Compendium of Climate Resilient Technologies

ICAR- Agricultural Technology
Application Research Institute (ATARI)
CRIDA Campus, Santhoshnagar, Hyderabad-500059
Telangana, India.

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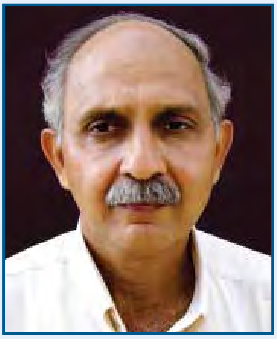

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भाकृअनुप ICAR

Preface

Considering the extreme vulnerability of dryland farming to climate change and significant rise in the frequency of extreme weather events in recent years ICAR has launched National Initiative on Climate Resilient Agriculture (NICRA) Project to enhance the resilience of Indian agriculture. As a part of this initiative, extensive technology demonstrations of location-specific best-bet practices are conducted on farmers fields in 13 vulnerable districts of the Zone-V through Krishi Vigyan Kendras. Based on the performance of the technologies demonstrated in Zone V under varied agro-climatic conditions the “Compendium of Proven Climate Resilient Technologies” has been prepared by the Institute to facilitate the up scaling of these technologies for the benefit farmers in similar agro-ecological regions of the country.

I am highly grateful to Dr. S Ayyappan, Director General, ICAR and Secretary, DARE, Dr. A.K Singh, DDG (Agril. Extension) for involving KVKs in implementing the technology demonstrations, an important component of the NICRA project and extending necessary support.

My sincere thanks to Dr. G. Rajender Reddy, Sr. Scientist (Soil Science) & Nodal Officer for NICRA, Zone-V and Dr.G.Subba Reddy, Former Head Crop Science Division & Principal Scientist, CRIDA for their commitment and dedicated efforts in carrying out the programme systematically and successfully by the selected KVKs. I appreciate the Progrmme Coordinators, Subject Matter Specialists, Research Associates and Senior Research Fellows of Krishi Vigyan Kendras of Zone-V involved in NICRA activities. I appreciate all my colleagues who are directly or indirectly involved in bringing out this Compendium of Proven Climate Resilient Technologies and contributing in programme development, implementation and monitoring the technology demonstrations by the KVKs. I am sure that this publication would serve as a useful reference to scientists, technocrats and administrators involved in planning and implementing appropriate programmes to make the Indian agriculture climate change resilient and profitable.

Dated the 1st August, 2015
Hyderabad

(N.Sudhakar)

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1. INTRODUCTION

1. INTRODUCTION

Climate is one of the main determinants of agricultural production. Throughout the world there is significant concern about the effects of climate change and its variability on agricultural production. Researchers and administrators are concerned with the potential damages and benefits that may arise in future from climate change impacts on agriculture, since these will affect resource use and food security. Since climatic factors serve as direct inputs to agriculture, any change in climatic factors is bound to have a significant impact on crop yields and production. In developing countries, climate change will cause yield declines for the most important crops and South Asia will be particularly hard hit (IFPRI, 2009). Many studies in the past have shown that India is likely to witness one of the highest agricultural productivity losses in the world in accordance with the climate change pattern observed and scenarios projected.

Climate change is expected to influence crop and livestock production, hydrologic balances, input supplies and other components of agricultural systems. However, the nature of these biophysical effects and the human responses to them are complex and uncertain. For example, crop and livestock yields are directly affected by changes in climatic factors such as temperature and precipitation and the frequency and severity of extreme events like droughts, floods, and wind storms. In addition, carbon dioxide is fundamental for plant production; rising concentrations of CO_2 have the potential to enhance the productivity of agro ecosystems. Climate change may also change the types, frequencies, and intensities of various crop and livestock pests; the availability and timing of irrigation water supplies; and the severity of soil erosion.

Agriculture is the source of livelihood for nearly two-thirds of the population in India. The impact of climate change and variability in the country on agricultural production is quite evident in the recent years. The weather aberrations like drought and floods, extreme events like high intense and excess rainfall, frost, hail storm, heat wave, cold wave etc are becoming recurring phenomena in most parts of the country in the crop growing seasons. Major crops are affected due to these aberrant situations which often lead to poor crop performance or total crop failures in major crops.

Technological interventions related to land, water, soil and crop or institutional based were implemented as a part of Technology Demonstration Component (TDC) of NICRA project from 2010-11 to 2013-14. Some proven climate resilient technological options from different NICRA centers located in the states of Andhra Pradesh, Telangana and Maharashtra are summarized.

2. BASIC RESOURCES OF SELECTED NICRA VILLAGES

Andhra Pradesh

Anantapur

Anantapur is the second most drought-affected district of India. It falls under scarce rainfall zone of Andhra Pradesh. It is in the arid agro ecological zone and is marked by dry summers and mild winters The NICRA programme is implemented in three clusters of the villages namely Chamaluru, Chakrayapeta and Peravali. The cluster of Chamaluru receives an average rainfall of 311 mm from June to September, 147 mm from October to December and 61mm from April to May. The village Chamaluru has the population of 2790 with 519 total households. This cluster has the cultivated area of 2167 ha. The mean annual rainfall of the cluster is 522 mm. The village has 280 bore wells and 40 open wells. The predominant crops grown in this village are: kharif groundnut, castor, pigeonpea, maize, paddy, tomato and brinjal. The major rabi crops grown in this village are groundnut, paddy, brinjal, tomato and fodder crops. The live stock is an important component in the village. The village has 60 cattle, 200 buffaloes, 150 goat, 900 sheep, 10 pairs of bullocks and 300 poultry birds.

The Chakrayapeta village has a population 180, 36 households and 104 ha of cultivated area. It receives an annual rainfall of 498 mm. The village has 5 bore wells. The major crops grown in this village are groundnut, castor, pigeonpea and fodder crops. Cattle (10), buffaloes (100), goat (50), sheep (2200), bullocks (5 pairs) and poultry birds (200) constitute important components of livestock grown in this village.

The village Peravali has a cultivated area of 714 ha with 431 households. It receives 498 mm of annual rainfall. Groundnut, castor, tomato, pigeon pea and fodder crops are mainly cultivated in this village. The village has 62 bore wells and 66 open wells. It has 25 cattle, 200 buffaloes, 50 goats, 2250 sheep and 50 poultry birds. The cluster has both red and black soils. The range of ground water depletion in both black and red soils is 0.13-5.3m and 2.3-13.34 m respectively. The area experiences frequent droughts and water scarcity. Frequent dry spells, occurrence of late leaf spot (LLS), poor soil health and labour scarcity are few major constraints affecting the productivity in groundnut. Increased cost of cultivation due to high fertilizer application, high seed cost and poor LLS management are main reasons for low net returns. Horticultural crops (Mango, Citrus, Tamarind, Guava, Ber and Vegetables) are grown under irrigation. The important livestock in this village are dairy animals and poultry. Mortality and morbidity losses due to biotic and a biotic stress, fodder scarcity and poor access to live stock services are major livestock problems in this village.

Kurnool

Kurnool is one of the drought prone districts of Andhra Pradesh. Yagantipalle village which is located at a distance of 4 km from Banaganapalle   Panchayat of Banaganapalle mandal with 70% of rainfed agriculture was selected for implementing NICRA project. The village has 361 households with 640 ha of cultivated area. The major soil types are sandy clay loam to clay loam. The village has 176 cattle, 976 buffaloes and 300 sheep and Goat. Desi cotton and pigeonpea are the main crops grown during kharif and sorghum, sunflower and chickpea in rabi. The village Meerapuram has 1835 population with 381 households and 200 ha of cultivated area. The major livestock in this village are cattle (12), buffaloes (1154), sheep and goat (570). Sorghum and pigeonpea are important crops grown in this village. The major source of irrigation is bore wells. Most of the crops are affected by late onset of monsoons followed by dry spells during critical crop growth periods, which in turn is severely affecting the yield of these crops . The villages on an average receive a rainfall of 633 mm annually. Water scarcity, poor soil health, frequent droughts and losses due to pest and diseases are major climatic vulnerabilities faced by the farming community. Mortality and morbidity losses due to a biotic and biotic stresses, fodder scarcity and poor access to livestock services are major constraints for increased profitability in livestock.

Srikakulam

Srikakulam district of Andhra Pradesh is one of the flood prone districts in Andhra Pradesh. Heavy floods occur generally during September and occasionally in October and November due to heavy rain fall and depressions formed in Bay of Bengal. Sometimes, the crops at early stage are also prone to inundation due to heavy rain fall received in July. The normal annual rainfall received in the district is 1162 mm. But, the rainfall distribution is quite erratic. The Annampeta, Thimadam and Adduripeta villages in Burja mandal were selected for implementing the project activities during first year. These villages are mostly rain fed. The rainfall distribution in these villages is irregular and the crops are mostly rain fed. During second year (2011-12), to cover the flood prone area, Sirisuwada village of Kothuru mandal was selected in Rabi 2011-12 to make technological interventions in flood prone areas. The village is situated 3 km away from Kothuru mandal Head-Quarters. It has 250 village households with total cultivated area of 600 ha. The major existing soil types are red sandy and red sandy loams with clay base. The mean annual rainfall received is about 982 mm. The major existing cropping systems in this selected village are paddy/cotton/vegetables/pulses/groundnut. Mid

seasonal drought is most frequent due to erratic distribution of rainfall. The village is prone to floods due to excess rainfall received during monsoon season in low lying areas of around 150 acres lying near to Jagannathanaidu tank either due to overflow of hill stream in Marripadu gedda or water from Vamsadhara river.

West Godavari

Floods and cyclones are the major climatic constraints in the Godavari districts of Andhra Pradesh state. Rice is the major crop in this district and most of the crop gets damaged by heavy rains during August to September months. Matsyapuri village was selected to implement the activities of NICRA. The village has 1602 households. Rice is the major crop grown in 616 ha area. The village has 150 ha fish and prawn ponds. It receives a mean annual rainfall of 1185 mm. The major soil types are alluvial soils. The major existing cropping systems are paddy-paddy-pulses. Floods and cyclones are major climatic vulnerabilities limiting the productivity of crops. Water logging, mid season drought, poor soil health are major limitations that affect the crop productivity in this village. The major livestock in this village are small ruminants (62). Large ruminants in this village are 1041. The village has 1179 poultry birds. Mortality and morbidity during and post flood, loss of fish during floods and fodder scarcity are major constraints for livestock in this village

Telangana

Khammam

Khammam district is situated in Northern Telangana State. Within the geographical coordinates of 17° 250' Northern latitude and 80°.15'Eastern longitude. The district comprises of 46 mandals under four revenue divisions namely, Khammam, Kothagudem, Palvoncha and Bhadrachalam. It is one of the agriculturally important districts in the state with a total geographical area of 16, 02,900 ha and net sown area of 4, 69,710 ha (29%). Nearly 47% area is under forests.

