	**Improved practice** : • Maize (Prakash) – Taramira (TMLC-2) • Maize (Prakash) – Raya (RLM-619) • Maize (Prakash) – Lentil (LL- 699) • Maize (Prakash) – Wheat (PBW-175) **Framers' practice :** Maize (Local) - Wheat (Local)
Theme 2 : Rainwater Management (*in-situ* & *ex-situ*)			
6	BALO/N/OS/RWM/2014	Effect of sowing on yield of maize and *in-situ* rain water harvesting	Treatments : • With summer plough • Without summer plough • Sowing across slope • Sowing along slope • No earthing up • Earthing up with wheel hoe
Theme 3: Soil Health and Conservation Agriculture			
8	BALO/N/OS/SHCA/2013	To maintain soil health with appropriate soil and crop management	Linked with PMTs
Theme 4 : Alternate Land Use Systems			
9	BALO/N/OS/AL	Evaluation of amla	Treatments :

	U/2014	and guava based agri-horti systems	• Guava + Greengram • Greengram • Amla + Greengram [*kharif* season] • Guava + Taramira • Guava [*rabi* season]

2014-15

Theme	**Experiment/ Demonstrations**	**Treatments**
Real time contingency planning	Demonstration of improved varieties of *kharif & rabi* crops	<u>Crops</u> <u>Varieties</u> ***Kharif* season** Maize: Prakash, PMH 2, Local Blackgram: Mash-338, Mash-114 Greengram: PAU 911, ML 818 Sesame: RT 346 Pearlmillet: FBC 16 ***Rabi* season** Wheat : PBW-660, PWB- 644 Raya: PBR-97, RLM-619 Chickpea: PBG-1, PBG-5, PBG 7 Taramira: TLMC-2 Lentil: LL-699, LL 931
	Evaluation of improved intercropping systems	*Kharif* : • Maize sole • Maize + Blackgram • Maize + Greengram *Rabi* : • Wheat sole • Wheat + Raya • Wheat + Chickpea
	Evaluation of maize based double cropping system	Improved practice : • Maize– Taramira • Maize– Raya • Maize– Lentil • Maize– Wheat
Rainwater Management (*in-situ* & *ex-situ*)	Effect of sowing on yield of maize and *in-situ* rain water harvesting	Treatments : • With summer plough • Without summer plough • Sowing across slope • Sowing along slope • No earthing up • Earthing up with wheel hoe
	Rain water harvesting in farm ponds and efficient utilization	• Storing of excess runoff water in the farm pond for effective use for high value crops

		• Supplemental irrigation of wheat/raya/taramira at critical growth period
	Effect of sowing methods on the performance of maize, blackgram and greengram	Treatments : • Ridge and furrow planting • Flat planting

2015-16

Sl. No.	Code	Interventions	Crops/Treatments
A. ON -STATION			
a. Real Time Contingency Plan Implementation			
1	BALO/N/OS/RTC/2015-18 AK VK AS	RTCP under delayed onset of monsoon	Block No. 2 (Delayed onset of monsoon) Crops: *Kharif* –Alternate crops like Blackgram, Sesame & Pearlmillet (fodder)
2	BALO/N/OS/RTC/2015-18 AK VK AS	RTCP under normal sowing and early season drought	Block No. 1 (Normal Sowing) Crops: *Kharif* -Maize, *Rabi*- Wheat Contingency measures for early season drought in maize: T1: No intervention T2: Crop residue Mulching T3: Foliar spray of 1% KNO3 T4: Reduction in plant population T5: T2+T3 T6: T2+T4 T7: T3+T4 During *rabi* season seed priming with water, molybdenum, thiourea, KH_2PO_4, foliar spray of thiourea etc. will be done.
3	BALO/N/OS/RTC/2015-18 AK VK AS	RTCP under normal sowing and mid season drought	Block No. 1 (Normal Sowing) Crops: *Kharif* -Maize, *Rabi*- Wheat Contingency measures for mid season drought: T1: No intervention T2: Crop residue Mulching T3: Foliar spray of 1% KNO3 T4: Reduction in plant population T5: T2+T3 T6: T2+T4 T7: T3+T4

<table>
<tr><td></td><td></td><td></td><td>During rabi season seed priming with water, molybdenum, thiourea, KH_2PO_4, foliar spray of thiourea etc. will be done.</td></tr>
<tr><td>4</td><td>BALO/N/OS/RTC/2015-18

AK
VK
AS</td><td>RTCP under normal sowing and terminal drought</td><td>Block No. 1 (Normal Sowing)
Crops: Kharif -Maize,
Rabi- Wheat
Contingency measures for terminal drought:

1. Farmer practice
2. Detasseling in maize
3. Foliar spray of 1% KNO_3
4. Detasseling + Foliar spray of 1% KNO_3
5. Harvesting and vertical staking
6. Harvesting of green cobs and stalks as fodder.
During rabi season seed priming with water, molybdenum, thiourea, KH_2PO_4, foliar spray of thiourea etc. will be done.</td></tr>
<tr><td colspan="4">b. Preparedness</td></tr>
<tr><td colspan="4">Theme 1: Rainwater Management (in-situ&ex-situ)</td></tr>
<tr><td>5</td><td>BALO/N/OS/RWM/2015

AK
SWE</td><td>Effect of sowing methods on the performance of maize, blackgram and greengram</td><td>Treatments :
• Ridge and furrow planting
• Flat planting
• Bed Planting</td></tr>
<tr><td>6</td><td>BALO/N/OS/RWM/2015
AK
SWE</td><td>Rainwater harvesting in farm pond and efficient use</td><td>• Supplemental irrigation to maize/wheat during critical growth period</td></tr>
<tr><td colspan="4">Theme 2: Crops/Cropping Systems</td></tr>
<tr><td rowspan="2">7</td><td>BALO/N/OS/RTC/2015

VK
AK</td><td>Demonstration of improved varieties of kharif crops</td><td>Maize: Prakash, PMH-2 and Local
Blackgram: Mash-338 and Mash-114
Sesame: Punjab til No. 2 and RT-346</td></tr>
<tr><td>BALO/N/OS/RTC/2015

VK
AK</td><td>Demonstration of improved varieties of rabicrops</td><td>Wheat :PBW-660, PWB- 644
Raya:PBR-97, RLM-619
Chickpea:PBG-1, PBG-5
Taramira:TMLC-2
Lentil:LL-699</td></tr>
<tr><td>8</td><td>BALO/N/OS/RTC/2015

AK
AS</td><td>Evaluation/demonstration of risk resilient intercropping systems</td><td>Kharif :
• Maize sole
• Wheat + Raya
• Wheat + Chickpea</td></tr>
</table>

			• Wheat + Lentil • Wheat + Taramira
9	BALO/N/OS/RTC/2015 AK AS	Evaluation/demonstration of risk resilient intercropping systems	*Rabi* : • Wheat sole • Wheat + Raya • Wheat + Chickpea • Wheat + Lentil • Wheat + Taramira
10	BALO/N/OS/RTC/2015 AK AS	Evaluation/demonstration of risk resilient double cropping systems	• Maize– Wheat • Maize– Raya • Greengram-Wheat • Greengram-Raya • Sesame-Wheat • Sesame-Raya
Theme 3: Nutrient/Carbon Management			
11	BALO/N/OS/SHCA/2015 VS MJS	To maintain soil health with appropriate soil and crop management	Linked with PMTs
12	BALO/N/OS/INM/2015 AK VS	Site-specific nutrient management (SSNM) in wheat	• Blanket application of recommended fertilizers • Fertilizer application on soil test basis • Nitrogen application using Leaf Colour Chart & other fertilizer as per recommendation
Theme 4: Energy Management			
13	BALO/N/OS/EM/2015 AK	Energy use efficiency with improved implements	1. Rotavator vs Conventional tillage 2. Seed drill vs pora/kera method
Theme 5: Alternate Land Use System			
14	BALO/N/OS/ALU/2015 VK YK	Evaluation of mango and gauva and based agri-horti systems	Treatments : *Kharif* • Guava + Blackgram • Mango+ Blackgram • Sole Blackgram *Rabi* • Guava + taramira • Mango+ taramira • Sole taramira

2016-17

1. Real time contingency plan implementation

Sl. No.	Code	Interventions	Crops/Treatments
1.1 Delayed onset of monsoon			
1	BALO/N/OS /RTC/2015-18 AK VK AS	RTCP under delayed onset of monsoon	Crops: *Kharif* –Alternate crops like Blackgram, Sesame & Pearlmillet (fodder)
1.2 Early season drought			
2	BALO/N/OS /RTC/2015-18 AK VK AS	RTCP under normal sowing and early season drought	Crops: *Kharif* -Maize, *Rabi*- Wheat Contingency measures for early season drought in maize: • T1: No intervention • T2: Crop residue Mulching • T3: Foliar spray of 1% KNO_3 • T4: Reduction in plant population • T5: T2+T3 • T6: T2+T4 • T7: T3+T4 During *rabi* season seed priming with water, molybdenum, thiourea, KH_2PO_4, foliar spray of thiourea etc. will be done.
3	BALO/N/OS /RTC/2015-18 AK VK AS	RTCP under normal sowing and early season drought	Blackgram & Greengram • T1: No intervention • T2: Crop residue Mulching • T3: Foliar spray of 1% KNO_3 • T4: Reduction in plant population • T5: T2+T3 • T6: T2+T4 • T7: T3+T4
1.3 Mid-season drought			
4	BALO/N/OS /RTC/2015-18 AK VK AS	RTCP under normal sowing and mid-season drought	Crops: *Kharif* -Maize, *Rabi*- Wheat Contingency measures for mid season drought: • T1: No intervention • T2: Crop residue Mulching • T3: Foliar spray of 1% KNO3 • T4: Reduction in plant population • T5: T2+T3 • T6: T2+T4 • T7: T3+T4 During *rabi* season seed priming with water,

			molybdenum, thiourea, KH_2PO_4, foliar spray of thiourea etc. will be done.
5	BALO/N/OS /RTC/2015-18 AK VK AS	RTCP under normal sowing and mid-season drought	Blackgram & Greengram T1: No intervention T2: Crop residue Mulching T3: Foliar spray of 1% KNO_3 T4: T2+T3
1.4 Terminal drought			
6	BALO/N/OS/ RTC/2015-18 AK VK AS	RTCP under normal sowing and terminal drought	Block No. 1 (Normal Sowing) Crops: *Kharif* -Maize, *Rabi*- Wheat Contingency measures for terminal drought: • Farmer practice • Detasseling in maize • Harvesting and vertical staking • Harvesting of green cobs and stalks as fodder. During *rabi* season seed priming with water, molybdenum, thiourea, KH_2PO_4, foliar spray of thiourea etc. will be done.
	BALO/N/OS/ RTC/2015-18 AK VK AS	RTCP under normal sowing and mid-season drought	Blackgram & Greengram • T1: No intervention • T2: Foliar spray of 1% KNO_3
2. Preparedness			
2.1 Rainwater Management (*in-situ* & *ex-situ*)			
7	BALO/N/OS/ RWM/2015 AK SWE	Effect of sowing methods on the performance of maize, blackgram and greengram	Treatments : • Ridge and furrow planting • Flat planting • Bed Planting
8	BALO/N/OS/ RWM/2015 AK SWE	Rainwater harvesting in farm pond and its efficient use	Supplemental irrigation to maize/wheat during critical growth period
2.2 Crops and Cropping Systems			

9	BALO/N/OS/ RTC/2015 VK AK	Demonstration of improved varieties of *kharif* crops	**Maize:** Prakash, PMH-2 and Local **Blackgram:** Mash-338 and Mash-114 **Sesame:** Punjab til No. 2 and RT-346
10	BALO/N/OS/ RTC/2015 VK AK	Demonstration of improved varieties of *rabi* crops	**Wheat :**PBW-660, PWB- 644 **Raya:**PBR-97, RLM-619 **Chickpea:**PBG-1, PBG-5 **Taramira:**TMLC-2 **Lentil:**LL-699
11	BALO/N/OS/ RTC/2015 AK AS	Evaluation / demonstration of risk resilient intercropping systems	*Kharif* : • Maize sole • Maize + Greengram • Maize + Blackgram • Maize + Sesamum
12	BALO/N/OS/ RTC/2015 AK AS	Evaluation / demonstration of risk resilient intercropping systems	*Rabi* : • Wheat sole • Wheat + Raya • Wheat + Chickpea • Wheat + Lentil • Wheat + Taramira
2.3 Alternate Land Use Systems			
14	BALO/N/OS/ ALU/2015 VK YK	Evaluation of mango, gauva and galgal based agri-horti systems	Treatments : *Kharif* • Guava + Greengram • Mango+ Greengram • Galgal + Greengram • Sole Greengram *Rabi* • Guava + raya • Mango+ raya • Galgal + raya • Sole raya

7.0 Detail of experiments Conducted under NICRA project

7.1 Detail of the On –Station experiments

7.1.1 Crop-wise contingency plans for weather aberrations

A. Preparedness

Cultivation of improved high yielding varieties

Cultivation drought tolerant high yielding hybrids/varieties of maize and other crops recommended by the university as well as hybrids from other sources perform better than farmer's cultivar.

Sowing of *Kharif* crops on ridges

In monsoon season rainfall distribution is very erratic and is not spatially well distributed. Rainfall generally occurs in big storms or there are long dry spells. The crops are badly affected by excess rain and/or long dry spells. To mitigate the effect of excess rain and dry spells, ridge sowing gives higher yield of maize, greengram and sesame than flat sowing. The furrows act both as drainage channels during high rainfall events and as moisture conservation furrows when rainfall is low.

Pre-sowing and post-sowing inter-culture operations

About 80% of rainfall is received during *kharif* season (June-September) which is quantitatively enough for most of the crop needs. However, the aberration in temporal and spatial distribution makes the crop vulnerable to drought as well as flood. Such adverse effects on crops can be combated through in-situ conservation practices like earthing up in maize crop, summer ploughing, ploughing and sowing across the slope to develop a ridge and furrow type of land configuration for effective soil moisture conservation to overcome drought for longer period.

Experiment 1: Evaluation of different crop varieties under rainfed conditions.

Objectives:

- To demonstrate the performance of improved varieties of different crops under rainfed conditions.

Technical Program:

***Kharif* crops**

Maize: Maize hybrids (PMH 2, JH 3459 & Prakash) and local cultivar were sown in first fortnight of July at row and plant spacing of 45 cm and 20 cm, respectively on medium textured soils. Out of the recommended dose of 80 kg N, 40 kg P_2O_5/ha and 20 kg K_2O/ha, half N and full P & K were applied as basal and remaining half N was applied at knee height stage of the crop just before earthing-up. Pre-emergence weedicide atrazine @ 2.0 kg/ ha was sprayed after diluting in 200 liters of water.

Black Gram: Mash cultivars i.e. Mash 114 & Mash 338 was sown at 30 cm row spacing with seed rate of 15-20 kg/ha. The recommended dose of fertilizer (12.5 kg N and 25 kg P_2O_5/ha) were applied as basal dose. All other agronomic practices were followed as per the recommendation of PAU for kandi area.

Green Gram: Greengram, cultivar ML 2056, PAU 911 & ML 818 were sown at 30 cm row spacing with seed rate of 15-20 kg/ha. The recommended dose of fertilizer (12.5 kg N and 40 kg P_2O_5/ha) were applied as basal dose. All other agronomic practices were followed as per the recommendation of PAU for kandi area.

Sesame: RT-346 and Punjab Til No. 2 was planted at 30 cm row spacing with seed rate of 2.5 kg/ha with recommended package of practices for sesame as per the recommendation of PAU for kandi area.

Table 1: Performance of improved varieties during *kharif* season

Crop & variety	**Yield (kg/ha)**								**RWUE (kg/ha-mm)**	**B:C ratio**
	2011-12	**2012-13**	**2013-14**	**2014-15**	**2015-16**	**2016-17**	**Mean**	**% increase over local**		
Maize										
PMH 2	2393	-	3389	3640	3080	3460	3192	34	6.6	1.90
JH 3459	2734	2548	2767	-			2683	18	4.8	1.84
Parkash	1951	2785	-	3380	2950	3140	2841	23	6.3	1.75
Local	1492	1731	1856	2860	2240	2480	2110	-	4.7	1.35
Mash										
Mash 338	-	648	608	495	520	480	550	88	1.19	1.35
Mash 114	-	512	783	540	560	540	587	100	1.26	1.38
Local	-	486	100	-	-	-	293	-	0.64	0.72
Moong										
PAU 911	-	-	-	680	620		650	-	1.02	1.05
ML 818	-	-	-	650	610	590	617	-	1.30	1.40
ML 2056	-	-	-	-	-	635	635	-	1.04	1.25
Sesame										
RT-346	-	-	-	-	430	405	418	-	0.91	2.42
Punjab til No. 2	-	-	-	-	442	420	431	-	0.94	2.50

Result:

Maize: Maize cultivars PMH 2, Prakash and Local were demonstrated to farmers for their yield performance under rainfed conditions. Maize hybrid PMH 2 performed during all the years and average grain yield was maximum of (3141 kg/ha) with B: C ratio 1.98 which was 36.8 per cent higher over local.

Blackgram: Among the Blackgram cultivar mash 114, mash 338 and local, mash 114 gave highest average seed yield (540 kg/ ha) and BC ratio (1.42).

Green gram: Green gram cultivar PAU 911 and ML 818 were demonstrated to farmers and PAU 911 recorded higher yield (680 kg/ ha) and BC ratio (1.64) over ML 818.

Rabi season

To demonstrate the potential of improved varieties to the farming community, the improved varieties of *rabi* crops were sown in the first week of November after giving pre-sowing irrigation as there were no rains September onwards.

Wheat: PBW 660, PBW 644, PBW 527 and PBW 175 were sown at on-station in the first week of November, by using 100 kg seed/ha at 30 cm row spacing. The half of the recommended dose of N (40 kg/ha) and full dose of recommended P_2O_5 (40 kg/ha) and K_2O (30 kg/ha) was applied as basal and remaining half N was applied when moisture conditions were favourable after the rains. The crop was grown as per the packages of practices recommended by PAU.

Chickpea: The chickpea cultivars namely PBG 1, PBG 5 and PBG 7 variety were sowing at depth of 10-12.5 cm by *pora* method at 30 cm row spacing. Before sowing, seeds were treated with chloropyriphos @ 10 ml/kg seed for termite control. The crop was grown as per the recommended packages of practices for *rabi* crops (PAU).

Lentil: LL 699 and LL 931 were sown in rows 30 cm apart by using 35 kg seed/ha and 12.5 kg N & 20 kg P_2O_5/ha.

Raya: RLM 619 and PBR 97were planted with pora method at 30 cm row spacing by using seed rate of 3.75 kg/ha and recommended fertilizer dose of 37.5 kg N/ha and 20 kg P_2O_5/ha. All other agronomic practices were followed as per the recommendations of PAU.

Taramira: Sowing of TMLC-2 cultivar of taramira in rows 30 cm apart using 3.75 kg seed/ha and 30 kg N/ha was done.

Linseed: LC 2063 was sown in rows of 30 cm apart by using 37.5 kg seed/ha and 67.5 kg N & 40 kg P_2O_5/ha.

Table 2: Performance of improved varieties during *rabi* season

Crop & variety	Yield (kg/ha)							% increase Over local variety	B:C ratio
	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	Mean		
Wheat									
PBW 175	2069	2903	3167	-	-	-	2713	12	2.01
PBW 527	1986	-	-	3000	-	-	2493	5	2.01
PBW 644	-	2875	3236	3280	3040	3250	3136	24	2.31
PBW 660	-	-	-	3640	3260	3380	3427	31	2.68
Local	1833	2472	2833	-	-	-	2379		1.87
Raya									
PBR 97	1167	1250	1556	920	-	-	1223	17	2.78
RLM 619	1458	1458	-	1080	1120	1180	1259	24	3.26
Local	931	1069	1039	-	-	-	1013		2.35
Chickpea									
PBG-1	972	1014	1328	990	720	-	1005	19	2.39
PBG-5	1000	1069	1703	1040	880	960	1109	27	2.63
PBG-7	-	-	-	1220	1050	1040	1103	26	2.73
Local	569	694	1175	-	-	-	813		1.73
Taramira									
TMLC-2	722	722	458	560	640	630	622	26	2.1
Taramira local	514	611	264	-	-	-	463		1.52
Lentil									
LL-699	694	708	1247	610	530	540	722	45	2.02
LL931	-	-	-	600	580	610	597	34	1.48
Local	389	406	392	-	-	-	396		1.05

In wheat, PBW 175, PBW 527, PBW 644, PBW 660 and local were evaluated at on-station to compare the yield and economics of wheat. Wheat var. PBW 175 was superior to PBW 527 and local. Wheat variety PBW 644 was superior to PBW 175 while PBW 660 was superior over PBW 644. In Raya, RLM 619 gave maximum seed yield 1259 kg/ha and B:C ratio 3.26 which was 2.8 and 19.5 per cent higher over the PBR97 and local. In Chickpea, PBG 1, PBG 5 and PBG 7 cultivars gave 19, 27 and 26 per cent higher grain yield over the local cultivar. Taramira cultivar TMLC-2 gave 24.8 per cent higher grain yield than local cultivar. Lentil cultivar LL 699 gave maximum yield (815 kg/ha), which was 45 and 34 per cent higher over the local and LL 931 cultivars.

Experiment 2: Demonstration of improved intercropping systems

Objective:

- To compare the performance of maize, greengram and blackgram as sole and as inter crop with maize.

Background information:

The *Kandi* region is characterized by erratic distribution of rainfall, delayed onset and an early withdrawal of monsoon, moisture stress caused by dry spells, light textured soils with poor water retention capacity. Maize (*Zea mays* L) is the major cereal crop cultivated under rainfed conditions in the *Kandi* region during *kharif* season. As maize crop is highly susceptible to water stress, under such conditions it gives low yield and sometimes fails totally. Crops like green gram and black gram which are resistant to moisture stress may be grown as intercrop in maize crop under rainfed condition to provide insurance against complete crop failure. Maize-legumes intercropping system, besides increasing productivity and profitability also improves soil health and conserves soil moisture.

Technical Program

To cover the risk of total crop failure and to take the additional crop yield maize crop was sown with 100% recommended population at spacing of 60 cm x 20 cm and one row of greengram and blackgram were planted after every two rows of maize during *kharif* season. All agronomic practices were followed as per the recommendation of PAU, Ludhiana for kandi area.

Table 3: Performance of improved intercropping systems

Crop/ Intercropping system	Maize equivalent yield (kg/ha)							% increase over sole crop	RWUE (kg/ha-mm)	B:C ratio
	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	Mean			
Kharif										
Maize (Sole)	2010	2592	2063	3396	-	3244	2661	-	5.6	2.85
Maize (Maize + Blackgram)	2191	2787	3023	3436	-	3724	3032	12.2	5.7	2.97
Maize (Maize + Greengram)	1797	2484	2516	3635	-	4069	2900	8.2	6.0	3.10
Rabi										
Wheat (Sole)		2445	2903	3144	2356	3828	2935	-	12.5	2.2
Wheat+ chickpea			3267	3372	2563	4722	3481	15.7	14.5	2.6
Wheat+lentil			3254	3111	2578	4026	3242	9.5	13.5	2.4
Wheat+Raya		2997	3254	2977	2622	4001	3170	7.4	13.5	2.4

Intercropping of maize with blackgram gave highest MEY (3032 kg/ha) but WUE (6.0 kg/ha-mm) with BC ratio (3.1) was highest in maize + greengram intercropping system. During *rabi* season wheat + chickpea intercropping gave highest WEY (3481kg/ha) with BC ratio (2.6) followed by wheat + lentil and wheat + raya intercropping.

Experiment 3: Evaluation/ demonstration of risk resilient double cropping systems
Objectives:

- To find the suitable cropping sequence in terms of productivity and economics

Background information:

Maize-wheat is a predominant cropping system in the *Kandi* area of Punjab. Besides this, maize-raya, maize-raya, maize-chickpea cropping system are also practiced in this region. Therefore, it was needed to evaluate/demonstrate the performance of different cropping sequence for production enhancement and economic viability.

Technical program:

After the harvest of *kharif* crops maize (PMH 2/JH 3459/Parkash), greengram (PAU 911/ML818) and sesame (Punjab til No.2/RT 346) *rabi* crops viz. wheat (PBW 175/PBW 660), raya (PBR 97/RLM 619) and chickpea (PBG 7/PBG 5) were sown in first week of November. All the crops were raised as per the recommended package of practices of Punjab Agricultural University.

Table 4: Productivity and economics of maize based cropping systems under rainfed conditions from 2011-2015.

Cropping System	**Grain yield(Kg/ha)**		**WEY**	**Cost of cultivation (Rs)**	**Gross Retrun (Rs)**	**Net Return (Rs)**	**B:C Ratio**
	Maize	***Rabi* crops**	**(kg/ha)**				
Maize-Wheat	3199	2958	3,029	15,956	32,975	33,952	2.39
Maize-Taramira	3199	365	881	7,580	6,804	2,553	1.25
Maize-Raya	3199	1015	2,443	10,931	24,308	18,628	2.22
Maize-Lentil	3199	569	1,946	14,280	22,611	6,961	1.35

Among various maize based cropping systems evaluated during rabi season, maize - wheat system performed better than other maize based systems mainly due to the damage to other crops like taramira, raya and lentil by unseasonal rainfalls, while rainfed wheat was benefitted from these rains. The highest net returns of Rs 32975/ ha and B:C ratio of 2.39 with wheat equivalent yield (WEY) of 3029 kg/ ha were obtained in maize - wheat.

Table 5: Productivity and economics of cropping systems under rainfed conditions 2015-17.

Normal crop	Treatment	System productivity (kg/ha)		% increase in yield	Net returns (Rs/ha)	B:C ratio
		With improved practice	With normal practice			
Maize - Wheat			5366		46544	1.82
	Maize-Raya	4813		-11.25	32358	1.67
	Maize-Chickpea	6288		12.00	50504	1.95
	Greengram-Wheat	5706		7.85	65026	2.33
	Greengram-Raya	5040		-5.60	48231	2.23
	Greengram-Chickpea	7019		25.40	74044	2.65
	Sesame-Wheat	5282		0.65	51920	2.19
	Sesame-Raya	4458		-18.25	33895	1.98
	Sesame-Chickpea	5388		1.70	42967	2.06

Among various 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 74044/ ha and B:C ratio of 2.65 with wheat equivalent yield (WEY) of 7019 kg/ ha were obtained in greengram – chickpea cropping sysem and recorded an increase in system productivity to the tune of 25.4 per cent over maize wheat system.

Experiment 4: Effect of different methods of sowing on yield of maize and rainwater use efficiency.

Objectives:

- To study the effect of summer ploughing, sowing across the slope and earthing up on yield of hybrid maize.

Background information:

About 80% of rainfall is received during *kharif* season (June-September) which is quantitatively enough for most of the crop needs. However, the aberration in temporal and spatial distribution makes the crop vulnerable to drought as well as flood. Such adverse effects on crops can be combated through in-situ conservation practices like earthing up in maize crop, summer ploughing, ploughing and sowing across the slope to develop a ridge and furrow type of land configuration for effective soil moisture conservation to overcome drought for longer period.

Table 6: Effect of different methods of sowing on yield attributes and yield of maize

Type of *in-situ* conservation technologies	Yield (kg/ha)					RWUE (kg/ha-mm)	B:C ratio
	2011-12	2012-13	2013-14	2014-15	Mean		
With Summer ploughing	4973	3946	3130	3463	3878	7.5	2.54
Without Summer ploughing	3098	3522	2565	3031	3054	6.0	2.03
Sowing along slope	3235	3461	2130	3185	3003	5.9	1.90
Sowing across slope	3876	3862	2245	3380	3341	6.5	2.11
No earthing- up	3273	3433	1986	3218	2978	5.9	1.94
Earthing up with wheel hoe	3624	3648	2454	3528	3314	6.5	2.13
Earthing up manually	3785	3886	2648	3731	3513	6.9	2.17

Summer ploughing vs without summer ploughing: Summer ploughing of field before the onset of monsoon to conserve the soil moisture gave maximum yield (3878 kg/ha) with WUE of 7.5 kg/ha-mm and B:C ratio 2.54 as compared to without summer ploughing with grain yield (3054 kg/ha), WUE (6.0 kg/ha-mm) and B:C ratio (2.03).

Sowing across the slope vs Sowing along slope: Sowing of maize across the slope gave maize grain yield of 3341 kg/ha with WUE of (6.5 kg/ha-mm) with B:C ratio of 2.11, which was 10.1 per cent higher over sowing of maize along the slope (3003 kg/ha).

Earthing up manually vs no earthing up and earthing up with wheel hoe: Earthing up manually in maize resulted in maximum yield of 3513 kg/ha which was 15.2 and 5.7 per cent higher in comparison to no earthing up and earthing up with wheel hoe, respectively with WUE of 6.9 kg/ha-mm and B:C ratio of 2.17.

Experiment 5: Effect of crop establishment methods on the performance of maize, greengram and blackgram.