The village of Nacharam situated in Enkoor mandal of Khammam district is selected for implementing the project activities.

General Information of the NICRA Village

Name of the village	:	Nacharam and Cluster villages; Gangulanacharam, colony nacharam, Ramatanda, Bhadrutanda, Muniya tanda and Bheemlatanda
Population	:	3246
No. of households	:	749
Cultivated area	:	1382 ha.
Major crops	:	Paddy, Cotton, Chilli & Sugarcane
Soil type	:	Heavy and Light soils
Source of irrigation	:	Streams & Bore wells
Major climate challenges	:	Uneven distribution of rainfall, Seasonal drought and heat waves
Average rainfall	:	1053.5 mm
Water streams	:	4
Animal population	:	4352 (White cattle-897, Black cattle-928, Sheep-913, Goat-1614)

Nalgonda

Nalgonda district falls under Southern Telangana region. The village Nandyalagudem, Boring Thanda of Atmakoor (S) Mandal is selected for NICRA project activities. The village is having 50 ha total cropped area with 155 households. Sandy loams, loamy sands and light black to medium black soils exist in this village. The average rainfall is 750-850 mm. But the distribution of rainfall is erratic. The major crops grown in these villages are cotton, pigeon pea, green gram, paddy and vegetables. Late onset of monsoon, mid and terminal dry spells and poor soil health are most common climatic vulnerabilities of this village. Wells and bore wells are major sources of irrigation water. Heat wave affects the yield of Mango and sweet orange crops. Mortality and morbidity losses due to biotic and a biotic stresses and fodder scarcity are major causes for low productivity of livestock. Low seed replacement rate, poor access to improved seeds and farm machinery and poor livestock services are major Institutional limitations for enhanced livelihoods in this village.

Maharashtra

Ahmednagar

The village Nirmal Pimpri was selected to implement the NICRA activities in Ahmednagar district. The village has a total population of 1268 with 319 households. The major soil types in the village are black soils. The village receives mean annual rainfall of 537 mm. The main source of the irrigation is open wells. Pearl millet, rabi sorghum, maize, wheat and onion are the main crops grown in the village. Drought is the major climatic vulnerability of the village. The village has 859 cows, 454 goats, 6 buffaloes and 53 bullocks. The soils in the selected village are medium in nitrogen, low in phosphorus and high in potassium. The average EC and pH of soil: EC-1 to 2 and pH-8.3 to 9.0.The average EC and pH of water: EC-1 to 4 and pH-8.0 to 9.0. The average EC and pH of silt: EC-0.26 and pH 7.97. The soils in the village have 1-3m soil depth. These soils have low infiltration capacity. Hence water stagnation and soil erosion are major problems in the village. The soils show micro nutrient deficiencies like Fe and Mn. Low rainfall, frequent droughts, and fodder scarcity during summer are major constraints that limit the living standards of farmers in the village.

Amravati

NICRA village Takali (Bk), Nanggaon Kh (Taluk) is selected for implementing the project activities in Amravati district. The village has 424 village households. It has total cultivated area of 880 ha. Medium black cotton soils are the major soils in this selected village. The village receives an annual normal rainfall of 650 mm. Cotton, soybean, pigeon pea, chickpea and wheat are major crops grown in this village. Drought, water stress and heat waves are major climatic vulnerabilities faced by the farming community.

Aurangabad

The Shektha village in Gangapur tehsil is selected for implementing the NICRA activities in Aurangabad district of Maharashtra. The farmers in selected village are cultivating 120 ha of cereals, 36 ha of pulses, 15 ha of oil seeds and 226 ha of cotton. The village has 380 ha of cultivated area out of which 75.5% area is rain dependent. The village on an average receives mean annual rainfall of 625 mm. It is predominated with black soils (Shallow to light). Water scarcity, poor soil health, intermittent dry spells are limiting the productivity of crops. Mortality losses due to

abiotic and biotic stresses, scarcity of fodder resources are main constraints for stepping up milk productivity of live stock. Low seed replacement, poor access to improved seeds, farm machinery and livestock services are limiting the standards of living of the farmers

Gondia

The Krishi Vigyan Kendra, Hiwara of District Gondia is implementing the NICRA project in selected village Katangtola, The village has 862 households and has total cultivated area of 572 ha. The major soil types are loamy, sand and sand loamy. The village receives annual normal rainfall of 1400 mm. Rice is an important crop grown in this village. Drought is an important climatic vulnerability in this village.

Nandurbar

Umarani (NICRA village) is situated in the Satpura ranges of Nandubar district. It receives an annual normal rainfall of 813 mm. The frequency of intense rainfall is 2.5 as decadal average in that area. It has 257 households and also has total cultivated area of 539 ha. The main source of irrigation in the village is bore wells and natural drains. The existing soil types are red and black. The soils are having shallow rooting depth, prone to soil erosion (moderate to severe). Soil erosion is a serious problem faced by the farmers. Major cropping systems in the village are soybean, sorghum, maize and pigeon pea. The village on an average receives 813 mm of rainfall. The major crops grown in the village are kharif sorghum, soybean, chickpea and mango. The major climatic risks in this village are drought and heat stress. Most of the tribal farmers have 7-8 mango trees in their fields. Preparation of mango slices from raw mango (Amchur) is the main activity in summer season which is very important monitory source for upcoming kharif season.

Pune

The village Jalgoan KP, located in Baramati tehsil was selected to implement the NICRA programme in Pune district of Maharashtra. It is located at a latitude of 18.2282 and a longitude of 74.4561 and is situated at an elevation of 574m. It comes under western Maharashtra zone. The village has 398 households and has the population of 1268. The village on an average receives an annual rainfall of 537 mm. The major soil types existing in the village are medium black soils and are calcareous in nature. The village has total cultivated area of 1094 ha, out of which 980 ha are rainfed. It has livestock population of 869 cows, 454 goats, 6 buffalos and 53 bullocks. The major crops grown in the village are pearl millet, rabi sorghum, maize, onion and wheat. Drought is the major climatic vulnerability in this area.

Ratnagiri

Ratnagiri district of Maharashtra is high rainfall area with scarcity of water. The village selected under NICRA is Haral, Tehsil-Rajapur. The village has 353 households with a cultivated area of about 139 ha. Major existing soil types are red lateritic soils. It receives mean annual rainfall of 3594 mm. The major cropping systems in the village are rice and small millets. Farmers are cultivating crops like horse gram which can be grown on residual moisture. Cashew and mango are important fruit crops in this village. Sheep, goat, and dairy are important livestock enterprises in this village. Farmers are dependent only on agriculture for their livelihood and very few are engaged in agro enterprises. High rainfall with scarcity of water as a result of runoff is a major climatic vulnerability in this village.

Table 1: Details of various NICRA centers of Zone-V

Selected District	Name of NICRA village/villages	Soil types	Major climatic variability
Andhra Pradesh			
Anantapur	Chamaluru and Chakrayapeta	Red soils	Drought
Kurnool	Yagantipalle	Black soils	Drought
Srikakulam	Sirusuwada	Red sandy soils	Floods
West Godavari	Matsyapuri and Veera Varsam	Alluvial soils	Floods
Telangana			
Khammam	Nacharam	Black red soils	Drought, Heat stress
Nalgonda	Nandyalagudem and Boring Thanda	Black soils	Drought, Heat stress
Maharashtra			
Ahmednagar	Nirmal Pimpri	Black soils	Drought
Amravati	Takali BK	Black soils	Drought, floods
Aurangabad	Shekta	Black soils	Drought
Gondia	Katangtola and Chandinitola	Sandy loams	Drought
Nandurbar	Umarani	Red&Black soils	Heat stress, drought
Pune	Jalgoan KP	Black soils	Drought
Ratnagiri	Haral	Red &Lateritic solis	Floods

2.1 Rainfall pattern of NICRA villages

The rainfall pattern in different NICRA centers in Andhra Pradesh showed that Chamaluru and Chakrayapeta villages in Anantapur district received deficient annual rainfall by 26, 36 and 49 per cent compared to the corresponding normal rainfall in 2011, 2012 and 2013 respectively. While the NICRA centre in Kurnool district received excess rainfall by 9.34 percent compared to normal rainfall of 567 mm in 2013. In Srikakulam district, the selected village received 2.5 per cent less rainfall than its normal in 2012. While in West Godavari District the rainfall was higher by 43.10 and 40.0 percent than normal annual rainfall in 2012 and 2013 respectively. In Telangana State, excess rainfall of 110 and 35 percent was received in NICRA centre of Khamam than its normal rainfall during 2012 and 2013 respectively. In Nalgonda, the annual rainfall was excess compared to the normal rainfall in all the three years.

Among the centres in Maharashtra, the highest rainfall was noticed in Ratnagiri followed by Amravati and Gondia in 2011. Higher amount of rainfall by 62, 10 and 26 percent than corresponding normal rainfall was received in Amravati, Nandurbar and Ratnagiri centres respectively in 2011. The rainfall was higher by 85 and 25 percent than corresponding normal's in Amrvati and Gondia during 2012 respectively. The Shekta village in Aurangabad received deficient rainfall than its annual normal in all the three years. All the NICRA centers located in Maharashtra received excess rainfall than corresponding to their normal's in 2013 except in Aurangabad and Pune.

The NICRA centers located in Kurnool, Srikakulam and West Godavari districts of Andhra Pradesh and Amravati, Nandurbar, Pune and Ratnagiri districts in Maharashtra receive excess rainfall compared to the respective annual rainfall during 2014. The centers located in Anantapur (Andhra Pradesh), Khamam and Nalgonda (Telangana) and Ahmednagar, Aurangabad (Maharashtra) districts received deficit rainfall during 2014 (Table 2). In Andhra Pradesh, the centers of Kurnool and Srikakulam districts received excess rainfall by 21 and 666 mm compared to the normal annual rainfall respectively. But the rainfall in Anantapur was deficit by 247 mm than annual rainfall. The rainfall in the districts of Khamam and Nalgonda was deviated to the extent of 24.97 and 56.32 percent compared to the respective normal rainfall received during 2014. The rainfall received in the districts in Ahmednagar and Aurangabad was less by 133 and 185 mm respectively than corresponding normal annual rainfall. The rainfall was excess by 55, 34 and 40 mm in Amravati, Nandurbar and Ratnagiri districts over corresponding normal annual rainfall in 2014.