Objectives:

- To compare the effect of ridge planting and flat planting on the yield of *kharif* crops viz. maize, greengram and blackgram.

Background information:

In monsoon season rainfall distribution is very erratic and is not spatially well distributed. Rainfall generally occurs in big storms or there are long dry spells. The crops are badly affected by excess rain and/or long dry spells. To mitigate the effect of excess rain and dry spells, ridge-furrow system of sowing is adopted in which series of small ridge and furrows are formed, seeds being sown on ridges. The furrows act both as drainage channels during high rainfall events and as moisture conservation furrows when rainfall is low.

Flat sowing

Ridge sowing

Table 7: Effect of crop establishment methods yield, rainwater use efficiency and economics

Crop	Method of planting	Yield (kg/ha)				RWUE (kg/ha-mm)	B:C
		2014-15	2015-16	2016-17	Mean		
Maize	Ridge planting	3656	2324	4462	3481	7.64	1.89
	Flat sowing	3270	1611	3970	2950	6.43	1.63
Greengram	Ridge planting	1153	635	898	895	2.28	2.13
	Flat sowing	931	478	740	716	1.80	1.73
Blackgram	Ridge planting	861	588	1028	826	1.90	1.77
	Flat sowing	667	527	811	668	1.53	1.46

Sowing of maize, greengram and blackgram on ridges proved to be superior than flat sowing. The yield, WUE and economics indices were higher in ridge sowing. The increase in grain yield of maize, greengram and blackgram was 15.0, 20.0 and19 per cent over flat sowing respectively with corresponding RWUE of 7.64, 2.28 and 1.90 kg/ha-mm and B:C ratio of 1.89, 2.13 & 1.77.

Experiment 6: Site specific nutrient management in maize

Objective:

- To demonstrate the importance of site specific nutrient management

Background information:

Farmers generally apply nutrients without considering the nutrient status of the soil. This leads to imbalance use of nutrients. This also causes environmental damage and increases the total cost of production. To eliminate wastage of fertilizers and increase farmer's income, a new approach called Site Specific Nutrient Management (SSNM) is recommended. SSNM ensures application of nutrients as and when needed by the crop. Hence the present investigation is carried out to study and demonstrate importance of SSNM.

Technical program: In blanket N application treatment the 80 kg N/ha was applied considering the soil to be medium in N. In N application on soil test basis treatment 25 % more N was applied as the soil was lower in N. In 100% N application on leaf colour chart (LCC), 188 kg urea/ha was applied on the basis of the leaf colour as the colour of leaves was lighter than strip number 5.

Table 8: Productivity and economics of Site Specific Nutrient Management.

Normal Practice	**Treatment**	**Yield` (kg/ha)**		**% increase in yield**	**Net returns (Rs/ha)**	**B:C ratio**	**RWUE (kg/ha-mm)**
		With improved practice	**With farmers practice**				
Blanket 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
Rainfall	*Kharif: 560.9* mm						

Application of 100% N based on LCC gave highest grain yield (4253 kg/ha), net returns (Rs. 40489/ha) and BC (2.28) followed by N application on soil test basis with grain yield of 4166 kg/ha, net returns of Rs. 38926/ha and BC 2.23. Application of 75% N (141 kg urea/ha) as per LCC gave yield (3796 kg/ha), net returns (Rs. 35363/ha) and BC (2.14) at par with blanket application of recommended N (176 kg urea/ha). The increase in grain yield with fertilizer application on LCC and soil test basis over blanket fertilization was 9.8 and 8.3 %, respectively.

Experiment 7: Site specific nutrient management in wheat using leaf colour chart

Objectives:

- To demonstrate the importance of site specific nutrient management

Background information:

Farmers generally apply nutrients without considering the nutrient status of the soil. This leads to imbalance use of nutrients. This also causes environmental damage and increases the total cost of production. To eliminate wastage of fertilizers and increase farmer's income, a new approach called Site Specific Nutrient Management (SSNM) is recommended. SSNM ensures application of nutrients as and when needed by the crop. Hence the present investigation is carried out to study and demonstrate importance of SSNM.

Technical program: In blanket N application treatment the 80 kg N/ha was applied considering the soil to be medium in N (176 kg urea/ha). In N application on soil test basis treatment 25 % more N was applied as the soil was lower in N (220 kg urea/ha). In 100% N application on leaf colour chart (LCC), 150 kg urea/ha was applied on the basis of the leaf colour as the colour of leaves was lighter than strip number 4.

Table 9: Productivity and economics of Site Specific Nutrient Management

Treatment	Yield (kg/ha)			% increase in yield	Net returns (Rs/ha)	B:C ratio	RWUE (kg/ha-mm)
	2015-16	2016-17	Mean				
Blanket N application (100%)	2778	3743	3261		41747	2.5	14.8
N application on soil test basis	3007	3863	3435	5.1	45874	2.7	15.7
N application as per leaf colour chart	2844	4034	3439	5.2	45817	2.6	15.5

Nitrogen application based on leaf colour chart and on soil test basis gave grain yield higher than blanket application of N and also gave higher net returns, B:C ratio and water use efficiency. The increase in grain yield with fertilizer application on soil test and leaf colour chart over blanket fertilization was 5.1and 5.2 %, respectively.

Experiment 8: Energy use efficiency with improved sowing implements in wheat.

Objectives:

- To work out the comparative performance of different sowing implement.

Background information:

Rainfed wheat is raised on the conserved soil moisture from the preceding *Kharif* season. The soil moisture is generally low at the time of sowing, so the seed must be sown by correct method to ensure its placement at proper depth, which ensures better emergence and subsequent crop growth. Further the farmers of rainfed regions are resource poor and they cannot afford costly implements. Thus present study was conducted to evaluate the performance of different implements and their effect on yield.

Technical program:

The field was prepared by *giving* two cultivations/ploughings with a tractor-drawn cultivator followed by planking. The crop was sown on conserved soil moisture during the first fortnight of November by using 100 kg seed/ha at 30 cm row spacing. Three methods of sowing were followed. In one method sowing was done with seed-cum-fertilizer drill at a depth of 4-6 cm, in second method sowing was done with *pora* and in third method sowing was done with manually operated seed drill. The half of the recommended dose of N (40 kg/ha) and full dose of recommended P_2O_5 (40 kg/ha) and K_2O (30 kg/ha) was applied as basal and remaining half N (40 kg/ha) was applied when moisture conditions were favourable after receipt of rains. The crop was grown as per the packages of practices recommended by PAU.

Table 10: Productivity and economics of sowing implements under rainfed conditions

Treatment (Sowing Implement)	**Yield (kg/ha)**	**% increase in yield over broadcasting**	**B:C ratio**	**RWUE (kg/ha-mm)**
Broadcasting	2076	-		
Seed-cum-fertilizer drill	3035	32	2.4	13.8
Manual sowing with pora	2728	24	2.1	12.4
Sowing with manually operated seed drill	2660	22	2.2	12.1

Table 11: Input-Output energy of sowing implements under rainfed conditions

Treatment (Sowing Implement)	**Input energy (MJ/ha)**	**Output energy (MJ/ha)**	**Energy use efficiency**
Broadcasting	10476	70663	6.75
Seed-cum-fertilizer drill	11327	106859.5	9.44
Manual sowing with pora	10713	94443	8.82
Sowing with manually operated seed drill	10547	92560.5	8.78

Sowing of wheat crop 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 32.0, 24.0 and 22.0 per cent respectively over sowing by broadcasting. The maximum increase in yield (3035 kg/ha) and BC 2.40 was recorded with seed-cum-fertilizer drill. Highest energy use efficiency (9.44) was also observed in sowing with tractor operated seed-cum-fertilizer drill.

Experiment 9: Evaluation of mango, gauva, lemon and galgal based agri-horti system.

Objectives:

- To maximizing productivity per unit area and minimize the risk of crop failure under adverse weather conditions.

Background information:

The marginal lands of rainfed area are not able to sustain arable crops particularly during the drought years and results in low, unstable and uneconomic yield. The alternate land use systems are effective means of stabilizing both productivity of dryland and incomes of dryland farmers, besides generating employment. They also make efficient use of off - season rains which may otherwise go waste as runoff and prevent degradation of soils.

Technical Programme:

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, 30cm and 30 cm, respectively.

Table 12: Yield, growth parameters and economics of Guava and Amla plants

Fruit Plant	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

Table 13: Crop yield under different Agro-horticulture system

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

The plantation of guava, galgal, mango and baramasi lemon are in 3rd year and no fruit yield was taken. The growth data in terms of average plant height was 2.4 m, 1.2 m, 0.9 m & 1.4 m in case of guava, guava, galgal, mango and baramasi lemon, respectively. The collar diameter was 12.2 cm, 4.5 cm, 9.8 cm and 5.3 cm, respectively for guava, galgal, mango and baramasi lemon. The yield of blackgram in association 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.

B. Real Time contingency crop planning for *Kharif* cropping

i. **Normal monsoon onset and early stress during first fortnight during 2016**

Crop	Real time contingency interventions
Maize	• Earthing up with improved wheel hand hoe to create soil mulch • Reduce plant population by removing weaker plants • Apply foliar spray of 1% KNO_3, • Use harvested rainwater for irrigation in some area • Remove weeds to avoid competition for water • In case of crop failure grow alternate crops like Sesame, blackgram and greengram up to mid July

Experiment 1: Real time contingency plan implementation under normal sowing and early season drought during 2016.

Treatment	**MEY (kg/ha)**	**% increase in yield over no intervention**	**RWUE (kg/ha-mm)**	**B:C ratio**
T1:No intervention	2664		5.17	1.34
T2: Soil mulching with wheel hoe	2871	7.2	5.57	1.40
T3: Foliar spray of 1% KNO3	3007	11.4	5.83	1.51
T4: Reduction in plant population	2802	4.9	5.44	1.43

T5: T2+T3	3282	18.8	6.37	1.60
T6: T2+T4	3190	16.5	6.19	1.60
T7: T3+T4	3255	18.2	6.31	1.67
Blackgram as alternate crop	3520 (1056)	24.3	2.28	2.20
Sesame as alternate crop	3153(473)	13.7	1.02	2.66
Mean	3083	14.4	4.91	1.71
DOS: Maize: 06-07-16, Blackgram & sesame: 16.7.16				

Growing of alternate crops of blackgram and sesame resulted in obtaining 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 BC ratio (2.20 and 2.66).

ii. Normal onset and mid-season stress

Crop	Real time contingency interventions
Maize	• Supplemental irrigation, if available • Removal of less vigorous plants up to 20% and use as fodder • Apply foliar spray of 1% KNO_3 pre tasseling stage, • Remove weeds to avoid competition for water. • Mulching with locally available vegetative material between crop rows

Experiment 2: Real time contingency plan implementation under normal sowing and mid-season drought situation in maize during 2011, 2013 and 2014.

Treatment	Yield (kg/ha)	% Increase in yield over no intervention	RWUE (kg/ha-mm)	B:C ratio
T1: No intervention	2432	-	4.34	1.47
T2: Crop residue Mulching	2672	9.9	4.77	1.5
T3: Foliar spray of 1% KNO_3	2865	17.8	5.11	1.53
T4: Reduction in plant population	2641	8.6	4.71	1.54
T5: T2+T3	2979	22.5	5.32	1.55
T6: T2+T4	2839	16.7	5.06	1.53
T7: T3+T4	2885	18.6	5.15	1.58
Mean	2759	13.4	4.92	1.53
CD (0.05)	391.5			

Contingency measures adopted to overcome the dry spell in maize crop from pre-tasseling to early grain formation stage had significant effect on yield. Surface mulching of crop residues along with foliar spray of 1% KNO_3 showed maximum improvement in yield of maize as compared to no intervention, reduction in plant population and other combinations. Residue mulching along with foliar spray of 1% KNO_3 gave highest grain yield (2979 kg/ha) and WUE (5.32 kg/ha/mm**)** but B: C ratio (1.58) was highest with reduction in plant population along with foliar spray of 1% $KNO_{3.}$

Experiment 3: Real time contingency plan implementation under normal sowing and mid-season drought situation in blackgram

Treatment	Yield (kg/ha)	% Increase in yield	RWUE (kg/ha-mm)	B:C ratio
T1: No intervention	475	-	1.15	1.15
T2: Soil Mulching	509	7.17	1.27	1.23
T3: Foliar spray of 1% KNO_3	535	12.61	1.33	1.29
T4: Foliar spray of 0.1% thiourea	524	10.46	1.30	1.27
T5: T2+T3	573	20.68	1.39	1.39
T6: T2+T4	545	14.85	1.37	1.32
Mean	527	10.96	1.30	1.27
CD (0.05)	59	-	-	-

Contingency measures adopted to overcome the dry spell in blackgram from flowering to pod formation had significant effect on yield. Soil mulching along with foliar spray of 1% KNO_3 gave highest grain yield (573 kg/ha), B: C ratio (1.39) and WUE (1.39 kg/ha/mm).

Experiment 4: Real time contingency plan implementation under normal sowing and mid-season drought situation in sesame

Treatment	Yield (kg/ha)	% Increase in yield	Net returns (Rs/ha)	B:C ratio
T1: No intervention	383	-	21136	2.23
T2: Soil Mulching	406	6.1	22341	2.22
T3: Foliar spray of 1% KNO3	391	2.2	20389	2.09
T4: Foliar spray of 0.1% thiourea	389	1.6	20939	2.17
T5: T2+T3	435	13.5	24241	2.26
T6: T2+T4	412	7.5	22691	2.23
Mean	403	5.1	21956	2.20
CD (0.05)	NS			

The sesame crop was least affected by the dry spell and so the contingency measures adopted to overcome the dryspell in sesame from flowering to capsule formation had no significant effect on yield. However, the soil mulching with wheel hoe, foliar spray of 1% KNO_3 , 0.1% thiourea either alone or in combination improved sesame grain yield ranging from 2.2 to 13.2%. Soil mulching along with foliar spray of 1% KNO_3 gave highest grain yield (435 kg/ha), B: C ratio (2.26) and WUE (1.05 kg/ha/mm**).**

iii. Normal onset and terminal stress

Crop	Real time contingency interventions
Maize	• Apply one supplemental irrigation, if available. • Removal of cob less plants and use as fodder. • If grains are in milking stage harvest and sell the green cobs in market. • At dough stage harvest and do vertical staking of the crop. • If field is vacated due to early maturity of crop, then cultivate the field to conserve moisture for rabi crops. • Toria may be sown to compensate the loss due to failure of maize crop and sow late sown variety of wheat after the receipt of winter rains in December.

iv. Delayed onset of monsoon by 15 days

Crop	Real time contingency interventions
Maize	• If monsoon onset is delayed by 15 grow alternate crops like Sesame, blackgram and greengram.

v. Delayed onset of monsoon by 30 days

Crop	Real time contingency interventions
Maize	• If monsoon onset is delayed by 30 days then green gram and pearl millet as fodder are suitable alternate crops to maize

Experiment 1: Foliar application with need based chemicals/nutrients/water sprays for mitigating in-season dry spells/droughts.

Treatment	Yield (kg/ha)	RWUE (kg/ha-mm)	B:C ratio
	2014-15		
No spray	3534	8.0	1.90
Water spray	3570	8.1	1.92
Thiourea 1000 PPM	3914	8.9	2.06
KNO3 spray (1%) once	3849	8.8	1.92
KNO3 spray (1%) twice	4156	9.5	1.94
ZnSo4 spray (0.5%) once	3874	8.8	2.04
ZnSo4 spray (0.5%) twice	4045	9.1	2.13

Foliar spray of 1% KNO_3 twice and ZnSO4 spray (0.5%) twice at critical moisture sensitive stages resulted in maximum improvement in yield of maize as compared to control, water spray and thiourea spray. The water spray, thiourea spray, KNO3 spray (1%) and ZnSO4 spray (0.5%) increased maize yield by 12.6-15, 11.7-14.1, 3.2-5.8, 4.8-7.4 and 4.2-6.8 per cent over no spray, respectively. Foliar spray of 1% KNO_3 twice gave highest grain yield (4156 kg/ha) and WUE (9.5 kg/ha/mm**)** but B: C ratio (2.13) was highest with 0.5% ZnSO4 spray twice.

7.2 Detail of On-Farm demonstrations/activities

A. Preparedness

Crops and Cropping Systems

Activity 1: Evaluation of improved crop varieties under rainfed conditions.

Pearl millet (fodder): To evaluate the comparative performance of two pearl millet cultivars i.e. local and FBC-16 were sown by broadcasting methods on light to medium textured soils at village. The recommended dose of fertilizer 50 kg N/ha i.e. half N at sowing and remaining half N was broadcasted three week after sowing on well moist soil. The crop was harvested as green fodder 45-60 days after sowing in the month of September and October.

Table 14: Performance of improved varieties of pearl millet under rainfed condition

Year	Yield (kg/ha)		% Increase in yield	RWUE (kg/ha-mm)		Net returns (Rs/ha)		B:C ratio	
	Improved variety	Farmers' cultivar		Improved variety	Farmers' cultivar	Improved variety	Farmers' cultivar	Improved variety	Farmers' cultivar
2011-12	41250	31250	32.0	91.7	69.4	12192	7192	2.45	1.86
2012-13	44937	32062	40.2	108.8	77.6	22536	13503	3.02	2.28
2013-14	30000	22000	36.4	50.8	42.4	12527	5831	1.96	1.45
2014-15	27000	17983	50.1	50.9	33.8	13692	4862	2.03	1.38
2015-16	30869	23040	37.2	44.9	33.5	17849	3200	2.37	1.25
2016-17	32075	23845	34.6	53.6	34.4	8648	3763	1.63	1.29
Mean	34355	25030	38.4	66.8	48.5	14574	6392	2.24	1.59

The improved variety FBC 16 gave higher yield, net returns and B:C ratio than the local variety used by the farmers during all the years. The Mean yield over the years of FBC 16 was 34355 kg/ha which was 38.4 per cent higher than the local cultivar. The higher yield obtained with FBC 16 can be attributed mainly due to the rejuvenation capacity and longer vegetative period.

Black Gram: Mash cultivars i.e. Mash 114 was sown at 30 cm row spacing with seed rate of 15-20 kg/ha. The recommended dose of fertilizer (12.5 kg N and 25 kg P_2O_5/ha) were applied as basal dose. All other agronomic practices were followed as per the recommendation of PAU for *kandi* area.

Table 15: Performance of improved varieties of mash under rainfed condition

Year	Yield (kg/ha)		% Increase in yield	RWUE (kg/ha-mm)		Net returns (Rs/ha)		B:C ratio	
	Improved variety	Farmers' cultivar		Improved variety	Farmers' cultivar	Improved variety	Farmers' cultivar	Improved variety	Farmers' cultivar
2012-13	494	-	-	1.19	-	14242	-	1.95	-
2013-14	563	-	-	1.08	-	16691	-	1.98	-
2014-15	522	-	-	0.99	-	5774	-	1.28	-
2015-16	880	585	50.0	1.36	0.85	17969	5319	1.80	1.24
2016-17	630	460	37.4	1.05	0.66	9927	2151	1.44	1.10
Mean	603	523	43.7	1.1	1	12807	3735	1.70	1.17

Mash 114 cultivar recorded average grain yield of 603 kg/ha with net returns and B:C ratio of Rs 12807/ha and 1.70, respectively.

Sesame (RT-346)

Mash (Mash-114)

Sesame: RT-346 was planted at 30 cm row spacing with seed rate of 2.5 kg/ha with recommended package of practices for sesame as per the recommendation of PAU for kandi area.

Table 16: Performance of improved varieties of sesame under rainfed condition

Year	Yield (kg/ha)		% Increase in yield	RWUE (kg/ha-mm)		Net returns (Rs/ha)		B:C ratio	
	Improved variety	Farmers cultivar		Improved variety	Farmers' cultivar	Improved variety	Farmers' cultivar	Improved variety	Farmers' cultivar
2012-13	306	244	25.4	0.74	0.59	12786	7838	2.09	1.67
2013-14	300	217	38.2	0.57	0.41	14482	7376	1.94	1.51
2015-16	370	-	-	0.74	-	21082	-	2.33	-
2016-17	416	-	-	0.7	-	24133	-	2.38	-
Mean	348	231	31.8	0.7	0.5	18121	7607	2.19	1.59

Among the two sesame cultivars (RT 346 and local), cultivar RT 346 recorded higher average seed yield of 348 kg/ha which was 31.8 per cent higher than the local cultivar. The average net return and B:C ratio of RT346 was Rs. 18121 & B:C ratio 2.19. The higher yield realized from the improved cultivar RT 346 was due to tolerance to diseases as well as better yield potential than the local cultivars.

Wheat: Recommended cultivars of wheat i.e. PBW 660, HD 2967, WH 1105 and PBW 644 along with local variety were evaluated to compare their performance under rainfed condition. The recommended agronomic packages of practices of Punjab Agricultural University were followed.

Table 17: Performance of improved varieties of wheat under rainfed condition

Year	Yield (kg/ha)		% Increase in yield	RWUE (kg/ha-mm)		Net returns (Rs/ha)		B:C ratio	
	Improved variety	Farmers' cultivar		Improved variety	Farmers' cultivar	Improved variety	Farmers' cultivar	Improved variety	Farmers' cultivar
2011-12	2320	1833	26.6	17.44	13.78	25084	11114	2.59	1.74
2012-13	2691	1931	39.4	17.26	12.38	29794	17050	2.41	1.88
2013-14	3116	2519	23.7	13.43	10.85	31646	22588	2.36	2.03
2014-15	3144	2420	29.9	7.32	5.63	36936	20937	2.43	1.84
2015-16	2868	2094	37	32.22	23.54	35189	21284	2.35	1.88
2016-17	3450	2400	43.7	18.5	12.89	42362	22051	2.48	1.81
Mean	2932	2200	31.3	17.7	13.18	33502	19171	2.44	1.86

The average yield of the improved cultivars was higher than the farmers' cultivar with an average increase of 31.3 per cent compared to local cultivars. The average net returns of Rs. 33502/ha with a B:C ratio of 2.44 were realized from the cultivation of improved varieties in comparison to average net returns of Rs. 19171/ha with B:C ratio of 1.86 from local cultivar. The high yield obtained with improved varieties was mainly due to higher yield potential of the varieties and drought tolerance.

Chickpea: The recommended cultivar namely PBG 1, PBG 5 with local variety were evaluated to compare their performance under rainfed condition at farmers field. Sowing was done at depth of 10-12.5 cm by *pora* method at 30 cm row spacing. Before sowing, seeds were treated with chloropyriphos @ 10 ml/kg seed for termite control. The crop was grown as per the recommended agronomic packages of practices.

Table 18: Performance of improved varieties of chickpea under rainfed condition

Year	Yield (kg/ha)		% Increase in yield	RWUE (kg/ha-mm)		Net returns (Rs/ha)		B:C ratio	
	Improved variety	Farmers' cultivar		Improved variety	Farmers' cultivar	Improved variety	Farmers' cultivar	Improved variety	Farmers' cultivar
2012-13	1020	720	41.7	6.76	4.77	21509	10754	2.12	1.6
2013-14	1335	910	46.7	4.73	3.23	36091	20336	3.08	2.27
2014-15	850	633	34.3	1.98	1.47	20146	9296	1.9	1.42
2015-16	-	-	-	-	-	-	-	-	-
2016-17	900	560	61.1	4.8	3	35381	13281	2.53	1.57
Mean	1026	706	41	4.6	3.1	28282	13417	2.41	1.72

The average yield of improved chickpea varieties was 40.9 per cent higher (1026 kg/ha) than the farmers' cultivar (706 kg/ha). The net returns from the improved varieties was Rs. 28282/ha with B:C ratio of 2.41. The higher yield in case of improved varieties may be attributed to the higher yield potential as well as resistance/tolerance to the major diseases prevalent in the region.

Raya: To evaluate the comparative performance of different raya cultivars i.e. Local, and RLM 619, PBR 97 were sown with seed drill in low seed zone moisture at 30 cm row spacing by using seed rate of 3.75 kg/ha. All other agronomic practices were followed as per the recommendation of PAU for *kandi* area.

Table 19: Performance of improved varieties of raya under rainfed condition

Year	Yield (kg/ha)		% Increase in yield	RWUE (kg/ha-mm)		Net returns (Rs/ha)		B:C ratio	
	Improved variety	Farmers' cultivar		Improved variety	Farmers' cultivar	Improved variety	Farmers' cultivar	Improved variety	Farmers' cultivar
2011-12	1150	850	35.3	8.64	6.39	22372	13372	2.55	1.88
2012-13	957	742	29	6.13	4.76	19492	12102	2.4	1.87
2013-14	1070	711	50.5	3.79	2.52	22478	10030	2.5	1.68
2014-15	735	530	38.7	1.72	1.23	11306	5316	1.68	1.21
2015-16	810	550	47.3	9.1	6.17	15611	6720	1.93	1.18
2016-17	1130	865	30.6	6.05	4.64	27974	17399	2.62	2.01
Mean	975	708	40.1	5.91	4.29	19872	10823	2.28	1.64

The improved varieties of raya gave seed yield of 975 kg/ha which was 40.1 per cent higher than the farmers' cultivars having yielded 708 kg/ha. Net returns of Rs. 19872/ha with B:C ratio of 2.28 were realized from the improved varieties.

Taramira: To evaluate the comparative performance of different taramira cultivars i.e. Local, and TMLC 2 were sown with seed drill in low seed zone moisture at 30 cm row spacing by using seed rate of 3.75 kg/ha. All other agronomic practices were followed as per the recommendation of PAU for *kandi* area.

Table 20: Performance of improved varieties of taramira under rainfed condition

Year	Yield (kg/ha)		% Increase in yield	RWUE (kg/ha-mm)		Net returns (Rs/ha)		B:C ratio	
	Improved variety	Farmers' cultivar		Improved variety	Farmers' cultivar	Improved variety	Farmers' cultivar	Improved variety	Farmers' cultivar
2012-13	610	360	69.4	3.91	2.31	9714	1772	1.99	1.18
2013-14	606	334	81.4	6.09	3.36	8699	-26	1.81	1
2014-15	450	345	30.4	1.045	0.93	7487	3287	1.71	1.31
2015-16	727	430	69.1	8.17	4.83	31223	13800	2.52	2.08
2016-17	665	540	23.2	3.6	2.89	16270	10770	2.25	1.83
Mean	612	402	54.7	4.56	2.86	14679	5921	2.06	1.48

The mean seed yield from the variety TMLC 2 was 612 kg/ha in comparison to the local cultivar and it was 54.7 per cent higher than local variety. The net returns and B:C ratio was also higher compared to the local cultivars. The increase in yield observed was mainly due to the tolerance to alternaria blight which is the major disease of the crop in the area.

Activity 2: Demonstration of maize based / other cropping system

The beneficiaries of the adopted village were following the traditional maize-wheat system and were not fully aware about the sustainability of different cropping sequences under rainfed condition. Therefore, it was needed to evaluate the comparative performance of different cropping sequence for production enhancement and economic viability. So, to evaluate various cropping sequences and to demonstrate the latest rainfed production technologies at on farm, different trials were conducted at farmer’s field. In these demonstrations, package of practices were followed as per recommendations of PAU, Ludhiana.

Table 21: Productivity and economics of different cropping systems under rainfed conditions

Normal Crop	Yield (kg/ha)		% Increase in yield	Net returns (Rs/ha)		B:C ratio	
	Improved cropping system	Maize-Wheat		Improved cropping system	Maize-Wheat	Improved cropping system	Maize-Wheat
2011-12							
Mash - Raya	1300	2900	-55.2	25472	21432	2.88	2.37

Ash Guard - Taramira	1140	2900	-60.7	20672	21432	2.53	2.37
Maize - Raya	1053	2900	-63.7	18072	21432	2.34	2.37
2012-13							
Maize - Raya	4697	5333	-11.9	38442	57701	1.99	2.26
Maize - Taramira	4455	5333	-16.5	38990	57701	2.13	2.26
Ash Guard - Taramira	5314	5333	-0.4	50437	57701	3.28	2.26
2013-14							
Maize-Raya	6306	7198	-12.4	51580	56622	2.28	2.12
Maize -Taramira	5103	7198	-29.1	37801	56622	1.93	2.12
Pearlmillet-Wheat	5089	7198	-29.3	40177	56622	2.08	2.12
Pearlmillet-Raya	4197	7198	-41.7	35005	56622	2.24	2.12
Ash Gourd - Wheat	7586	7198	5.4	74791	56622	3.09	2.12
Ash Gourd - Raya	6694	7198	-7.0	69619	56622	3.24	2.12
2014-15							
Maize-Raya	5213	6819	-34.4	33420	61248	1.73	2.45
Maize-Taramira	4474	6819	-23.6	29195	61248	1.75	2.45
Ash gourd - Taramira	6108	6819	-10.4	58981	61248	3.31	2.45
Ash gourd - wheat	8091	6819	18.7	77670	61248	2.9	2.45
2015-16							
Maize-Taramira	5567	6042	-7.9	43320	57352	2.03	2.32
Ash gourd - Taramira	6340	6042	4.9	58981	57352	3.57	2.32
Ash gourd - wheat	7546	6042	24.9	73187	57352	2.81	2.32
2016-17							
Maize-Taramira	5122	7465	-45.7	43206	78369	2.04	2.35
Ash gourd - Taramira	5982	7465	-24.8	60595	78369	3.08	2.35
Ash gourd - wheat	8325	7465	10.3	95758	78369	3.10	2.35

Among different cropping sequence tested during the period, ash gourd based cropping system with wheat gave maximum net returns and B:C ratio in comparison to maize-wheat cropping systems, might be due to the higher net return from ash gourd crop. In oilseed based cropping systems gave lower maize equivalent yield (MEY) and net returns than maize – wheat cropping system due to unseasonal rainfall during the *rabi* season which lead to the attack of various diseases and insect-pest on the crops and resulted in lower yields.