Table 2: Amount of rainfall in different NICRA centers compared to the normal

location of NICRA village	Normal Annual Rainfall	Actual Rainfall (mm)				% Deviation of rainfall to the normal			
		2011	2012	2013	2014	2011	2012	2013	2014
Andhra Pradesh									
Anantapur	522	386	249	268	305	-26.05	-52.29	-48.65	-44.74
Kurnool	633	468	363	509	654	-26.06	-42.65	-19.59	3.32
Srikakulam	1264	1288	1134	1613	1682	1.89	-10.28	27.61	65.55
West Godavari	1077	847	1696	710	773	-21.35	57.47	-34.07	0.05
Telangana									
Khammam	1161	819	1645	1151	871	-29.45	41.68	-0.86	-24.97
Nalgonda	804	1006	918	1188	351	25.12	14.17	47.76	-56.32
Maharashtra									
Ahmednagar	457	278	347	511	324	-39.16	-24.07	11.82	-29.10
Amravati	943	1059	972	924	973	12.30	3.07	-2.01	6.03
Aurangabad	644	530	239	513	459	-17.70	-62.88	-20.34	28.75
Gondia	1284	974	1664	1418	-	-24.14	29.59	10.43	-
Nandurbar	813	896	621	1242	847	10.20	-23.61	52.76	4.15
Pune	505		348	451	511		-31.08	-10.69	1.21
Ratnagiri	3375	4532	2712	3781	3415	34.28	-19.64	12.02	1.18

2.2 Distribution of Rainfall in Different NICRA Centres

Andhra Pradesh

Anantapur

The rainfall of 75 mm received in July helped the farmers to sow groundnut only in limited area during 2012. There was a dry spell of 16 days after sowing of groundnut, after the dry spell some farmers have taken up groundnut and other crops with the receipt of 70 mm rainfall on 5th August. Groundnut experienced severe dry spells from August 24th to September 27th (36 days duration) which coincided with the pegging and flowering stages of the crop.

During 2013, total rainfall received was 268 mm in 15 rainy days. Rainfall received in the month of June was useful for land preparation. But rainfall received in the months of July and August was not sufficient to take up sowing of crops. Hence farmers of NICRA village could not take up sowings. But in the month of September, heavy receipt of rainfall (174 mm) occurred within 6 rainy days. Due to delayed monsoon, most of the farmers have taken up short duration contingent crops such as setaria, sorghum and sunflower, only few farmers cultivated groundnut. Distribution of rainfall was not uniform in NICRA villages due to temporal and spatial variability. Late sown groundnut crop was subjected to moisture stress during key developmental stages resulting in prematurity of the crop (90 days) and drastic reduction in yield. Other contingent crops performed better under delayed monsoon conditions.

During kharif 2014, the rainfed crops in Anantapur experienced prolonged dry spells during critical crop growth stages, which lead to reduction in yield. Total rainfall received during the year 2014 was 305 mm in 26 rainy days and rainfall during June-December is 235 mm in 19 rainy days. Rainfall received in the month of June is useful for land preparation. Farmers in NICRA village have sown groundnut crop in first fortnight of July with 20 mm rainfall only. From sowing to harvesting, every month recorded deficit rainfall when compare to normal. Some farmers have taken up sorghum, green gram and cluster bean (Guar) crops in the month of second fortnight of August, as contingent crops

Kurnool

During 2012, the rainfall received from 4th to 9th August, was useful for sowing of short duration crops like foxtail millet and even groundnut and cotton crops. These crops experienced severe moisture stress during reproductive stages with 21days dry spell from 5th to 26th September. The rains received from 27th September to 2nd October were helpful for land preparation and sowing of rabi sorghum and chickpea. But rabi crops sown on limited extent were also experienced severe dry spells in the months of November and December. Thus the rainfall pattern in NICRA village during rainy season was erratic and the yields of cotton, ground nut, sorghum and chickpea were drastically reduced.

During the Kharif 2013, sowings were taken up with the rainfall received during last week of July. Among the kharif crops seteria, pigeon pea and castor performed well with reasonable yields. The total rainfall was deficient by 42, 8, 72, 22 and 10 mm than normal rainfall received during the months of July, August, October, November and December respectively. Sowing of chickpea was taken up during rabi with the rainfall received during 2nd week of October. All rabi crops suffered acute moisture stress as there was dearth of stored soil moisture in the early stages of crop growth and subsequent prolonged drought conditions. Only during fag end of November scanty rain was received which could not boost crop growth. Ultimately these aberrant weather conditions reflected badly on the crop yields.

During Kharif 2014, there is a late onset of monsoon (Third week of July) in NICRA center of Kurnool district. Kharif sowings were taken up with the rain fall received during last week of July. The crops experienced prolonged dry spells during grand growth period. Cotton could not be taken up due to late onset of monsoon. Sorghum was sown but it was affected with terminal moisture stress. The demonstrations of short duration varieties of Seteria (Korra) SIA-3085 and Suryanandi escaped drought due to its shorter duration.

Srikakulam

The rainfall in NICRA village Siruswada of Srikaulam district was deficient in June, July, August and October by 26, 108, 99 and 10 mm respectively compared to the normal rainfall of respective months in 2012. The crops experienced dry spell of 21days from 7th to 30th of November.

In 2013, the centre received excess rainfall of 60, 54, 27, 100 and 253 mm during the months of June, July, August, September and October respectively than normal rainfall. Direct sown paddy at seedling stage was inundated nearly for 5 days and the crop failed in high inundated area. Medium duration varieties of paddy were affected at panicle initiation stage and the crop was slightly lodged. Boot leaf was twisted and crop was submerged in water. Long duration varieties were at maximum tillering to panicle initiation stage when the flooding took place. Vegetables crops were submerged while they were at vegetative stage.

In 2014, when the paddy crop was at seedling stage. There was occurrence of floods during14th to 21st July which coinsides the seedling stage of paddy. The crop experienced 5, 4 and 2 days of high, medium and low inundation respectively. Paddy crop experienced incidence of flood due to rains in village & back water from Vamsadhara river at tillering stage in the month of August. Paddy crop experienced 6, 6 and 2 days of high, medium and low inundation respectively. Further paddy crop underwent floods at tillering/panicle initiation stages from 14th to 21st in September. Paddy crop in NICRA village faced the occurrence of floods at Panicle initiation to flowering stages during 11th and 12th of October, where it experienced 7, 6 and 3 days of high, medium and low inundation respectively. Thus paddy crop faced 44, 34 and 13 days of high, medium and low inundations respectively during the growth stages of paddy.

West Godavari

The rainfall was deficient in the months of June and December by 26 and 10 mm compared to the respective normal rainfall in 2012. There was dry spell of 25 days duration from 6th to31st of November. Continuous rainfall from 7th to31st July (300 mm), 1st -14th of August and 29th August -11th September affected the growth of paddy. During the first week of November heavy rains occurred in this area due to Neelam cyclone and most of the fields were submerged and crops were damaged. Higher rainfall of 110,168 and 26 mm was received in the months of June, October and December than corresponding normal rainfall in 2013. The rainfall of 355 mm received in the month of October and occurrence of Helen cyclone in the months of November and December caused water stagnation for paddy crop.

There was occurrence of Hudhud cyclone during the month of October 2014 in Andhra Pradesh. The Hudhud cyclone affect was not much in West Godavari District and there was no crop damage. However increased incidence of BPH in paddy especially in the variety MTU 7029 was noticed which was due to climate change especially after Hudhud cyclone.

Telangana

Khammam

Paddy, Cotton, Maize and Chili are important crops grown in NICRA village of khammam district. The normal onset of the summer is around June 5 -10 and normal withdrawal is in first week of October during 2012. The rainfall of 131 mm received in the month of June was utilized for land preparation and sowing of cotton and maize. The nurseries for chilies and paddy were started in the months of June. The transplanting of paddy and sowing of maize were done with the rains received during first 3 weeks of July. The crops experienced the dry spells of 25 days during 5th to19th of October and also from 5th to 30th November. The reproductive phases of cotton and chilies were affected with these dry spells and the yields were reduced considerably.

Normally, sowing of paddy was taken up in third week of June and transplanting was done in 3rd week of July in 2013. The other crops grown in this village were cotton and pulses. A total of 190.4 mm rain fall was received compared to normal rainfall of 114 mm which was 67% excess than the normal rainfall received in the month of October, 2013 due to the attack of Phailin cyclone. The paddy crop was seriously affected during the harvesting stage due to heavy rains. In cotton which was at boll ripening and bursting stage damage occurred due to boll rotting and some of the seeds germinated on standing crop and also the quality of lint was badly affected.

The cluster of villages of Nacharam in Khammam district received the deficit rainfall of 92.6. 18.0, 56.0, 60.8 and 100 percent compared to the normal rainfall received in the months of June, July, August, November and December respectively during 2014. The village tank was dried due to the deficit rainfall. Paddy crop could not be cultivated during rabi season. The paddy area in the village was reduced by 50%. The germination of cotton and pulses were affected and poor growth was observed in green manure crop Dhaincha. The incidence of sucking pests in cotton was increased. There was fodder shortage to the livestock in the project village.

Nalgonda

Cotton, pigeon pea, green gram chillies, vegetables and paddy are important crops in NICRA village of Nalgonda district. The rainfall of 131 mm received during June helped for land preparation and sowing of cotton and pigeon pea. The nurseries of paddy and vegetables were started with the receipt of 203 mm rain during the month of July. The dry spell of 11 days experienced from 13th to 22nd August affected vegetative growth of cotton and also reproductive phase of green gram. The flowering and pod/boll formation in pigeon pea and cotton were severely affected with the dry spells of 28days and 31days experienced in the months of October and November respectively.

The rainfall of 17 mm received in second fortnight of June facilitated land preparation for sowing crops of cotton, pigeon pea, greengarm and chillies in 2013. Sowing of rain fed crops was done during first fortnight of July. The crops experienced dry spells during first and second fortnights of August. However the crops recovered from the dry spells with the receipt of 218 mm of rainfall from 14th to 16th August 2013. Fifteen days of dry spell from 1st to 15th September affected flowering and boll formation of cotton and reproductive phase of green gram. The continuous dry spell from October and November severely affected the yields of cotton, chillies and pigeon pea. Thus it is concluded that erratic distribution of rainfall was not favourable to get normal yields of rainfed crops. The continuous wet spells received during the months of August, September and October created water stagnation in black soils resulting in damage of lint in cotton.