***Activity 3*: Demonstration of improved intercropping systems (*Rabi*)**

The performance of the crops under rainfed conditions depends entirely on rainfall. Cultivation of sole crop under such conditions is not profitable especially under severe drought conditions. Therefore, intercropping of different crops in main crop is the only alternative to compensate the total loss due to crop failure under mid and late season's drought and also to get an additional yield benefit in normal crop season.

To cover the risk of total crop failure and to take the additional crop yield wheat and raya intercropping during *rabi* season was suggested to the farmers of the area. To make awareness among the farmers regarding the improved technology on this aspect, field demonstrations on wheat and raya intercropping were conducted. To familiarize the farmers regarding the improved technology, sowing of raya rows was done at 3.0 meter apart in field trials. All agronomic practices were followed as per the recommendations of Punjab Agricultural University.

Table 22: Productivity and economics of raya intercropping in wheat under rainfed conditions

Year	WEY* (kg/ha)		% Increase in yield	RWUE (kg/ha-mm)		Net returns (Rs/ha)		B:C ratio	
	Wheat +Raya	Wheat		Wheat +Raya	Wheat	Wheat +Raya	Wheat	Wheat +Raya	Wheat
2012-13	3864	3513	10	16.35	16.07	31597	27360	2.54	2.37
2013-14	3099	2902	6.8	10.98	10.29	39126	33261	2.92	2.53
2014-15	3165	2935	7.8	8.75	6.83	33796	29251	2.35	2.14
Mean	3376	3117	8.2	12.03	11.06	34840	29957	2.60	2.35

WEY – Wheat equivalent yield

Field demonstrations of raya intercropping at row distance of 3 meters in wheat crop were conducted at during the period in both the adopted villages. Raya was sown for intercropping in wheat. The average wheat + raya intercropping WEY yield was 3376 kg/ha which was 8.2 per cent higher as compared to sole wheat crop (3117 kg/ha). The net return and B:C ratio of wheat raya intercropping was Rs 34840/ha and 2.60. Therefore, raya intercropping in wheat sustaining the productivity besides covering the risk of crop failure.

Rainwater management *(in situ and ex situ)*

Kandi region receives more than 1000 mm average annual rainfall. About 80 % of this is received during monsoon season of which 30-40% goes off as runoff. It has been observed that even under good conservation management, about 20% of summer rains will essentially go as runoff. One way of dealing with this situation is to direct the runoff from upper area to lower valley land or dug out pond and allow harvesting rain water. Runoff water retention proved to be a promising way to change temporarily the moisture status of the soil and to cause a large change in grass and vegetative characteristics and productivity. Therefore, runoff harvesting has potential in improving production in rainfed areas. A survey work was carried out in the village to assess the potential of rain water harvesting. After the survey work and meeting / discussion with farmers the existing farm pond of the village is renovated to harvest the rain water and to use the store water as a source of irrigation. After renovation water is stored in a pond having a capacity of 190 thousand cubic feet. The harvested rain water can be used efficiently with drip or sprinkler system to provide lifesaving irrigation to combat with adverse climatic conditions.

Survey work before the renovation work **View of Water Harvesting System before renovation**

Water harvesting structure – village Nainwan

Activity 4: Rain water harvesting in farm ponds and efficient utilization

Rain water was harvested in the village pond in Nainwan having a capacity of 190 thousand cubic feet. Harvested water in village rain water harvesting structure remained available throughout the year (2014-15), which was utilized efficiently for giving pre-sowing irrigation to about 10 ha of land for sowing of wheat crop as there was a long dry spell during the sowing season of *rabi* crops. There was no need for supplemental irrigation during the crop growth period due to sufficient rains.

The successful cultivation of wheat crop depends upon the good germination and the rainfall during *rabi* season. Due to early withdrawal of monsoons and no rains during the month of November and first fortnight of December, the sowing of the wheat crop was not possible due to less soil moisture. So, to ensure timely sowing of the wheat crop with irrigation (pre-sowing irrigation treatment as well as irrigation at CRI & flowering stage if required) was given and other treatment was sowing of wheat after the onset of rains. All agronomic practices were followed as per the recommendations of Punjab Agricultural University.

Unsown field due to dry spell

Wheat crop with pre sowing irrigation

Table 23: Productivity and economics of wheat cultivars with pre-sowing irrigation at under rainfed conditions in village Nainwan

<table>
<tr><th rowspan="2">Year</th><th colspan="2">Yield (kg/ha)</th><th rowspan="2">% Increase in yield</th><th colspan="2">RWUE (kg/ha-mm)</th><th colspan="2">Net returns (Rs/ha)</th><th colspan="2">B:C ratio</th></tr>
<tr><th>Life saving irrigation</th><th>Rainfed crop</th><th>Life saving irrigation</th><th>Rainfed crop</th><th>Life saving irrigation</th><th>Rainfed crop</th><th>Life saving irrigation</th><th>Rainfed crop</th></tr>
<tr><td>2012-13</td><td>2795</td><td>2250</td><td>24.2</td><td>10.55</td><td>14.43</td><td>31763</td><td>21991</td><td>2.5</td><td>2.06</td></tr>
<tr><td>2013-14</td><td>2975</td><td>2215</td><td>34.3</td><td>8.45</td><td>6.29</td><td>34274</td><td>20548</td><td>2.53</td><td>1.95</td></tr>
<tr><td>2014-15</td><td>3660</td><td>2160</td><td>69.4</td><td>8.52</td><td>4.39</td><td>44088</td><td>17796</td><td>2.67</td><td>1.72</td></tr>
<tr><td>2015-16</td><td>3215</td><td>2210</td><td>45.5</td><td>24.92</td><td>24.83</td><td>39856</td><td>20359</td><td>2.51</td><td>1.76</td></tr>
<tr><td>2016-17</td><td>3603</td><td>2240</td><td>60.8</td><td>15.93</td><td>12.02</td><td>45715</td><td>19628</td><td>2.59</td><td>1.72</td></tr>
<tr><td>Mean</td><td>3250</td><td>2215</td><td>46.8</td><td>13.67</td><td>46.8</td><td>39139</td><td>20064</td><td>2.56</td><td>1.84</td></tr>
</table>

During 2012-13, only lifesaving irrigation at CRI stage was given due to less water available in the pond which resulted in 24.2 per cent yield increase in wheat. While during 2013-14 to 2016-17, pre-sowing irrigation was also given as winter rains were delayed and sufficient moisture was not available for sowing. The pre sowing irrigation resulted in better germination of the crop and 46.8 per cent higher mean wheat yield was realized. This also resulted in substantial gain in the net returns also.

Activity 5: Demonstration of *in-situ* moisture conservation practices

Rain water was lost as runoff and goes unutilized in sloppy fields resulting in lower maize yields as well as conserves lesser moisture for succeeding *rabi* crops. Therefore, in situ rain water harvesting can be done by summer ploughing, sowing across the slope and earthing up in maize crop.

Table 24: Effect of different methods of sowing on yield of maize

Year	Yield (kg/ha)		% Increase in yield	RWUE (kg/ha-mm)		Net returns (Rs/ha)		B:C ratio	
	Maize with Summer ploughing	Without summer ploughing		Maize with Summer ploughing	Without summer ploughing	Maize with Summer ploughing	Without summer ploughing	Maize with Summer ploughing	Without summer ploughing
2011-12	3731	3065	21.7	5.69	4.58	27183	19560	2.55	2.13
2012-13	2500	2356	6.1	6.05	5.71	18239	16458	1.74	1.68
2013-14	3156	2833	11.4	4.23	3.8	29285	23982	2.04	1.86
2014-15	3458	3208	7.8	6.52	6.05	25714	22834	1.88	1.74
2015-16	3413	3167	7.8	4.96	4.60	30471	20277	1.96	1.68
2016-17	3485	3310	5.3	5.00	4.75	31933	22998	2.01	1.74
Mean	3291	2990	10.0	5.41	4.92	27138	21018	2.03	1.81

Table 25: Effect of different methods of sowing on yield of maize

Year	Yield (kg/ha)		% Increase in yield	RWUE (kg/ha-mm)		Net returns (Rs/ha)		B:C ratio	
	Sowing across slope	sowing along slope		Sowing across slope	sowing along slope	Sowing across slope	sowing along slope	Sowing across slope	sowing along slope
2011-12	3306	3027	9.2	5.07	4.65	21032	17392	2.23	2.06
2012-13	3111	2963	5.0	7.53	7.18	28841	26412	2.17	2.08
2013-14	3104	2654	17.0	4.12	3.52	28648	22269	2.02	1.81
2014-15	3188	2750	15.9	6.01	5.18	21604	16484	1.74	1.56
2015-16	3420	3260	4.9	4.91	4.68	32476	22287	2.08	1.72
2016-17	3200	2988	7.2	4.65	4.34	29179	17901	2.00	1.60
Mean	3222	2940	9.9	5.38	4.93	26963	20458	2.04	1.81

Table 26: Effect of different methods of sowing on yield of maize

Year	Yield (kg/ha)		% Increase in yield	RWUE (kg/ha-mm)		Net returns (Rs/ha)		B:C ratio	
	Earthing up of maize	Without earthing up		Earthing up of maize	Without earthing up	Earthing up of maize	Without earthing up	Earthing up of maize	Without earthing up
2011-12	3228	2904	11.2	4.84	4.34	19589	17237	2.05	1.95
2012-13	2694	2305	16.9	6.53	5.59	22005	15621	1.91	1.65
2013-14	4258	3658	16.4	5.65	4.85	45996	41780	2.62	2.5

2015-16	3455	3280	5.4	4.96	4.70	32493	22572	2.06	1.73
2016-17	3475	3140	10.7	5.05	4.56	32833	19919	2.14	1.67
Mean	3385	3046	11.3	5.28	4.73	30349	22505	2.13	1.85

The *in situ* moisture conservation techniques like summer ploughing, sowing across the slope and earthing up were demonstrated to the farmers of the adopted villages. The mean maize yield of 3291kg/ha, 3222 kg/ha and 3385 kg/ha were obtained with summer ploughing, sowing across the slope and earthing up, respectively. The average increase in yield was 10.0, 9.9 and 11.3 per cent with summer ploughing, sowing across the slope and earthing up, respectively. The net returns and B:C ratio was also higher with the *in situ* moisture conservation techniques. This was mainly due to better percolation of rain water in the soils and increased soil moisture due to these techniques.

Activity 6: **Promotion of ash gourd cultivation as alternate crop to maize under rainfed conditions**

To study the productivity and economics of ash gourd cultivation under rainfed conditions, 20 demonstration trials were conducted at both the villages. Improved practices of ash gourd gave the average yield of 32085 kg/ha with the net return of Rs 48939/- and B:C ratio of 4.82. Due to higher price in the market, the area under ash gourd crops is increasing rapidly. The net return is also much higher than maize and loss by wild and stray animals is also least damaged by the animals.

Ashgourd crop at NICRA village

Table 27: Cultivation of Ashgourd under alternate land use system

Year	**Yield (kg/ha)**		**Net returns (Rs/ha)**		**B:C ratio**	
	Ashgourd	**FP**	**Ashgourd**	**FP**	**Ashgourd**	**FP**
2011-12	33850		39275		4.41	
2012-13	32500		56167		7.38	
2013-14	31482		47141		3.97	

2014-15	26000		62769		5.12	
2015-16	29175		44314		4.16	
2016-17	39500		43970		3.88	
Mean	32085		48939		4.82	

***Activity 7*: Evaluation of alternative crops in wild animal damage prone area for *kharif* and *rabi* season**

The area which is far away from the village and more prone to stray / wild animal menace. The stray / wild animal damage discourage the farmer to cultivate the area. An attempt was made to identify suitability of kharif season crops i.e. maize, mash and, sesame under such conditions and rabi season crops i.e. wheat and taramira

During *kharif*, maize and sesame were sown in area prone to wild animal menace and all other agronomic practices were followed as per the recommendations of PAU, Ludhiana for kandi area. During *rabi*, Taramira and wheat were sown in area prone to wild animal menace and all other agronomic practices were followed as per the recommendations of PAU, Ludhiana for kandi area.

Sesame crop in NICRA village

***Kharif* season**

To evaluate the suitability crops in wild animal damage prone area, sesame and maize crops were in animal damage prone areas of the village. On the basis of the yield data, it was observed that average maize equivalent (MEY) yield of sesame in wild and stray animals' prone areas was 2483 kg/ha with B:C ratio of 2.14 compared to 1249 kg/ha of maize. The damage by wild and stray animals was more in maize crop in comparison to sesame crop. Hence, sesame crop has potential for its cultivation in areas adjoining to forest and prone to stray/wild animal damage.

Table 28: Productivity and performance of sesame compared to maize in wild animal damage prone area

Year	MEY* (kg/ha)		Net returns (Rs/ha)		B:C ratio	
	Sesame	Maize	Sesame	Maize	Sesame	Maize
2013-14	2000	1100	14482	-5071	1.93	0.78
2014-15	3697	1310	33574	-4280	2.85	0.86
2015-16	1734	1125	10068	-10776	1.64	0.63
2016-17	2500	1460	20007	-5687	2.15	0.80
Mean	2483	1249	19533	-6454	2.14	0.77

MEY – Maize equivalent yield

Rabi season

To evaluate the suitability of *rabi* season crops in wild animal damage prone area, wheat and taramira demonstrations were conducted in animal damage prone areas of the village. On the basis of the yield data, it was observed that wild and stray animals damaged the wheat to larger extent in spite of preventive measures, however, taramira crop was least damaged by wild and stray animals. Among different demonstrations, average wheat grain yield of 901 kg/ha was recorded in the animal prone areas, however the average wheat equivalent yield (WEY) of taramira was 1467 kg /ha with B:C ratio of 1.88.