During 2014 the farmers utilized the receipt of 30 mm of rainfall for land preparation of various crops. The rainfall received 30 mm in last week of July and also about 55mm received in first fortnight of August were used for sowing of pigeon pea and short duration of pulses. The crops experienced severe moisture stress at vegetative stage of long duration crops like pigeon pea and at flowering growth stages of short duration pulses.

Maharashtra

Ahmednagar

The crops texperienced severe moisture stress with dry spell of 26 days in the months of August and also in October from 4th to 30th (26 days duration). The rainfall distribution was erratic during the season. As result the yield of crops was reduced considerably. The rainfall was deficient by 22 mm in the month of August 2013.The onset of rainfall was in time i.e. in second week of June. Sowing of kharif crops was completed in the second and third weeks of June in 2013. After sowing there was a dry spell of 23 days during 4th week of June to 3rd week of July. Initial vegetative growth of the crop was adversely affected. Crop reached reproductive stage without sufficient vegetative growth. During flowering and pod filling stage there were again continuous dry spells of 11 and 26 days, which badly affected pod filling. Grain size was smaller than average and farmers who could not give protective irrigation suffered losses due to reduced yields.

During 2014, the onset of rainfall was late by 45 days i.e. by the end of July. The sowing of kharif crops were completed at end of July and first week of August. A dry spell of 19 days immediately after sowing of crops affected initial vegetative growth of crops. The dry spell of 41-days from flowering to harvest growth stages resulted in wilting of crops The deficit rainfall at harvesting stage of crops affected the yield and quality. The limited rainfall in the months of October and November affected the sowing of rabi crops.

Amravati

The rainfall received in the month of June (128 mm) helped in land preparation and sowing of soybean and cotton in 2012. The rainfall distribution in the month of July was favorable for the vegetative growth of crops. The rainfall of 195 mm received in the month of October helped in sowing of chickpea. The distribution of rainfall was very good for the growth and of soybean. The rainfall of 332 mm received in the month of June facilitated the farmers for land preparation and also timely sowing of kharif crops in 2013. The rainfall was much favourable for short duration crops like soybean and also for vegetative growth of long duration crops like pigeonpea and cotton. Long duration crops like cotton and pigeon pea experienced moisture stress at reproductive phases due to long dry spells in the months of November and December. The excess rainfall received in the month of September created the problem of water stagnation and also resulted in sprouting of seed in the standing crop of soybean. Hailstorms and excess rainfall caused lodging of wheat, cotton and chickpea.

During 2014 a deficit rainfall of 7.16, 33.44, 54.7 in terms of percentage of deviation during the months of June, July and october as compared to normal rainfall received in corresponding months during rainy season. The rainfall received on10 and 100 mm on 11th and 17th of June fecilitated in land preparation and sowing of soyabean, cotton and pigeonpea. But severe dry spell immidiately after sowing affected the vegetative stage of cotton, pigeon and soyabean. The dryspell experianced during the month of october affected flowering of pigeonpea and boll formation of cotton. The wetspell experianced in the month of August and September resulted in water logging in fields, which affeted aeration problem in soil and also eventually yields.The cold wave occurance during first fortnight of december 2014 adversely affect the yields of pigeonpea.

Aurangabad

The rainfall of 28th mm received in the month of June helped in land preparation for sowing of cotton and pigeonpea in 2012. These crops suffer with moisture stress for 16 days during its vegetative stage. But the rainfall of 40 mm received in first week of September resulted in profuse flowering of cotton. These crops underwent severe moisture stress at their reproductive stages which resulted in low yields. The rabi crops chickpea and sorghum were sown with 36 mm of rainfall received during the first week of October. The NICRA village of Aurangabad district received excess rainfall of 26 mm during the months of July against the normal rainfall received in 2013. The rainfall of 125 mm received in the month of June facilitated land preparation for kharif crops. The complete dry spell experienced from October13th to December 30th affected the productivity of long duration crops like pigeonpea and cotton and rabi sorghum.

The Shekta village in Aurangabad district received the deficit rainfall of 92, 16, 63 and 84, percent during the months of June, July, September, October and December compared to the normal rainfall received in corresponding month during rainy season in 2014. The rainfall of 10.5 mm in the month of June and 50 mm received upto 17th July helped in land preparation and sowing of kharif crops (Cotton, pigeon pea, short season pulses and soyabean in the season. The severe dry spell from 10th September to October affected the yields of soya bean and cotton and also flowering in pigeonpea. The scarce rainfall received in the month of october and November affected the sowing of chickpea, rabi sorghum and wheat crops.

Gondia

The rainfall received during months of June was used for land preparation of pigeon pea and for raising of paddy nurseries in 2012. There was a dry spell to the end of October (37 days duration). As result, severe moisture stress was experienced during flowering and pod formation of pigeon pea. During the year 2013-14, rainy season started on 4th June at proper time. Land preparation completed in the summer season. Timely commencement of rains helped the farmers for sowing paddy seed in nurseries. The growth of seedlings was satisfactory. However the occurrence of excessive heavy rains (more than 60 mm/day) in 6 rainy days hampered the growth of paddy seedlings in nurseries and after transplanting, thereby reducing the number of tillers per plant, root establishment, photo-synthetic activities etc. The plants were also submerged affecting the growth adversely. Pest attack was also observed on the crop. All the above conditions drastically reduced the yield of paddy, as the tillering and flowering stages were affected.

Nandurbar

The rainfall received in July was helpful for land preparation of maize, soybean, pigeon pea and groundnut in 2012. The rainfall of 224 mm received in August was helpful for good vegetative growth of these crops. But the dry spell of 20 days experienced in the month of September and 15days in first fortnight of October affected the flowering and grain formation of maize, soybean and groundnut. The rainfall of 64 mm received on16th October helped in sowing of chickpea. The rainfall of 181 mm received in the month of June was helpful for land preparation and sowing of kharif crops in 2013. The excess rainfall received in the months of July, August and September created water stagnation in the fields.

During 2014, Umarani village in Nandurbar district received the deficit rainfall 61, 19, 3 and 54 percent during the months of June, August, September and October comapred to the corresponding normal monthly rainfall respectively during this year. The onset of monsoon was delayed by one month (14th July). The sowing of kharif crops were done during 15th-16th July. Due to continous rainfall, sowing of crops (Maize, desi cotton, horsegram and short duration pulses) could not be done upto first week of August. There was dryspell for two months from 16th September. Heavy rainfall events occurred three times during rainy season

Pune

The crops of soybean, cotton were sown with the receipt of 35 mm rain received in the month of July in 2012. But these crops experienced 17 days of dry spell which affected their vegetative growth. But the rainfall received in 29th and 30th August (62 mm) helped in recovering of these crops. The crops also experienced a dry spell of 22 days which affected their reproductive phase .Thus the rainfall distribution was erratic and caused severe yield reduction in soybean and cotton. The rainfall of 52 mm received on 1st October helped in sowing of rabi chickpea.

The rainfall during the year 2013 was characterized by 3 dry spells ranging from 10 to 28 days and annual rainfall of 451.2 mm which is 84.02% of annual average rainfall. There was 62 mm rainfall on June 2, 2013 which was effective for the sowing of pearl millet crop in the village. Farmers in the village undertook tillage practices in the month of April and May prior to the onset of monsoon. Sowing of pearl millet was done in the second and third week of June at available soil moisture condition. After sowing of pearl millet there was no effective rainfall in the succeeding month and therefore no water harvesting took place in the village and in turn no ground water recharge. Farmers were not able to give protective irrigations to pearl millet. Farmers have chosen cultivation of onion, maize and sunflower as contingency crops. These crops were sown during last week of July and first week of August when there were showers of rain ranging from 2 to 16 mm. In the second week of September there was good rainfall which was necessary for sowing of rabi sorghum. The rabi sorghum was sown during the last week of September and in the first week of October. It was observed that June and September months received much of the annual rainfall which was 115.2 and 203.4 mm respectively. Though the monsoon was earlier than its regular arrival during kharif and rabi seasons, there was yield reduction in the crops grown in kharif due to long dry spell. The off season rainfall and hailstorm in the month of February and March 2014 were detrimental to the quality of rabi sorghum (dry fodder). It was observed that there was increase in disease incidence in rabi Sorghum in the month of December 2013 and January 2014.

The village Jalgaon in Baramati tehsil of Pune district received deficit rainfall of 40, 50 and 60 mm percent during the months of June, Sept and October compared to the normal rainfall of respective months during 2014. The rainfall received at this site was near to normal in the month of July. In moth of February to May the total rainfall received is 156.2 mm during the months of February to May damaged the wheat crop in the village. On set of rain fall during kharif was normal. But there was long dry spell of 22 day in month of June 2014. Rain fall received in the month of June is (38.2 mm) helped the farmers for preparatory tillage operation; The pearl-millet crop could not be sown due to insufficient rainfall the month of June and July. Fodder maize was sown as contingency crop with the receipt of 57.4 mm in the month of July. The amount of 190.6 mm rainfall received in the month of August helped for filling of desilted check dams and cement Bandhara. This situation helped in deep percolation and increased water levels in open wells. It helped for sowing of Rabi Sorghum. In the month of August there is long dry spell of 21 days and there was no rainfall in month of September. In total there are 4 long dry spell of more than 20 days and one dry spell of more than 10 days was observed from June to October. These dry spells adversely affected the Kharif as well as Rabi crops in the area.

Ratnagiri

The rainfall received in the months of June helped in sowing of groundnut, cowpea and dolichos. Mango is an important fruit crop grown in this region in 2012. But the rainfall received was excess by 186, 487 and 12 mm during the months of June, July and October than the respective normal rainfall during 2013 (rainy season). The amount of 1727 mm rainfall received during the month of July resulted in loss of paddy seedlings transplanted in the field. The rainwater flow from upper regions caused severe soil loss and the nalas and bunds constructed in the fields were washed away. Under this situation cow pea became alternative crop in place of rice.

Haral, in Ratnagiri district received deficit rainfall of 485.8, and 70 mm in the months of June and August as compared to the monthly respective normal rainfall in the cropping season during 2014. The rainfall was excess by 236, 135, 63, 61 and 57 mm in the months of July, September, October, November and December respectively.