Table 29: Productivity and performance of taramira compared to wheat in wild animal damage prone area

Year	WEY* (kg/ha)		Net returns (Rs/ha)		B:C ratio	
	Taramira	Wheat	Taramira	Wheat	Taramira	Wheat
2013-14	920	840	1901	-2240	1.19	0.88
2014-15	1366	865	9287	-4562	1.88	0.65
2015-16	1875	900	15843	-11281	2.31	0.58
2016-17	1707	1000	14730	-10840	2.14	0.64
Mean	1467	901	10440	-7231	1.88	0.69

WEY – Wheat equivalent yield

B. Real time contingency plan implementation

I. RTCP Implementation to cope with weather aberrations

Maize hybrid (Ptrakash/JH 3459/PMH 1/PMH 2) were sown in the farmers' fields after the onset of monsoon. The dryspells of varying lengths were observed during the different years and to overcome the effect of drought contingency measures like surface mulching between crop rows with locally available grasses/crop residues, reduction in plant population by removal of weaker plants. The material used for mulching included locally available grasses like *Sachharum munja*, *Arundodonax spp etc.*

Situation 1: Normal Sowing & Early Season drought (*Kharif*) – 2011-12

Weather aberration	Crop	Stage of crop	Real time contingency measure implemented
a. Early season drought	Maize	Vegetative growth	• Creation of soil mulch by hoeing & removal of weeds. • Mulching with the locally available material. • Reduction in plant population.

Table 30: Impact of RCTP on crop yield and economics

Normal Crop	Yield (kg/ha)		% Increase in yield	RWUE (kg/ha-mm)		Net returns (Rs/ha)		B:C ratio	
	RCTP	No Intervention		RCTP	No Intervention	RCTP	No Intervention	RCTP	No Intervention
Maize	4185	3383	23.7	6.14	5.2	32001	23222	2.79	2.3

Situation 2: Normal Sowing & Mid season drought (*Kharif* season) – 2014-15 & 2015-16

Real Time Contingency practices (RTCP) implemented	
Crop	**RTCP implemented**
Maize (silking)	• About 15% plant population (weak plants) were removed and used as fodder. • Removal of the tassels from 25% of the random plants and use as fodder. • Removal of weeds to reduce competition for soil moisture.

Table 31: Impact of RCTP on crop yield and economics

Normal Crop	Yield (kg/ha)		% Increase in yield	RWUE (kg/ha-mm)		Net returns (Rs/ha)		B:C ratio	
	RCTP	No Intervention		RCTP	No Intervention	RCTP	No Intervention	RCTP	No Intervention
2014-15									
Maize	3152	2100	50.1	5.95	3.96	20992	5231	1.72	1.18

2015-16									
Maize	3573	2880	24.1	5.19	4.19	35093	15460	2.16	1.52

Situation 3: Normal onset of monsoon & Terminal Drought (*Kharif* Season) -2012-13

Real Time Contingency practices (RTCP) implemented	
Crop	**RTCP implemented**
Maize (Dough stage)	Weak plants were removed and used as fodder.

Table 32: Impact of RCTP on crop yield and economics

Normal Crop	Yield (kg/ha)		% Increase in yield	RWUE (kg/ha-mm)		Net returns (Rs/ha)		B:C ratio	
	RCTP	No Intervention		RCTP	No Intervention	RCTP	No Intervention	RCTP	No Intervention
Maize	3507	2449	40.8	8.49	5.93	39305	23363	2.58	2.06

The implementation of the RCTPs resulted in higher productivity of maize which was 23.7, 40.8, 50.1 and 24.1 per cent higher than the farmers practice during 2011-12, 2012-13, 2014-15 and 2015-16, respectively. These small but effective interventions resulted in higher net returns and B:C ratio duirng the years.

Activity 8: **Demonstration of need based agricultural implements for various agricultural operations**

During *rabi* season, sowing of crops is generally depend on residual soil moisture. In case the proper sowing method is not followed, or the seed is just at shallow depth, the germination as well as the crop stand is affected. To acquaint the farmers in this regard, field demonstrations on sowing of crops with seed cum fertilizer drill were carried out to compare this method with broadcasting method of sowing in wheat. Similarly, in raya & taramira, demonstration on drill and broadcasting methods of sowing were laid out at farmers' field.

The placement of seed in moisture zone and proper row spacing are the key factors for the germination of crop under limited moisture availability in dryland agriculture. To study the effect of mechanized sowing of wheat, raya and taramira on its productivity, field trials cum demonstrations were laid out at different locations. Wheat, raya and taramira were sown with seed cum fertilizer drill and broadcasting method was kept for comparison purpose. All other agronomic practices were followed as per the recommendation of PAU, Ludhiana.

Modified wheat seed drill bullocks drawn

Wheat Seed Drill at village Achalpur

Table 33: Effect of sowing method on productivity and economics of wheat under rainfed conditions

Year	Yield (kg/ha)		% Increase in yield	RWUE (kg/ha-mm)		Net returns (Rs/ha)		B:C ratio	
	Sowing with drill	Broad casting		Sowing with drill	Broad casting	Sowing with drill	Broad casting	Sowing with drill	Broad casting
2012-13	2670	2436	9.6	17.13	15.63	29531	25326	2.41	2.22
2013-14	3099	2287	35.5	10.98	8.1	35479	19753	2.53	1.84
2014-15	3057	2460	24.3	7.12	5.73	34015	21824	2.32	1.87
2015-16	2355	2075	13.5	28.45	23.31	28266	23645	2.1	1.98
2016-17	2910	2395	21.5	15.7	12.85	32147	21975	2.16	1.8
Mean	2818	2331	20.7	15.88	13.12	31888	22505	2.30	1.94

Table 34: Effect of sowing method on productivity and economics of raya under rainfed conditions

Year	Yield (kg/ha)		% Increase in yield	RWUE (kg/ha-mm)		Net returns (Rs/ha)		B:C ratio	
	Sowing with drill	Broad casting		Sowing with drill	Broad casting	Sowing with drill	Broad casting	Sowing with drill	Broad casting
2012-13	893	607	47.1	5.73	3.89	19356	9657	2.63	1.83
2013-14	1040	825	26.1	3.69	2.92	23296	16082	2.77	2.25
2014-15	758	600	26.3	1.77	1.4	12199	6176	1.73	1.37
2015-16	-	-	-	-	-	-	-	-	-
2016-17	1040	835	24.8	5.59	4.48	24399	16199	2.42	1.94
Mean	933	717	33.2	4.2	3.2	19813	12029	2.39	1.85

Table 35: Effect of sowing method on productivity and economics of taramira under rainfed conditions

Year	Yield (kg/ha)		% Increase in yield	RWUE (kg/ha-mm)		Net returns (Rs/ha)		B:C ratio	
	Sowing with drill	Broad casting		Sowing with drill	Broad casting	Sowing with drill	Broad casting	Sowing with drill	Broad casting
2012-13	560	400	40	3.59	2.57	8114	2994	1.83	1.31
2013-14	615	425	44.7	2.18	1.51	10919	4269	2.03	1.4
2014-15	456	381	19.5	1.05	0.89	7687	4747	1.73	1.45
2015-16	675	395	70.9	7.58	4.43	28073	13075	3.26	2.04
2016-17	705	500	41.0	3.8	2.68	18030	9010	2.39	1.69
Mean	602	420	43.8	3.6	2.4	14565	6819	2.25	1.58

The effect of mechanized and traditionally sowing method in wheat, raya and taramira were illustrated in field demonstration. The data revealed that sowing of wheat with seed cum fertilizer drill gave net returns of Rs 31888 per hectare, grain yield of 2818 kg/ha which was 20.7 per cent higher over broadcasting method of sowing with B:C ratio of 2.30. The sowing of oilseed crops like raya & taramira was also done with seed drill. In raya, seed drill sowing gave seed yield 933 kg /ha, which resulted in 33.2 per cent higher over broadcasting method of sowing. In taramira, seed drill sowing gave seed yield 602 kg /ha, which was 43.8 per cent higher over broadcasting method of sowing. The mechanized sowing clearly indicated the superiority, which gave higher net return over broadcasting method of sowing method.

8.0 Overall impact

Interventions demonstrated:

Under NICRA scheme, a defunct village pond in village Nainwan was renovated with the help of the farmers of the village and panchayat. After renovation water was stored in a pond having a capacity of 190 thousand cubic feet. The rainwater harvested during the rabi season in village rain water harvesting structure remains available from August to February, which was utilized efficiently for life saving/supplemental irrigation. *In-situ* moisture conservation practices such as summer ploughing, ploughing across the slope, earthing up in maize, laser land levelling and compartmental bunding were demonstrated which are being spread to other farmers through convergence with other line departments.

High yielding drought tolerant varieties of maize (Prakash, JH 3459, PMH 1 & PMH 2), wheat (PBW 175, PBW 644, PBW 660), Mash (mash 114), Moong (PAU, 911, ML 2056, ML 818), Sesame (RT 346, Punjab Til No. 2), Raya (RLM 619, PBR 91), Taramira (TMLC 2) and Chickpea (PBG 1, PBG 7 & PBG 5) were demonstrated through FLDs and most of them have been adopted by the farmers.

The farm mechanization was very poor in the villages and during *rabi* season the moisture in the soil is very low due to which there was problem of germination and crop stand in the crops. To tackle this problem the sowing with seed-cum-fertilizer drills was demonstrated to the farmers. The placement of the seed with seed-cum-fertilizer drills was in the moist zone in the soil and furrows remained one which resulted in higher and uniform germination.

The wild animal damage to the crops is a major problem in the area. To address this problem, crops like sesame, ashgourd and taramira which are immune/tolerant to the animal damage along with improved crop management practices were demonstrated in the farmer’s field. In addition to this there is scarcity of fodder in the region, so the high fodder yielding varieties of bajra (FBC 16) was provided to the farmers. The cuttings of Napier Bajra hybrid (high fodder yield) for plantation on the field bunds were also provided to the farmers. Custom hiring center was established in the village and different types of implements were procured and made available in the custom hiring centre, viz., rotovator, seed cum fertilizer drills, bund maker, power sprayers, wheel hand hoe, engine for uplifting the water from village pond and delivery pipes for irrigation.

Table: Impact on yield & income of the crops

Crop	Impact		Overall yield increase or decrease (kg/ha)	Overall increase or decrease in net returns (Rs/ha)
	Area (ha)	Production (tons)		
Maize	68	250.58	911	14139
Wheat	106	326.08	836	15423
Raya	13	12.19	245	8177
Taramira	15	8.25	176	5930
Bajra (fodder)	12	396	10432	8813
Sesame	8	2.84	63	4948
Moong	11	7.62	195	10884
Mash	10	5.98	124	7965
Ashgourd	120	3777.84	-	-

The implementation of NICRA scheme in the village Achalpur and Nainwan has resulted in the adoption of new and improved dryland technologies and enhancement of the technical knowhow of the farming community of the area and diffusion of the technologies in the surrounding villages also. Main impact of the NICRA is given below:

1. The renovation of the village pond in the Nainwan village enhanced its storage capacity to 190 thousand cubic feet. The harvested rainwater in the village pond is being used for giving pre-sowing as well as life-saving irrigation to the crops during *rabi* season in case of delayed rains in area of 10-12 ha. During 2012-13, only lifesaving irrigation at CRI stage was given due to less water available in the pond which resulted in 24.2 per cent yield increase in wheat. While during 2013-14 to 2016-17, pre-sowing irrigation was also given as winter rains were delayed and sufficient moisture was not available for sowing. The pre sowing irrigation resulted in better germination of the crop and 46.8 per cent higher mean wheat yield was realized. This also resulted in substantial gain in the net returns also.
2. Majority of the NICRA farmers have adopted the *in situ* moisture conservation technologies like summer ploughing, ploughing across the slope, earthing up in maize, laser land levelling and compartmental bunding because these technologies have resulted in better soil moisture for the succeeding *rabi* crops.
3. During *rabi* season, sowing of crops is generally depend on residual soil moisture. In case the proper sowing method is not followed, or the seed is just at shallow depth, the germination as well as the crop stand is affected. To acquaint the farmers in this regard, field demonstrations on sowing of crops with seed cum fertilizer drill were carried out to compare this method with broadcasting method of sowing in wheat, raya and taramira. The placement of seed in moisture zone and proper row spacing are the key factors for

the germination of crop under limited moisture availability in dryland agriculture. The effect of mechanized and traditionally sowing method in wheat, raya and taramira were illustrated in field demonstration. The sowing of wheat with seed cum fertilizer drill gave net returns of Rs 31888 per hectare, grain yield of 2818 kg/ha which was 20.7 per cent higher over broadcasting method of sowing. The seed drill sowing gave seed yield 933 kg /ha & 602 kg/ha, which was 33.2 & 43.8 per cent higher over broadcasting method of sowing in raya and taramira respectively. The mechanized sowing clearly indicated the superiority, which gave higher net return over broadcasting method of sowing method. After the introduction of the seed-cum-fertilizer drills in the NICRA villages, the adoption of this technology is very high and more than 90 per cent area under wheat and 60 per cent area under oilseeds is being sown with seed drills.

4. High yielding drought tolerant varieties of maize, wheat, mash, moong, sesame, raya, taramira and chickpea gave higher yield than farmers' varieties. The increase in yield over farmer's variety ranged between 31.3 to 54.7 per cent for different crops. Most of the farmers of the area have adopted the introduced varieties.
5. The damage to the crops from the wild/stray animals in the region is very and in some of the area the net returns from the crops is negligible or even negative. In addition to that the farmers have to spend their nights in the fields for the watch and ward of the crops from the animals. Ashgourd and sesame were tested during *kharif* season and taramira during *rabi* season against animal damage. Net return of Rs 48,939/ha & Rs. 19,533/ha with B:C ratio of 4.82 & 2.14 were given by ashgourd and sesame, respectively in high animal damage prone areas, whereas net returns from maize were negative. Similarly, during *rabi* season taramira net returns to the tune of Rs. 10,440/ha, while the returns in case of wheat were negative from the same area.

The various NICRA interventions in the adopted villages have resulted in the enhancement in production and productivity of the crops. This has resulted in stability in the crop productivity as well as better net returns to the farming community.

Impact of VCRMC, CHCs, fodder banks, seed banks

The meetings of the VCRMC and CHC were conducted from time to time to discuss the intervention to be selected and implemented, keeping in view, the climatic scenario in the NICRA villages. The VCRMC played pivotal role in mitigation of the aberrant weather conditions.

Details of Village Climate Risk Management Committee

Sr. No	Category	Achalpur	Nainwan
1	Sarpanch	Sh Paramjit Lal S/o Sh. Amar Chand	Sh. Harmesh Singh S/o Sh Harwail Singh
2	VDC	Sh. Avinash Kumar S/o Sh. Bishan Das	Sh. Darshan Singh S/o Sh. Anurudh Singh
3	Official	Sh Ashok Kumar, Soil Conservation Officer	
4	Progressive farmer	Sh Kashmir Singh S/o Sh Babu Ram,	Sh. Som Nath S/o Sh. Hazara Singh
5	Young farmer	Sh Jaswinder Singh S/o Sh. Gurdev Singh	Sh. Lakhvinder Singh S/o Sh. Chohar Singh
6	Lady	Smt Jaswinder Kaur W/o Sh Sohan Singh	Smt Giano Devi W/o Sh. Bachna Ram
7	SC/ST	Sh Sadiq Mohammad S/o Sh Gamma	Sh. Sukhvinder pal S/o Sh. Swarn Singh
8	Landless	Sh Kashmir Singh S/o Sh. Shangara Ram	Sh. Gurdev Ram S/o Sh. Parkash Ram
9	Farmers	Sh Gurdas Singh S/o Sh. Babu Ram	Sh Gandharav Singh S/o Sh. Ranbir Singh
10	Farmers	Sh Husan Singh S/o Sh Kartar Singh	Sh Amar Nath S/o Sh. Chet Ram
11	Farmers	Sh Mohinder Singh S/o Sh. Gurdhara Singh	Sh Mohan Lal S/o Sh. Hukam Singh
12	Farmers	Sh. Satnam Singh S/o Sh. Malkiat Singh	Sh. Bikram Singh S/o Sh. Lakho Ram
13	Farmers	Sh Parshotam Singh S/o Sh. Anant Ram	Sh. Dilawar Singh S/o Sh. Hazara Singh

Details of Custom hiring management committee

Sr. No.	Name of member	Category
1	Sh Harmesh Singh S/o sh Hawail Singh, Nainwan	Sarpanch
2	Sh Paramjit Lal S/o Sh. Amar chand, Achalpur	
3	Sh Darshan Singh S/o Sh. Anurudh Singh, Nainwan	VDC
4	Sh. Avinash Kumar S/o Sh. Bishan Das, Achalpur	
5	Sh. Rajinder Singh S/o Sh. Sheetal singh, Nainwan	Progressive Farmer
6	Sh. Purshotam singh S/o Sh . Anant Ram, Achalpur	
7	Smt Deepo W/o Sh .Mohan Singh, Nainwan	Lady (farm women)
8	Smt Manjeet Kaur W/o Sh. Satnam Singh, Achalpur	
9	Sh. Sohan singh S/o Sh. Hari Das, Nainwan	SC/ST
10	Sh. Harmesh Lal S/o Sh. Kartar Chand, Achalpur	
11	Sh. Agya Ram S/o Sh. Anant Ram, Nainwan	Farmers
12	Sh. Gurdas Singh S/o Sh. Babu Ram, Achalpur	

1. **Village seed bank:**

   The progressive farmers of the villages are producing the seed of the improved varieties of the self-pollinated crops. These farmers are then sharing the seed of these improved varieties with other farmers of the village and adjoining areas.

2. Fodder bank

The seed of the improved variety of pearl millet is being supplied to farmers every year along with napier-bajra hybrid cutting for establishment on the field bunds. The fodder is being used by the farmers individually for their cattle's. Napier-bajra hybrid grass is fulfilling their needs during lean period or offseason.

Fodder crop/ variety	Land (Individual/ community land)	Quantity of fodder produced (kg on dry weight basis) or planting material							Quantity of fodder seed (kg)/planting material (number or ha) supplied to farmers						
		2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	Total	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	Total
FBC 16	Individual	-	7280	6400	19660	11640	17840	62820	-	12	10	30	20	30	82
Napier – Bajra Hybrid cuttings/		-	-	5600	7800	10400	11200	35000	-	-	2400	600	1200	-	4200

3. Custom hiring centre (CHC)

Name of the implement / machine	No. of implements/ machines in CHC	Number of farmers and area* (ha) covered						Revenue generated (Rs)					
		2012-13	2013-14	2014-15	2015-16	2016-17	Total	2012-13	2013-14	2014-15	2015-16	2016-17	Total
Rotavator	1	-	9 (5.6)	16 (10.3)	14 (9.2)	9 (2.05)	48 (27.2)	-	700	2526	2770	1040	7036

Maize Planter	1	-	-	14 (3.85)	38 (6.35)	14 (3.6)	66 (13.8)	-	-	1120	1905	1040	4065
Iron Planker	2	-	4 (0.8)	-	6 (1.2)	-	10 (2.0)	-	40	-	140	-	180
Seed drill	1+1	-	26 (5.35)	40 (10.1)	12 (2.45)	9 (3.55)	87 (21.5)	-	535	2020	750	1255	4560
Bund former	1	-	18 (2.6)	6 (2.1)	2 (0.2)	-	26 (4.72)	-	156	210	40	-	406
Ridger	1	-	-	8 (1.4)	9 (1.8)	8 (1.45)	25 (4.65)	-	-	280	380	465	1125
Wheel hand hoe	5	-	-	-	-	-		-	-	-	-	-	0
Knapsack sprayer	8	-	-	-	-	-		-	-	-	-	-	0
Maize Sheller		-	-	-	-	-	-	-	-	-	-	-	0
Water Lifting pump	1	-	3 (0.4)	23 (12)	43 (15)	47 (19)	116 (39.4)	-	360	3517	7725	5155	16757
Total			60 (14.8)	74 (34.5)	48 (28.1)	50 (25.3)	378 (95.7)	-	1791	9673	13710	8955	34129

***Area covered (ha) is given in parentheses**

9.0 Capacity building

2011-12

Activity/subject	Organized on (date)	Beneficiaries	Brief outcome
Farmers group meeting related to NICRA project	RRSKA, Ballowal Saunkhri April 19, 2011	40	Interaction meeting with the farmers for implementation of NICRA scheme in the village
Regional Kisan Mela	RRS, Ballowal Saukhri, 08 Sept., 2011	4500	Dissemination of the lasted agro techniques for the *rabi* season crops.
Regional Kisan Mela	RRS, Ballowal Saukhri, 12 March 2012	4000	Dissemination of the lasted agro techniques for the *kharif* season crops.

NICRA Interaction Meeting (23-05-2011) at village Nainwan – AICRPDA, Ballowal Saunkhri

Interaction meeting in progress

Farmer interacting during interaction meeting

Farmers, Agriculture division bank officials and experts interaction explaining about agriculture related the schemes/loans of bank

Constitution of different committees like Village Climate Risk Management Committee, Village Implement Committee

2012-13

Activity	Organized on (date)	Beneficiaries	Brief outcome
Regional Kisan Mela	RRS, Ballowal Saukhri, 05.09.2012	5000 farmers	Dissemination of the lasted agro techniques for the *rabi* season crops.
Regional Kisan Mela	RRS, Ballowal Saukhri, 10.03.2013	4000 farmers	Dissemination of the lasted agro techniques for the *kharif* season crops.
Kisan Gosthi	Vill. Achalpur, Distt. Hoshiarpur 17.01.2013	45	Dissemination of the latest agro-techniques for the rainfed farming.
Kisan Gosthi	Vill. Nainwan, Distt. Hoshiarpur 13.03.2013	80	Dissemination of the latest agro-techniques for the rainfed farming.

Farming community of NICRA village Achalpur interacting with AICRPDA scientists on dated 21.01.2013

Awareness about soil health among the NICRA farmers and distribution of soil health cards

Farming community of NICRA village Nainwan interacting with AICRPDA scientists on dated 13.03.2013

Farmers of NICRA village attending the farmers fair (Kisan mela) at Ballowal Saunkhri on 05.09.2012

2013-14

S.No.	Activity	Organized on (date)	Beneficiaries	Brief outcome
1.	Regional Kisan Mela	RRS, Ballowal Saunkhri, 04.09.2013	3500 farmers	Dissemination of the lasted agro techniques for the *rabi* season crops.
2.	Regional Kisan Mela	RRS, Ballowal Saunkhri, 10.03.2014	3000 farmers	Dissemination of the lasted agro techniques for the *kharif* season crops.
3.	Field day (Rain water management & rainfed agriculture technologies)	Vill. Nainwan Distt. Hoshiarpur 25.07.2013	50 farmers	Awareness about *in situ* rainwater management techniques and latest rainfed agro-techniques.
5.	Interactive meeting of PC, AICRPDA, CRIDA, Hyderabad with NICRA -farmers & scientists	Village Achalpur Distt. Hoshiarpur 20.09.2013	35 farmers	Interaction of the farmers with PC, AICRPDA, CRIDA, Hyderabad
8.	Oil seed day for farmers awareness about importance of oilseeds and cultivation with improved practices	Vill. Nainwan, Distt. Hoshiarpur, 12.02.2014	25 farmers	Awareness about the new varieties of the oilseeds and benefits of oilseeds cultivation.
11.	Awareness workshop on impact of climate change on agriculture	Senior Secondary School, Habowal, Garhshankar, Distt Hoshiarpur , 21.03.2014	150 farmers from ORPs (Old and new), NICRA villages and other adjoining villages.	Awareness about the climate change and its impact on agriculture and how to mitigate or minimize its effects.

Sh Paramjit singh, NICRA farmer receiving certificate of appreciation at CSWCRTI, Dehradun

Awareness camp on processing of fruits, vegetables and milk products

NICRA farm women during exposure visit

2014-15

Activity	Organized on	Beneficiaries	Outcome
Awareness camp on processing of fruits, vegetables and milk products	18.06.2014	45	Farmers and farm women got awared about various processing techniques
Exposure visit of NICRA farm women to KVK Langroya	26.06.2014	35	Interaction of the NICRA farmers with the farmers from Himachal Pradesh regarding the rainfed farming/agriculture.
Regional Kisan Divas at AICRPDA centre, Ballowal Saunkhri	10.09.2014	5000	Dissemination of the lasted agro techniques for the *rabi* season crops.
Ash gourd (Petha) Day	19.09.2014	30	Addressed the problems being faced by the farmers in cultivation of ash gourd.
Farmers from Himachal Pradesh visited NICRA village Nainwan and Achalpur, Distt Hoshiarpur (Punjab)	17.10.2014	50	Interaction of the NICRA farmers with the farmers from Himachal regarding the rainfed farming/agriculture.
Kisan Gosthi on problems and prospectus of agriculture in kandi area of Punjab	03.11.2014	300	Identified the location specific problems/new problems being faced by the farmers.
Visit of Dr JVNS Prasad, Principal Scientist (CRIDA) to AICRPDA centre, Ballowal Saunkhri	11.11.2014	35	Interaction with the farmers regarding the on-going activities in the NICRA villages.
Visit of Dr G. Ravindra Charry, Project Coordinator, AICRPDA to NICRA and ORP village at Ballowal Saunkhri	20.11.2014	30	Interaction with the farmers regarding the on-going activities in the NICRA villages.
Awareness camps on yellow rust in wheat at village Nainwan and Achalpur Tehsil Garhshankar under NICRA scheme	19.01.2015	30	The incidence of yellow rust was very low in the area due to timely control by the farmers after attending this camp.
Regional Kisan Divas at AICRPDA centre, Ballowal Saunkhri	10.03.2015	Aprox. 5000	Dissemination of the latest agro techniques for the *Kharif* season crops.

First visit of New Chief Scientist, AICRPDA - Ballowal Saunkhri centre along with Dr Lopa Mudra Mohapatra, Department. of Extension Education, Punjab Agricultural University, Ludhiana to NICRA Village Nainwan and Achalpur.

Exposure visit of women from NICRA villages Achalpur & Nainwan to KVK, Langroya

One day training camp on post harvest technology to women in NICRA village Achalpur

Visit of Dr. Ravindra Chary PC, AICRPDA to NICRA villages and interaction with the farmers

Interaction meeting with farmers (11.11.2014)

Ashgourd cultivation in farmers field

2015-16

Topic	No. of beneficiaries	Date	Place
Kisan mela	60	10.09.2015	AICRPDA centre Ballowal Saunkhri
Visit of Dr Ramesh Chand, Member NITI Aayog, GOI, New Delhi	65	23.10.2015	Achalpur
Village fair	300-400	18.10.2015	Village Achalpur
Stakeholder meeting	15	19.11.2015	AICRPDA centre Ballowal Saunkhri

Dr Ramesh Chand, Member NITI Ayog, New Delhi visit to NICRA village (23.10.2015)

NICRA farmers attemding the Stake holder meeting held at AOICRPDA centre Ballowal saunkhri (19.11.2015)

2016-17

Topic	No. of beneficiaries	Date	Place
Seminar on organic farming	65	27.07.2016	AICRPDA centre Ballowal Saunkhri
Training of farm women for making cleaning agents	25	17.08.2016	Achalpur
Camp on silage making	45	23.08.2016	Village Achalpur
Kisan Mela	4000	09.09.2016	AICRPDA centre Ballowal Saunkhri
Field day on promotion of kitchen gardening	65	26.09.2016	Village Achalpur
Seminar on processing and value addition	72	21.10.16	AICRPDA centre Ballowal Saunkhri
Field day on Improved Production Technologies of *rabi* crops	48	27.10.2016	Village Achalpur
Interaction meeting of Farmers with PC, AICRPDA, CRIDA, Hyderabad	55	04.12.2016	Village Achalpur
One day training of farm women on ashgourd processing	30	27.12.2016	AICRPDA centre Ballowal Saunkhri
Kisan Mela	4500	8.3.2017	AICRPDA centre Ballowal Saunkhri

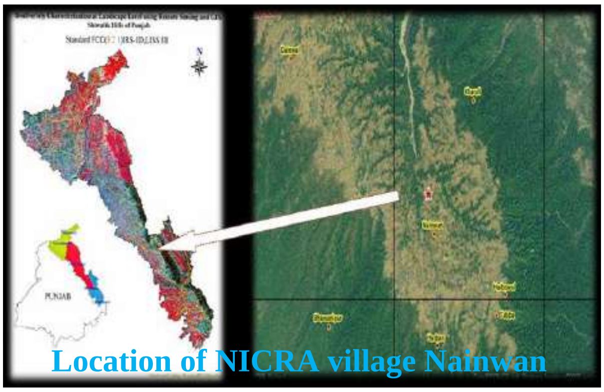
Dr. G. Ravindra, PC, AICRPDA, CRIDA Hyderabad visited NICRA on dated 04/12/2016 and interacted with the farmers

Organization of field days on silage making, promotion of kitchen gardening and improved agro techniques for rabi crops.