3. PROVEN CLIMATE RESILIENT TECHNOLOGIES

3.1 *In-situ* Moisture Conservation Technologies for Stabilization of Yield in Rainfed Groundnut

Major Climate Variability: Drought

Background information

Groundnut is a major oil seed crop grown in majority of red soils in Anantapur district. The productivity of this crop reduced many times due to fluctuations of rainfall during the crop growth. Long and intermittent dry spells at the time of pegging, flowering and pod development stages causes drastic reduction in the yield sometimes the crop failures were also noticed in many regions, hence there is need to stabilize the productivity of groundnut in rainfed red soils through adoption of insitu-moisture conservation technologies.

Existing practice

Many farmers grow the crop with the onset of monsoon during kharif season. Sowing of groundnut in this area is delayed (Even up to the end of August) due to late onset of monsoon. Farmers traditionally operate gorru 4/5 times not only to control weeds but also to create dust mulch in the rows.

Resilient practice/Improved technology

Insitu rain water management practices like contour farming and conservation furrows play an important role to improve the productivity of rainfed groundnut. Adoption of conservation furrows at 3.6 m in a crop will be helpful to improve the soil moisture availability at the root zone and eventually stabilize the productivity. It comprises of a series of furrows across the slope at 3-5m interval where the size of the furrow is about 20 cm wide and 15 cm deep. The furrows can be made either at planting time or during intercultural operations using country plough.

Performance

Keeping the situation in view assessment of conservation furrows along with the local practice was organized in selected NICRA villages Chamaluru and Chakrayapet during 2011-13 as a part of NICRA (National ainitiative on Climate Resilient Agriculture) programme.

The studies were conducted with active participation of 21 farmers covering 16.6 ha each. based on the studies over the period of three years (2011-13) formation of conservation furrows at 1.3 m interval in groundnut (K-6) contributed for additional pod yield (153 kg/ha) and higher net income of Rs 1310/ha over farmers practice of no conservation furrows (582 kg/ha). This practice enhanced the rainfall use efficiency by 10% over farmers practice in respect of pod and haulm yields.

Up scaling

The improved practice of conservation furrows can be upscaled in red soils of different Mandals through KVKs, Watershed programmes, SFDA (Small Farmers Development Agency), State Department of Agriculture and other related agencies involved in technology transfer related to Agriculture.

3.2 Improvement of the Productivity in Rainfed Castor through *in-situ* Moisture Conservation Technologies

Major Climate Variability: Drought

Background information

Kurnool district falls under scarce rainfall zone and frequent drought occurs during critical crop growth stages. Castor and pigeon pea are important crops grown in rainfed black soils. The yield of castor is quite often reduced due to long dry spells experienced in vegetative, spike and capsule formation stages.

Existing practice

Farmers in this area operate blade harrow to control the weeds in between the rows. This practice helps in conservation of moisture for a short time.

Resilient practice/Improved technology

Formation of conservation furrows of 30 cm size in between rows of castor up to 60 DAS is helpful to improve the productivity. This practice comprises of a series of furrows across the slope at 3-5 m interval where the size of the furrow is about 20 cm wide and 15 cm deep. The furrows can be made either at planting time or during intercultural operations using country plough.

Performance

In order to popularize insitu moisture conservation technologies, assessment studies on formation of conservation furrows along with local checks (No conservation furrows) was organized with active participation of 75 farmers covering 30 ha area during 2011-13. The results showed that formation of conservation furrows of 30 cm size in NICRA village Yagantipalle helps to cope with the terminal moisture stress. Farmers realized the yield benefit of 160 kg/ha and also additional net income of Rs 4036/ha with conservation furrows over the period of three years. Farmers felt that this practice is simple and easy to adopt.

Up scaling

This practice can be up scaled in mandals having black soils through different agencies involved in technology transfer like NGOs, Water shed programmes, State Department of Agriculture and other related agencies.

3.3 Stabilization of Productivity of Rainfed Crops through *in-situ* Moisture Conservation Technologies

Major Climate Variability: Drought

Background information

Cotton maize and pigeon pea are major crops grown in black soils of Aurangabad district of Maharashtra. The yield of these crops in this district depends upon the total quantity and distribution of the rainfall during kharif season. Late onset of monsoon and long dry spells are major climatic vulnerabilities causing drastic reduction in yield.

Existing practice

Farmers in this area operate blade harrow to control the weeds in between rows. This practice helps in conservation of moisture for a short time.

Resilient Practice/Improved Technology

Adoption of conservation furrows after every 4 rows up to 30 DAS will improve the productivity of rainfed crops in this region.

Performance

Assessments studies on formation of conservation furrows were organized in cotton (Bt-cotton) and pigeon pea (BDN-711) along with local checks in selected NICRA village of Shekta in Aurangabad district of Maharashtra. These studies were organized in 69.8 ha with active participation of 122 farmers from 2011-13. The team of NICRA scientists was involved in implementation of the activity. The results showed that opening of Conservation furrows in cotton conservation furrows after every 4 rows up to 30 days after sowing in cotton and pigeon pea was useful in conservation of moisture. The farmers could realize highest cotton and pigeon pea yields of 1000 kg/ha and 900 kg/ha by opening furrows. Farmers also got the yield benefit of 25% by forming conservation furrows for every four rows in hybrid maize. Farmers perception is this is a simple practice to follow even with available local implements like plough.

Up scaling

The yields of major rainfed crops cotton and pegionpea can be upscaled with the perusal involved in technology transfer like SAUs, Watershed programmes, State Department of Agriculture and other related agencies.

3.4 Improvement in the Yield of Cotton through Conservation Furrows

Major Climate Variability: Drought

Background information

Cotton is one of the important crops grown in rainfed black and red soils in Nalgonda district of Telangana state. This crop is severely affected with moisture stress either at vegetative or boll formation or in combination of both the stages under rainfed environment. Late onset of monsoon and uneven distribution of rainfall affect the crop yield drastically. There is need to stabilize the productivity of cotton through adoption of insitu conservation technologies like conservation furrows.

Existing practice

Farmers grow cotton either by sowing through dibbling or with the help of plough. Continuous rainfall during cropping season results in water logging. Farmers normally operate a blade harrow to control the weeds as well as to conserve the moisture as a part of traditional practice.

Resilient practice or improved technology

Improved insitu moisture conservation practices like conservation furrows after every 10 rows in cotton stabilize the productivity in rainfed environment. It comprises of a series of furrows across the slope formed at every 10 rows. The size of the furrow is about 20 cm wide and 15 cm deep. The furrows can be made either at planting time or during intercultural operations using country plough.

Performance

The assessment studies on improved insitu conservation methods (Conservation furrows) along with the farmers check was organized in 66 farmers fields covering 49.2 ha area each. The studies were organized with active participation of the farming community in selected villages of NICRA from 2011-13. The studies indicated that conservation furrows after every 10 rows of cotton on an average recorded the additional yield of 2.82 kg/ha and net income of Rs.10720/ha as against no conservation measures. The farmers who were not adopted conservation measures realized the yield of 24.58 kg/ha and net income of Rs 51092/ha.

Up scaling

The experiences in NICRA villages of Nalgonda district conclusively indicated that conservation furrows contributed to derive the net income of Rs.62370/ha.

3.5 Trench Cum Bunding to Conserve Resources of Soil and Water in Black Soils

Major Climatic Vulnerability: Drought

Background information

The NICRA Village Umarani, in Maharashtra is situated in the Satpuda ranges where the soils are shallow, prone to soil erosion (Moderate to severe). It receives an annual rainfall of 813.2 mm. The frequency of intense rainfall (> 60 mm/day) is 2.5 as decadal average. The top productive layer of the soil has been deteriorating day by day causing decrease in productivity of soil.

Existing technology

Farmers in this region cultivate the crops either across or along the slope depending on convenience of sowing. Some farmers adopt bunding based on property boundaries. This practice results in heavy run-off in the fields. Many times it results in the loss of top soil layer which eventually reduce the fertility and productivity of the soil.

Resilient technology/practice

Soil and water are the basic resources essential for survival of human kind on earth. These are to be conserved and utilized for sustained crop productivity in rainfed agriculture. This can be done with appropriate land treatments such as bunding to check soil erosion and increasing rainwater infiltration. Among various types of bunds, trench cum bunding is a modified version of regular bund in which the earth required for the making the bund is obtained from a trench or scoop dig on upstream side. These trenches retain the runoff water, augmenting the moisture regime in their vicinity and improve the survival of the plantation in the trench or on the bund. A trench length of 5.0 m and width of 1.0-2.0 m and depth of 0.3 m with 0.5 m septa between the trenches have been found suitable in many situations. The volume of water that can be stored in each trench would be 3 Sq.m (3000 liters). The approximate no. of trenches per ha is 48 i.e. the earth work involved is 144 Sq.m. It can cost approximately Rs 5500/ha.


Trenches and compartment bunds

Performance

Trenches with compartmental bunds across the slope have been under taken in NICRA village Umarani of Nandurbar district in 67 ha covering 167 farmers prior to monsoon. It was done to prevent the soil erosion and sustain the productivity of cultivable land. The trenches of 2x5x4 m size were made across the slope in May 2011. Each trench was separated by 1 feet of un-dug soil. The soil removed was used to make the bund along the trench to reduce the speed of run-off water due to rain, and allowing the eroded soil to deposit in the trenches for percolation of rain water. In each field one stone outlet was made to let out excess water, if any, out of the field. There was high intensity rainfall of 58 and 86 mm on 6th and 19th July 2011 respectively. The top soil carried by water was deposited in trenches. 11.5- 21.2 m^3/acre of fertile top soil had been saved by making trenches. The details of soil trapped in the farmers fields are given below.

Soil trapped in the field due to trenching cum bunding

S.No	Name of the farmer	Area (Acres)	Soil trapped m^3 /acre
1	Shri. Boka Nagarya Pawara	1	21.20
2	Shri. Shivala Lala Pawara	1	18.75
3	Shri. Kalshya Nerabya Pawara	1	16.85

Impact and up scaling

This practice can be extended in tehsils of Akrani, Akkalkuwa, Shahede, Nawapur and in Nandurbar district of Maharashtra.

3.6 Jalkund Technology for Water Harvesting and Recycling in High Rainfall Areas

Major Climatic Vulnerability: Floods

Background information

Unavailability of adequate amount of water during the dry season is a serious problem for successful farming in high rainfall areas. Ratnagiri district of Maharashtra is high rainfall area with scarcity of water. The village Haral was selected to implement the project activities. Even though this village is receiving high annual rainfall of around 3500-4000 mm, village faces the problem of water scarcity for agriculture from December onwards.