10.0 Success stories

Water resource development in NICRA village

The Project on National Initiative on Climate Resilient Agriculture (NICRA) was started under All India Coordinated Research Project on Dryland Agriculture (AICRPDA) – Ballowal Saunkhri centre at villages Achalpur and Nainwan in Tehsil Garhshankar of district Hoshiarpur, Punjab. These villages are approximately 35 km from AICRPDA – Ballowal Saunkhri centre on Pojewal – Jhungian road and lies in plateau (*beet* area) of *kandi* area of Punjab. The villages are located between 31^{o}14.55’N latitude and 76^{o}18.16’E longitude at an elevation of 493 meter above mean sea level. The domain area under NICRA falls in ACZ-1 of North Eastern Punjab known as *kandi*. The area is characterized by erratic distribution of rainfall, delayed onset and early withdrawal of monsoon resulting in uncertain crop yields. Crop failures are common due to moisture stress caused by dry spells.


Location of NICRA village Nainwan

Selected villages and adjoining area is dominated by maize based cropping system. More than 80 % area of the selected site is under rainfed agriculture, having very deep groundwater (water table depth ≥ 650 feet). There is potential for water harvesting and its efficient utilization due to sloppy lands resulting in high surface runoff. The existing pond in NICRA village Nainwan was defunct inspite of good runoff from catchment.

Interactive Meet for Problem Identification

The launch workshop for NICRA project was organized in village Nainwan during April, 2011 in which farmers of both NICRA villages (Achalpur & Nainwan) and AICRPDA scientists interacted to discuss the problems of villages particularly related to agriculture. Farmers raised the issue of village pond which was defunct even after the renovation efforts made at different levels with the support of the farming community. After discussion with the farmers it was unanimously decided that with the support of farming community, NICRA project and Punjab State Department of Soil Conservation the efforts will be made to renovate the defunct pond. The AICRPDA scientists along with farmers visited the whole area to identify the main problems of defunct pond. The


Farmers’ feedback

scientists came to conclusion that the pond area was too big, heavily infested with weeds & bushes and soil from the pond bed was excavated for brick kiln that lead to heavy seepage losses. Further, a breach in the inlet to the pond enhanced the problem. In view of this, AICRPDA scientists decided that pond area to be in catchment – command relationship and runoff.


Survey work in village pond

Renovation of pond

The survey was conducted by the engineering team of Regional Research Station (RRS), Ballowal Saunkhri to estimate the catchment – command area and potential of rainwater harvesting. The survey revealed that the pond has catchment area of approximately 25 ha and surface area of approximately 1.6 ha. The map along with estimate was prepared for the renovation of pond that got approved from the competent authority.

Following interventions were made for the renovation of the pond:


NICRA Village Pond (Before Renovation)

- Excavation of earth from the pond nearer to the inlet structure and using the excavated earth to divide the pond into four parts
- Excavation of earth for proper inlet channel along with provision of a culvert to divert runoff flowing downstream towards pond and filling the eroded portion adjacent to inlet drop structure
- Cleaning of shrubs, bushes etc. growing in the pond by the villagers

The excavation of earth from pond and inlet channel was executed by the Punjab State Department of Soil Conservation with design and technical guidance of AICRPDA scientists and financial support of NICRA. The culvert for diverting runoff was installed by the Punjab State Department Soil Conservation.

NICRA Farmers' Contribution in Renovation of Pond


NICRA Village Pond (After Renovation)

The pond area was prone to snakes and no one was willing for cleaning shrubs and bushes growing in the pond. One farmer voluntarily spared JCB and other his tractor trolley for site clearance and transportation of material. The joint efforts of farmers, state department and NICRA contributed to renovation of the village pond that resulted in water resource development in NICRA village.

Water Availability and Utilization

Storage capacity of the pond was approximately 4500 m^3, with average depth of 2.9 m and cost of water was approximately 0.08 per litre water. With reduced surface area, clayey soil and bed compaction reduced evaporation and seepage losses. Further no seepage control measure required at this stage. Evaporation losses can be controlled by providing shade nets, asbestos sheet etc. but their use was not feasible in present scenario. The centrifugal pump and diesel engine for lift irrigation was provided by RRS, Ballowal Saunkhri.

Use of stored water with lift irrigation

Wheat crop during *rabi* season was raised on residual profile moisture. However, supplemental irrigation to about 3 ha wheat crop was applied at crown root initiation (CRI) and flowering stages during 2012-13 and 2013-14, using lift irrigation with diesel engine pump. The supplemental irrigation enhanced wheat (PBW-175) grain yield by 33 % when irrigations were applied at CRI & flowering stage and 22 % when irrigation was given at CRI stage as compared to yield without irrigation. The B:C ratio with one and two irrigations was 2.41 and 2.60, respectively as compared to 2.02 without irrigation. During *rabi* 2014-15, due to early withdrawal of monsoon and long dry spell for about 90 days, there was no sufficient moisture for sowing of *rabi* crops. However, there was approximately 3100 m^3 stored rain water in the pond at the start of sowing of *rabi* crops. As a result, sowing of wheat with pre-sowing irrigation was possible on about 10 ha land which otherwise would have been left unsown.

For using the water judiciously and creating awareness about water use efficiency, portable sprinkler system was installed as technological intervention. A water user society was formed to regulate the water distribution and use/maintenance of micro-irrigation system (MIS). The society unanimously fixed Rs. 50 per hour for renting engine and contributing diesel for its operation with the condition to revise rates periodically. The generated amount is deposited in the bank account of society.

Irrigation with portable sprinkler system

Ashgourd cultivation for better returns

In 2010, All India Coordinated Research Project on Dryland Agriculture (AICRPDA) centre – Ballowal Saunkhri launched Central Research Institute for Dryland Agriculture (CRIDA) funded National Innovations on Climate Resilient Agriculture (NICRA) project at villages Achalpur and Nainwan Tehsil Garhshankar of district Hoshiarpur. Under NICRA project, all the interventions for rainfed agriculture developed by AICRPDA centre Ballowal Saunkhri are being transferred to farmers' field at village Nainwan and Achalpur. Awareness camps and training programmes are also being organized in the village for the welfare of the farming community of the area. Custom Hiring Centre for latest agricultural implements has been established in NICRA village to increase the use of latest technology and to reduce the cost of cultivation. Few farmers in the area were growing ashgourd crop before NICRA interventions and there was wide variation in the fruit size, yield and rate of the produce.

Ashgourd cultivation:

Ashgourd (*Benincasa hispida*) is a warm season crop and its fruits are cultivated mainly for culinary purpose. The fruits are covered by white, chalky wax, which deters microorganisms and helps impart an extraordinary longevity to the gourd. The optimal temperature for the growth of ash gourd is in the range of 22-35^{o}C and it is very sensitive to frost and low temperature conditions. The ideal season for growing ashgourd is February-March and June-July. Under rainfed conditions sowing can be done after the first showers in May-June. The recommended manures and fertilizers are 10-15 tonnes of well rotten FYM / compost alongwith 100 kg nitrogen, 50 kg phosphorus and 50 kg potassium per hectare. The full dose of FYM, phosphorus and potassium and half dose of nitrogen is applied in band placement during bed / pit preparation and rest half of the nitrogen during flowering. PAG-3 is the recommended variety of ashgourd by the Punjab Agricultural University for Punjab conditions. Ashgourd hybrids of private seed companies are also available in the market. The recommended seed rate for ashgourd is 4-5 kg /ha. Sowing of 2-3 seeds per hill is recommended at a row to row spacing of 3.0 m and plant to plant spacing of 0.8-0.9 m. Seed soaking for 7-8 hours in cold water and then its treatment with 0.2% bavistin solution for 2 hours improves the germination percentage as well as it saves the crop from soil borne diseases. Avoid deeper sowing and excess moisture in the ashgourd field. Ashgourd nursery can be raised in the plastic bags and can be transplanted in the field after 15-20 days when seedlings are of 10-15 cm in length. After two weeks remove the unhealthy plants and keep two plants per hill for better growth and yield of ashgourd crop.

During the initial stages of crop growth, irrigate it at weekly interval, and then after 3-4 days during flowering/fruiting. During rainy season, drainage of excessive water is essential for plant survival and growth. Ashgourd is a cross pollinated crop. Insects especially bees play a vital role in pollination hence avoid the spray of insecticides during the flowering stage. The fruits are ready for picking after 120-150 days. The average yield of ashgourd crop is 35-45 t/ha.

NICRA interventions for promotion of ashgourd cultivation:

The ashgourd cultivation was promoted in the NICRA villages using cluster approach during the last three years i.e. from 2012-2014 under the technical guidance of the AICRDA – Ballowal Saunkhri centre. The good quality seed was provided to farmers and technical know-how was imparted through demonstrations, field days and diagnostic visits about the cultivation of crop

The ashgourd gave an average fruit yield of 26 - 33.8 t/ha over the years (Table 1) with mean of 30.5 t/ha and net return ranged from Rs 39275/- per ha (2012) to Rs. 77994/- per ha (2014). The average B:C ratio during the year varied from 3.98 to 5.12 (mean 4.50). The rate of the ashgourd varied from Rs 5-10/- per kg every year. The main advantage of the crop is that it is being purchased by the contractors on the spot thus saving the cost on harvesting as well as on transportation to market. The damage of the wild and stray animals in ashgourd crop is minimum as compared to maize crop.

Table 1: Productivity and economics of ashgourd at NICRA village Achalpur and Nainwan

Year	Crop	Yield (t/ha)	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net Returns (Rs/ha)	BC Ratio
2012	Ash gourd	33.9	11500	50775	39275	4.41
2013	Ash gourd	31.5	15823	62964	47141	3.98
2014	Ash gourd	26.0	15225	77994	62769	5.12
	Average	**30.5**	**14183**	**63911**	**49728**	**4.50**

Ashgourd transplanting **Ashgourd seedlings**

Ashgourd crop in the fields

Ashgourd Fruit in field **Marketing of Ashgourd crop**

Seed cum Fertilizer Drill- Cost effective implement for sowing crops under rainfed conditions

In *rabi* season, crop failure has become a common problem in the region and famers even keep some of their land fallow because sowing of crops generally depends on residual soil moisture. In case the proper sowing method is not followed, or the seed is sown at shallow depth, the germination as well as the crop stand is affected. Earlier in most of crops, seed sowing was done by *kera* method with bullock ploughing. But with the passage of time, farmers started ploughing field with tractors and broadcasting of seed has become the common method of seed sowing in *kharif* and *rabi* season. Broadcasting method of seed sowing is imprecise and leads to uneven distribution as well as depth of the seeds, poor germination and ultimately low crop productivity.

The use of seed cum fertilizer drill during *rabi* season is widely accepted by the farmers due to significant increase in crop yield and reduction in cost of cultivation. Seed cum fertilizer drill is a sowing implement that precisely places seeds and fertilizers in the soil moisture zone at equal distances and proper depth. The implement reduces the quantity of seed and fertilizer resulting in uniform germination and higher grain yield compared to other methods of sowing.

AICRPDA - Ballowal Saunkhri centre promoted the use of seed cum fertilizer drill for wheat and oil seed crops through technical guidance (demonstrations, field days) as well as by providing the seed cum fertilizer drill in ORP and NICRA adopted villages. More than 100 demonstrations were conducted in the adopted villages from 2012-2015, to demonstrate the impact of seed cum fertilizer drill in improving crop productivity and net returns.

Improvement in crop productivity and economic benefits:

Sowing of wheat with seed cum fertilizer drill gave 10-12 per cent higher grain yield over wooden plough and 25-35 per cent over broadcasting method of seed sowing under rainfed conditions. In oilseed crops, drill sowing has resulted in significantly high grain /seed yield, which varied from 18-121 percent. The sowing with seed cum fertilizer drill resulted in uniform germination and optimum crop stand throughout the field even under rainfed conditions. It also increased the rain water use efficiency compared to sowing with other methods.

The net return and benefit cost ratio of the crops increased significantly with the use of seed cum fertilizer drill. Additional income of Rs. 4,000-6,000 in wheat, Rs. 7,000-11,000 in raya and Rs. 3,000-5000 in taramira was realized (on average basis) with B:C ratio of 2.42, 2.15 and 2.10, respectively with drill sowing over other methods of sowing.

Impact

The cost of cultivation in crops is increasing every year due to increase in price of inputs and labour. Non-availability of labour is the utmost problem in the agriculture sector. Introduction of the agricultural implements such as seed drills have significantly reduced the labour as well as other inputs due to their judicious utilization. Thus, it is helping in reducing the cost of cultivation and increasing the crop yield significantly. Presently, most of the

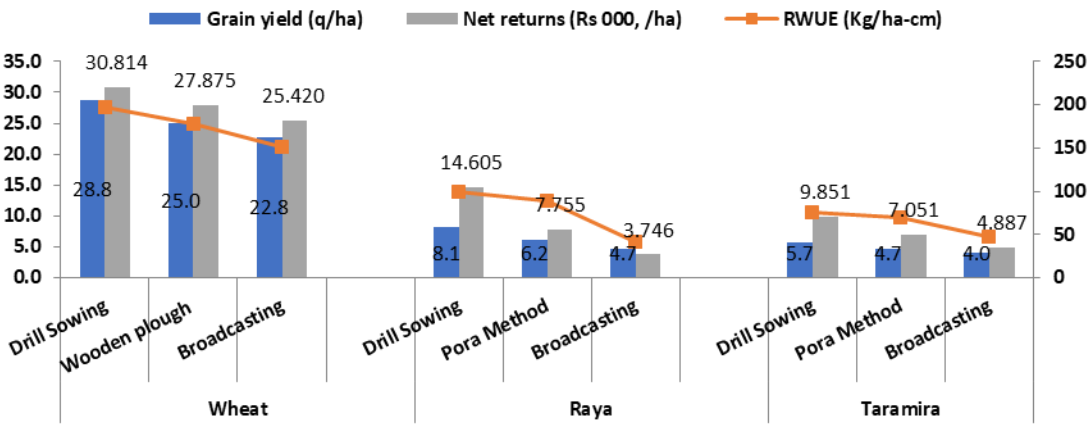


Fig: Effect of sowing method on productivity and economics of wheat, raya and taramira under rainfed conditions

The farmers in the adopted villages are using the seed cum fertilizer drill. The use of seed cum fertilizer drill is also becoming popularized among the farmers in the adjoining villages. Custom hiring centre of agricultural implements or use of agricultural implements on community sharing basis has become a great asset for the small and resource poor farmers of the *kandi* area of Punjab. Hence, there is need to further popularize such type of agricultural implements to improve and sustain the agriculture productivity under rainfed conditions.

Seed cum Fertilizer Drill sowing of wheat **Drill sowing of rainfed wheat**

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Ballowal Saunkhri, District Shaheed Bhagat Singh Nagar, Punjab – 144521