Improved/Resilient Technology

This problem can be minimized by rainwater harvesting and its judicious use for crop production. Direct rainfall collection through water catch ponds/pits (Jalkund) can be highly beneficial to farmers for providing irrigation to crops during moisture scarcity conditions during dry seasons. Rainwater can be stored directly in Jalkunds during the rainy season which can be utilized to provide protective irrigation to the crops for successful cultivation. Otherwise, it may cause soil erosion and nutrient loss through runoff. Stored water can also be utilized for animal husbandry activities, piggery, poultry and duckery.

Performance

Interventions were taken up in 2012-13 to popularize low-cost rainwater harvesting structures 'Jalkund' (5x4x1.5 m) in NICRA villages. Silpaulin lining was done to have a storage capacity 30,000 liters for harvesting rainwater during the rainy season and its subsequent use during dry periods to provide critical irrigation to high value winter vegetables. Fifteen farmers took up the intervention including self help group members who underwent training at KVK, Ratnagiri. Training was imparted to selected beneficiaries and farmers were initially supported for lining of ponds with silpaulin sheets and seeds of high value winter vegetables like broccoli, celery, capsicum. Farmers could fully harvest rainwater and use it in the dry season for crop production and also as drinking water source for animals.

Impact and up scaling

This practice can be extended in Dapoli, Mandanghad, Khed, Chiplun, Ratnagiri, Sangameswar, Nainagiri, Rampur tehsils of Ratnagiri district where steep slopes exists, through watershed development (NWPDA), Mahatma Gandhi Rural Employment Guarantee Scheme (MGREGS) etc.,

3.7 Desilting of Community Tank to Improve Soil Fertility and to Improve Groundwater Level

Major Climatic Vulnerability: Drought

Background information

Kurnool is one of the drought prone districts in Andhra Pradesh. The district on an average receives an annual rainfall of 546 mm. Water scarcity, poor soil health and frequent droughts are the major climatic constraints faced by the farming community. About 200 tube wells were non-functional due to low water table during post-monsoon period

Existing practice

The rich silt deposited in these structures was used by farmers for spreading in the fields, wherever necessary, to improve the water holding capacity of soils. This intervention helped in increasing the surface water resource availability, increased ground water recharge observed through measurement of water table in wells located nearer to the tanks.

Improved Technology

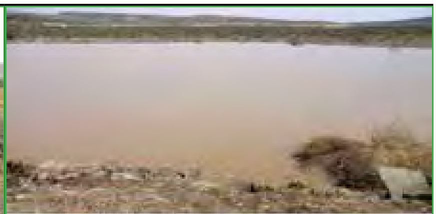
Desliting of existing check dams improves the storage capacity of rainwater, Thus the rainwater collected in these check dams will be useful for drinking purpose for livestock and also for recharge of bore wells.

Performance

As a part of NICRA project, team of expert organized awareness programme on need of existing desilting tanks to improve the ground water recharge and also to use the tank silt available by deepening the tanks to use the fields to improve the soil fertility. The team facilitated to form project committee.

The project committee proposed to de-silt the existing percolation tank (Burrakunta) for deepening and use of tank silt for marginal soils to improve soil physical properties and fertility. Focus group interactions were held with the villagers to sensitize them on the importance of water harvesting and application of tank silt. The de-silting of Burrakunta (PT) was taken up during July 2012 and 1260 Cu.mt silt was excavated. The silt was applied to 6 ha covering 10 farmers and transportation cost was borne by the farmers. Chemical properties and nutrient status of tank silt was analyzed before application into the fields and the average pH and EC of tank silt was 7.95 and 0.35 dSm^{-1} respectively which were under normal range. Whereas organic carbon content (0.89 %), available phosphorus (112 ppm), potassium (883 ppm), calcium (52 me.eq /100g soil), magnesium (5.5 me.eq /100g soil), ferrous (33.5 ppm), copper (3.62 ppm) were in high range. The farmers applied the tank silt to their field and sown the crops.

Application of tank silt into farmer's field



Tank filled with water after desilting

Out comes:

- Water table of around 250 bore wells surrounding the percolation tank raised by 12 ft from August to November 2012
- Deepening of percolation tank increased the additional water storage capacity (12.60 lakh litres)
- Cotton and castor crops cultivated on silt applied soils gave 15 to 18 % higher yield over the check

Farmers' feedback: Farmers were satisfied with de-silting of existing Burra Kunta and expressed that it is more useful for increased storage of rain water and soil fertility and productivity.

Up scaling

The technology can be promoted in all rainfed balck soil mandals through watershed programme, Mahatma Gandhi Rural Employment Guarantee scheme and Department of Agriculture NGOs and related Rural Development agencies of the district.

3.8 Desilting of Existing of Tanks to Improve Groundwater Storage in Drought Prone Areas

Major Climatic Vulnerability: Drought

Background information

Anantapur is one of the drought-prone districts in the rain shadow area of Andhra Pradesh particularly in southern India. Over the years, the process of desertification has been taking place in large tracts of the district because of soil erosion and sand casting on the one hand, and Monocropping, chemicalisation, deforestation, and excess use of ground water on the other. The area experiences frequent droughts and water scarcity. The ground water table is gradually decreasing. There is no water for even life saving irrigation for crops.

Existing Practice/Technology

Large number of tanks with substantial water storage capacity, constructed long back has become defunct due to neglecting, non-maintenance and silting up in the district. Due to neglecting of community tanks, surplus rainfall (runoff) during *kharif* is not stored and used properly. Hence, due to prolonged dry spells at critical stages, crop failures are experienced in some years or production is seriously affected.

Resilient Technology/Practice

Desliting of existing defunct tanks/ ponds through community mobilization improves the storage capacity. Further the fertility of degraded soils can be improved by application of silt realized by deepening of the structures.

Performance

Keeping this alarming situation in view, KVK team selected NICRA villages of Chamaluru and Chakrayapeta as a part of NICRA project. The team organized awareness programme on need of renovation of existing tanks for improving water storage during 2012-13.farmers took initiation in desilting of existing tanks through community mobilization. The implementation of this activity by the farming community resulted in increased groundwater table of 17 bore wells by 2-3 feet. It facilitated the beneficiaries to give supplementary irrigation for irrigated dry crops.

3.9 Construction and Renovation of Water Harvesting and Recharging Structures for Combating Water Scarcity

Major Climatic Vulnerability: Drought

Background information

Anantpur is one of the drought prone districts of Andhra Pradesh. The yields of crops in this district are low and unstable due to frequent droughts. Water scarcity is the most common problem in this district. Unavailability of drinking water is also a serious problem in many mandals of the district. Hence there is need to renovate existing ponds and also to construct water harvesting structures like check dams for combating water scarcity.

Existing Practice

Farmers in this region are making serious attempts to dug wells and bore wells to irrigate crops like groundnut, vegetables and fruit crops. The water in these structures is gradually decreasing. Crop failures are becoming common in some of the mandals of the district.

Resilient Technology/Practice

Construction of check dams and percolation tanks/farm ponds will improve the ground water recharge for existing bore wells.

Performance

At present, the cluster of NICRA village Chamaluru in Anantapur district of Andhra Pradesh has five check dams.(*viz.,* Chamaluru **(3)**, Chakrayapeta (**02).** The storage capacity of these structures was reduced due to deposition of silt over the time. These check dams were constructed earlier and are not functioning well. The crops during rainy and post-rainy seasons were suffering due to lack of irrigation facility. At present, ground water table level in bore wells is decreased by 2 and 7ft/year in black and red soils respectively.

During focus group interaction, the farmers in NICRA villages expressed that water scarcity in the village is increasing year by year due to over exploitation of ground water for irrigating horticultural crops and high water requirement of paddy. They sought the help of NICRA coordinator in desilting 5 existing check dams for higher water storage. They further expressed that silt removed from the tanks can be applied to their own fields to improve the soil fertility. They were ready to contribute 25% cost by themselves and remaining 75% cost can be funded as grant from NICRA project. Keeping the demand of the farmers KVK initiated desilting of 5 defunct check dams to improve the storage capacity of check dams. The silt removed from these tanks was transported by the farmers to apply to their own fields.

Measurement of checkdams		
NICRA village	**Before desilting**	**After desilting**
Chamaluru	17x13x1m	25x13x2m
Chamaluru	30x15x1.5m	30x22x2.5m
Chamaluru	33x3x1.5m	33x7x2m
Chakrayapeta	Totally covered with balck soil	30ft barrier for collection of rainwater
Chakrayapeta	10x7x1.5m	10x8x2m
Impact	Capacity of structure (CU.m) 1149.5	2922 cu.m
	1. Amount of rain water harvested in rainy season (measure depth meters)	29,22,000 litres of rain water is harvested in the month of Sep,2013.
	a. Ground water recharge	About 6-8 borewells are located in the premises of checkdams and ground water table is increased by 2-3 meters and discharge is increased by ½ inch.

Impact and up scaling

Groundwater recharge technologies can be promoted in different mandals of Anantapur through Watersheds, MGREGS, SFDA, State Department of Agriculture and NGOs involved in rural development. Focused mandals (Rapthadu, Garladinnae, Atmakur, Anantapur, Kuderu, Tadimarri, C.K.palli, Ramgiri, Kanganapalli, Kalyandurg, Rayadurg, Settur, Gummagutta, Penukonda, Hirehal, Parigi, Lepakshi, Chilamathuru, Gorantla, Kadiri, Mudigubba, Nallamada and Talupula etc. to be promoted.

3.10 Edification of Farm Ponds for Groundwater Recharge

Climatic Variability: Low and Erratic Rainfall

Background information

During last 10 years, in NICRA village of Anantapur farmers suffer from water shortages for crop production due to declining water table. *Rabi* crops often suffered due to moisture stress affecting productivity. As farmers were not aware of in-situ soil and moisture conservation techniques, 35-40% of total rainfall was being lost as runoff.

Resilient Practice / Technology

To address this problem, recharging of tube wells was taken up as a major intervention. The technique involved is diverting runoff to a pit dug around the tube well after trapping the silt. About 8 to 10 cement rings were descended into the dugout around the tube well. Harvested rainwater is collected in a cement tank and allowed for the silt to settle down and then conveyed to the dugout using a PVC pipe. Material required for recharging included cement rings (8-10 numbers, 4.5 ft radius, 2 ft height), bricks (500), cement (1 bag), pipe (10 ft long) and one perforated pipe (6ft long). Average cost incurred was Rs.10,000 out of which 25 per cent of total cost and labor was shared by the farmer. In Chamaluru village of Anantapur district (Andhra Pradesh.) new farm ponds were constructed in farmers' fields to recharge bore wells. The size of the farm ponds was 22×22×1.5 m each having water storage capacity of 726 m^3.

Performance

Keeping the problem of water scarcity and low crop yields, Farm Science Center (KVK), Anantapur made efforts to bring awareness on utility of farm pond in harvesting rainwater and also recycle the rainwater for Improvement of ground water levels nearby bore wells there by increasing the crop productivity in the arid zone of the district. Farmers were educated with need based skills on farm pond technology by KVK scientists. Farmers were enthusiastic to have farm ponds on even contributory basis. As a part of NICRA programme, demonstrations on farm ponds were constructed in five farmer's fields to improve ground water resources. Farmers contributed 10% of the total cost of construction of farm pond. About 90% of construction was met as grant towards each demonstration. An amount of Rs 65000/pond was incurred towards each demonstration in this selected village. The water levels nearby farm ponds were monitored in the season with the help of water level indicator

The size of the farm pond in Eswara Reddy field was 22×22×1.5 m having water storage capacity of 7260001 lit. The farm pond was filled two times with runoff water with the receipt of 174 mm of rainfall in September 2013. Five borewells located in the premises of farm pond were recharged. One defunct borewell started functioning and irrigated area increased by 2 hectares.

In another farmer field (Ravi), 2 borewells located around the farm pond were recharged. The depth of the water table on 11th September in functioning well was 7.75 m as against 28.5 m on 11th April 2014. Another farm pond was dug with a size of 25×15×2 m in the field of the participating farmer (i.e Gopal Reddy). The farm pond has a storage capacity of 660000 liters. About 5-6 bore wells located in the premises of farm pond were recharged. The depth of water table in borewells has increased by 9 feet as against 30 feet from 26th February to 11th April, 2014.

Monitoring of water table in wells adjacent to farm pond

Well no.	Name of the Farmer	Distance from farm pond (m)	Water table depth (m)								Rainfall details		
			Sep, 13	Oct, 13	Nov, 13	Dec, 13	Jan, 14	Feb, 14	Mar, 14	Apr, 14	Month	Rainfall (mm)	Rainy days
1	Eshwar Reddy	64 m	9.4	9.8	13.0	14.9	17.1	11.75	12.50	12.50	Sep,13 Oct,13 Nov,13 Dec,13 Jan,14 Feb,14 Mar,14 Apr,14	174 24 0 0 0 0 28 13	6 3 0 0 0 0 2 1
2	Y.Ravi	128m	11.1	10.5	13.5	12.6	17.4	12.12	13.25	13.50			
3	S.Adi Narayan	75 m (defunt)	9.4	10.8	12.2	12.4	17.8	12.37	11.75	13.0			
4	Gopal Reddy	248 m	11.4	11.3	16.5	15.0	16.6	14.25	16.25	14.50			
5	Venkateswar	270 m	9.6	11.9	16.0	16.1	18.9	15.25	16.25	13.0			
	Average		**10.2**	**10.9**	**14.1**	**14.2**	**17.6**	**13.1**	**14**	**13.3**			

Scope for up scaling

The technology of ground water recharge can be promoted in scarce rainfall mandals in Anantapur district through watershed programmes, MGNREGS, SFDA, Department of Agriculture and NGOs and DRDA and other rural development programs for creating water resources.

3.11 Desilting of Check Dams for Augmenting Water Resources in Drought Prone Areas

Background information

Baramati is a drought prone tehsil of Pune district in Maharashtra with annual rainfall of 530 mm. KVK has chosen village Jalgaon Kade Pathar under NICRA project. It is characterized by drought with 4 to 5 dry spells in a rainy season. The village is situated on the bank of Karha River. There is another small river flowing at the other end of the village. The total area of the village thus lies between these two rivers. The check dams on these rivers were constructed by the Department of Agriculture, Government of Maharashtra which are the main water harvesting and conservation bodies.

Existing Technology/practice

Cotton and soyabean are important crops grown in raifed areas of Baramati in pune district of Maharashtra. The droughts and ill distribution of rainfall and decreasing ground water levels are major constraints to improve the productivity of these crops. The checkdams were made earlier by the Department of Agriculture. They have become defunct over the time due to silt accumulation over the time.

Resilient Technology/practice

Desilting of checkdams with community mobilization can improve the storage capacity in the structure. Silt available due to silting process can be applied to the fields to improve soil fertility and there by crop yields.

Performance

The Krishi Vigyan Kendra established in Baramati for implementing NICRA project activities. The problem of water scarcity was expressed by the farming community. The farmers themselves made a committee to implement the project activities. They showed keen intrest to desilting the existing check dams and observed increased the storage capacity of structure and also observed the ground water level of the wells. Farmers applied the silt accumulated due to desilting to their fields.

Outcomes of the intervention:

- Increased water storage capacity of the check dams by 40%. The storage capacity of these 6 check dam increased by 15 corer litter.
- The average pH and EC of the tank silt was 7.97 and 0.26 m moh /m^2 respectively. 35 farmers transported it to their uncultivable barren fields covering 25.8 ha.
- Total expenditure for de silting of 6 check dams under NICRA project was Rs.19.00 lakh.

- Farmer’s contribution was Rs. 7.42 lakhs for transporting of tank silt to their fields.
- The silt application made barren lands cultivable and resulted in increase in grain yield of pearl millet and rabi sorghum by 5 and 8.75 q /ha respectively.
- With rain fall of 73.4 mm in first fortnight of October 2011 all the check dams were filled with water recharged the 86 open wells in the village and raised water level by 7 to 10 feet.
- Farmers could give protective irrigation for the crops in 182 ha area during rabi 2011.
- Provided protective irrigation to crops in 56.4 ha in kharif and 34.5 ha in rabi which was only rainfed earlier.

3.12 Development of Water Resources through Konkan Vijaya Bandharas

Major Climatic Vulnerability: Drought/Floods/Temperature

Background information

Konkan region of Maharashtra belongs to high rainfall zone with annual average rainfall of 3500-4000 mm. In spite of this, region faces water scarcity during late rabi and summer seasons due to heavy surface runoff, less water holding capacity of lateritic soil and high degradation of land cover.

Existing practice

The important crops grown in this region are Paddy, Finger millet (Nagli), Lady's finger, Brinjal, Cowpea, Green gram, Smooth gourd, Chilli, Bottle gourd etc.Coconut, Arecanut, Cashewnut, Banana, Sapota, Betel vines and Mango, Mogra (Jasmine), Jai, Hibiscus are also grown in this region. But cropping intensity was very less at 89.80 to 186.18 per cent due to non-availbility of water from December onwards

Resilient Technology/Practice

Of late, farmers of Haral village of Ratnagiri District, Maharashtra were not able to cultivate rabi crops due to non availability of water source though few streams are flowing by the villages. The streams contain much water during monsoon and they does not stay alive long enough to serve as source of irrigation by November. Villagers discussed this problem with the KVK staff.

The KVK, after engaging with the community to evolve a possible solution, suggested arresting the flow of the streams during the end of monsoon so that water would be available for longer period and the same could be used for irrigation during post-rainy season. Enthused by this idea, the villagers agreed to contribute their labour through shramdaan and build check dams to partially arrest the flow of the streams.

Farmers from both villages and school children from Zilla Parishad School under N.S.S participated in shramdaan and constructed ten check dams across the streams. Konkan Vijay

Bandharas (Stone check dams) were constructed using available stones in the streams by arranging them one over other in a form of wall barrier and covering it with polythene sheet. Vanarai Bandharas (Using sand bags) were constructed where stones were not available, there by using empty cement bags which were filled with sand by the villagers and the bags were placed in rows one over the above in place of stones. These are temporary structures which are built to reduce the velocity of stream so that infiltration increases. As a result of this, a large quantity of water was impounded and the villagers could cultivate rabi crops using the impounded water within a short period, the villagers observed that the water table enhanced by around 25% and area expanded under off season vegetable cultivation is 10 ha and it helped in increasing farmers income by increasing cropping intensity. Apart from this, these spots have become a place of attraction for the people of many neighboring villages and are visiting to see these check dams. In short, it has become a symbol of self help to address local problems.

Impact and up scaling

The technology of Vijaya Bhandharas can be promoted in different taluks of Chipalun, Dapoli, Guhaghar, Khed, Lanja, Mandangad, Rajpur, Ratnagiri and Sangameswar through watershed programs, tribal development agency, MGREGS, SAUs and NGOs and other agencies involved in rural development.

3.13 Construction of Temporary Check Dam to Harvest Rainwater

Climatic Variability: Drought

Background information

The NICRA Village Umarani, in Maharashtra is situated in the Satpuda ranges where the soils are shallow, prone to soil erosion (Moderate to severe). It receives an annual rainfall of 813.2 mm. The main climatic challenges of the village are frequent droughts and heat stress.

Existing Practice

Some of the farmers cultivate chick pea under rainfed condition. Some of the farmers keep their land fallow in rabi season due to non-availability of water. Though the natural streams have been flowing throughout rabi season. As there is no sufficient storage of water for pumping, water is not being utilized by the farmers efficiently. The farmers who own their land along the sides of natural streams could not harness water for irrigation.

Resilient technology/Practice

Area under irrigation can be increased by constructing checkdam across the natural flow. The productivity of rabi crops like chickpea can improve the productivity of rabi crops through limited irrigation situation.

Performance

Krishi Vigyana Kendra (KVK) has identified four natural springs which gets dry by mid Jan-Feb in NICRA village in Umarani with active involvement of the farmers. The NICRA team of KVK advised the farmers to arrest the flow of the springs during the end of monsoon by construction of check dam. The water collected in the check dam could be made available for longer period to give life saving irrigation for rabi and summer crops. Farmers were enthused by the idea. The villagers agreed to contribute their labour through shramdaan to build 4 new check dams to partially arrest the flow of the springs

Four check dams were constructed by using low cost empty cement bags in which sand was filled and the bags were placed in rows one over the above. These temporary structures were constructed by the farmers to reduce the velocity of springs so that infiltration increases. As a result of this, a large quantity of water was impounded. The villagers could cultivate rabi crops using the impounded water. Water table enhanced by around 3-4 ft. 5 farmers were benefited due to expanded area under rabi and summer groundnut cultivation by 10.4 ha and formed 4 water usage groups of 4-5 farmers each.

KVK started assessing the increased well water level on monthly basis since June 2012. For this purpose 9 wells in the periphery of the water harvesting structure were selected. The impact of increasing well water level was observed during 2013.

Month	Depth of water level from top (ft)*	Available water in water storage structure (%)	Average irrigated area in acres /well	Rainfall (mm)
July	34	0	2	35.1
August	36	0	1	77.2
September	33	19	1	100.9
October	27	100	5	90.6

**** Lower is the depth from top; higher is the water level in the well.***

Up scaling

The technology of check dam construction can be promoted in different tehsils can be promoted in such areas where natural spring flows are observed through Watershed programme, MGNREGS, Tribal development, State Department of Agriculture and NGOs involved in technology transfer.

3.14 Check Dam - Storing Excess Runoff in Streams

Climate Vulnerability: Drought

Background information

Some of the structures in villages were not robust enough to withstand recurrent heavy rainfall and flash floods. The design used was probably not appropriate in the face of more extreme weather events which are expected to be more frequent and intense as a result of climate variability in the region. Accordingly, renovation and upgrading of these structures was included under NICRA project activities to enhance the resilience to current and future climate risks.

Resilient practice / Technology

Ex-situ storage of water in seasonal streams at suitable sites is an important strategy to conserve excess runoff water in different rainfall zones. Often, by virtue of the location with reference to nearby hilly areas, the village may receive copious amounts of surface runoff from surrounding areas. This excess runoff could be harvested on streams either for direct use or for improving the ground water availability. In high rainfall areas, though runoff availability is high, often it gets lost due to non-availability of storage structures. In these regions, on-stream storage structures could be built on first order streams to make water available for direct use during long dry spells by farmers. In majority of NICRA villages, check dams (new/ desilting of existing ones) were major interventions in drought prone districts in different rainfall zones.

Jalgaon village in Baramati, does not have much runoff from agricultural fields as the rainfall is 550 mm. The village survey indicated two major streams surrounding the village indicating surface inflows from upper catchment areas. Six structures constructed on the streams were not sufficiently catering to the needs due to siltation. One of the major activities carried out over two years is to completely desilt these structures.

3.15 Efficient Water Management through Drip in Chillies

Climate Vulnerability: Drought

Existing practice

Smallfarmers in Nalgonda district face numerous risks in agricultural production. Rainfall in the district is erratic and inadequate and the crops are mostly dependent on monsoon or with existing bore wells. The farmers grow vegetables like chillies under limited irrigation with water available through bore wells or with canal. Continuous use of water in bore wells results in decrease in ground water level over the time. Hence there need to use this scarce water though efficient methods like sprinkler or drip systems.

Existing Technology

The farmers in this region grow vegetables like chilies or tomatoes/leafy vegetables with available water from bore well through flood system. This method of irrigation causes much water wastage. Thus the ground water level in bore wells is decreasing over the time.

Resilient practice /Technology

Micro irrigation systems in scarce rainfall zone of Telangana state increases water use efficiency. More area can be covered by using drip irrigation system compared to flood system with the same quantity of water.

Performance

The villages of Nandyalagudem and Boring Thanda were selected to implement the climate resilient technologies in Nalgonda district of Telangana State. The NICRA team from KVK, Gaddipalli organized training programme to the farmers of both villages on efficient use of water for reaping increased profitability. As a part of follow-up, the team facilitated linkages with Department of Horticulture to get certain units of drip systems to the farmers in these villages. Installation of drip irrigation was completed in 18.6 ha covering 28 farmers covering chilies with the financial contribution of 90% from APMIP and 10% from farmers contribution. Demonstrations were organized with active participation of farmers on efficient use of water with the drip system on vegetables especially on chilies. Flood method of irrigation system was included as check. The yields of chillies under both the systems and the quantity of water saved with drip were documented. The results indicated that drip system of irrigation in chillies enhanced the yield by 800 kg/ha compared to the flood system of irrigation (600 kg/ha). The cost of cultivation was decreased by Rs 35000/ha over flood method of irrigation.

Up scaling

Micro irrigation systems under limited irrigation can be promoted through State Horticultural Mission, SFDA and lead banks to improve the livelihood of small farmers

3.16 Micro Irrigation for Efficient Water Use in Different Crops

Major Climatic Vulnerability: Drought

Existing practice

Across the tropics, smallholder farmers face numerous risks in agricultural production. Rainfall is erratic and inadequate and the crops are mostly dependent on monsoon. Climatic variability is expected to disproportionately affect smallholders and make their livelihoods even more precarious. Small scale water harvesting structures at individual farm level enable reuse of harvested water during critical periods of growth or for providing pre-sowing irrigation to *rabi* crops. Various models of small scale water harvesting systems have been promoted by governmental and nongovernmental organizations (NGOs) involving different farm pond sizes, lining material, reuse of harvested water for different crops at critical crop growth stages.

Resilient Technology

One way to cope with climate vulnerability is to collect rainwater in harvesting structures to increase the irrigated areas as well as crop productivity. Farm ponds have been considered as one of the key interventions in NICRA villages and have been widely adopted in the villages. Various cropping system modules were worked out by using harvested water. Majority of farmers opted cultivating vegetables with harvested water in a ratio of 1:10 (command to catchment area) with sustained profits.

Performance

The productivity of crops in rainfed areas of Maharashtra and Telangana quite often fluctuates due to vagaries of monsoon. The productivity under this situation will be low/ uncertain. Use of harvested rainwater either through drip/sprinkler/or any other means increases productivity and profitability of crops and also water productivity.

The performance of drip system with harvested rainwater was compared with rainfed environment with different crops by NICRA team members at Amravati, Baramati and Ahmednagar districts in Maharashtra and Khammam in Telangana state.

At Amravati, use of harvested rainwater through drip system in cotton gave higher yields (2574 kg/ha) and also net income (Rs 55866 /ha) compared to the rainfed cotton.

The demonstrations on protective irrigations by sprinkler irrigation system at Baramati to Rabi sorghum in 3.2 ha area. The number of average irrigations in demonstration by sprinkler was 2 and in farmers practice no irrigations were given. The average increase in yield by the sprinkler system was 28.9% over the farmers practice and average increase in net income was 40.4% was noticed with sprinkler system over farmers practice.

In Ahmednagar, drip/flood system of irrigation along with water absorbent polymer (WAP) increased the pomegranate yield by 5.6% and saved 5.1 lakh lit of irrigation water/ha/season. While in onion, Drip+WAP increased the bulb yield by 29 per cent and saved 3.9 irrigations and also saved 23.4 lakh liters of water/ha. In Khamam district of Telangana state two supplemental irrigations with drip/furrow method enhanced the grain yields in cotton (2250 kg/ha), oilpalm (2 t/ha) and fodder grass (20 t/ha) over respective yields of crops rainfed condition in khamam. Supplemental irrigation two times enhanced the income in cotton and fodder grass by Rs 44000 and Rs10900/ha respectively.

Up scaling

The technology of sprinkler and drip irrigation systems can be promoted in predominant rainfed areas of Maharashtra, Telangana and Andhra Pradesh through SFDA, RVKY Watersheds, ATMA and Central/ State Horticultural Missions for higher yields of agricultural crops.

3.17 Efficient Use of Rainwater to Improve the Productivity of Rainfed Crops

Major Climatic Vulnerability: Drought

Background information

Cotton, soybean and pigeonpea are important rainfed crops grown in Amravati district of Maharashtra. The yields of cotton, soybean and pigeonpea crops fluctuate quite often due to dry spells at different crop growth stages. The productivity of rainfed crops in this region can be improved by collection, storage and recycling of rainwater through efficient methods like drip systems.

Existing practice

Farmers in this area grow cotton in black soils. The crop faces severe moisture stress at different phonological growth stages and results poor yields.

Resilient technology/practice

In-situ conservation technologies like conservation furrows, BBF system and collection of rainwater in farm pond and its utilization through efficient methods of application like drip will improve the productivity of rainfed crops considerably.

Performance

The village Takali B.K., Nanggaon Kh in Amravati district of Maharashtra was selected to implement NICRA. The project team identified the constrains of improving the productivity of rainfed cotton in this area through participating tools like PRA. The scientists of NICRA team organized training programme on cotton production technology to these farmers. Farmers took keen interest to have farm ponds to supplement rainwater for different crops. As a part of NICRA, they dugout 3 farm ponds with the size of 24X25X3 ft. with a capacity of 14.61 lakh of water. They gave two irrigations at flowering and boll formation stages though drip system in cotton (Bt-3028) it was observed that Use of drip in Bt cotton enhanced the kapas yield by 151% over rainfed system (1708kg.ha) over 2011-2013.


3.18 Water Saving through SRI Cultivation in Paddy

Major Climatic Vulnerability: Drought

Existing practice

Rice is an important crop grown in the state of Andhra Pradesh and Telangana. Rice consumes lot of water. Due to depletion of water resources, and increase in cost of production, rice production is becoming uneconomical. This system is very much useful to utilize the family labour in case of small and marginal farmers. The farmers in NICRA village practicing normal cultivation of paddy where it requires more number of irrigations.

Resilience Technology

SRI technology uses less water, less seed (2 kg/acre), few plants/unit area, less chemical fertilizers and less pesticides. The six key principles in SRI are: Young-aged seedlings, Careful single seedling transplanting, Wider spacing, Water management, Weeding and Compost/organic manuring . We have to keep the soil moisture up to panicle initiation instead of submerging the paddy field continuously.

Performance

The farmers in NICRA village of Anantapur district were practicing cultivation of paddy through flood system of irrigation. Keeping this in view the demonstrations on water saving technologies through SRI cultivation were conducted. The results showed that SRI method of paddy cultivation increased the grain and straw yield by 26 and 11 percent respectively compared to the traditional method (6842 kg/ha). SRI method of cultivation produced higher growth and yield components than normal method.

In SRI cultivation, the number of irrigations was reduced to nearly 50 percent and irrigation interval has been increased from 2 to 5 days.

NICRA centre	Treatments	yield (kg/ha)	straw yield (kg/ha)	cost of cultivation (Rs/ha)	Gross income (Rs/ha	Net income Rs/ha)
Anantapur	SRI Method	8600	15000	53550	145125	91575
	Traditional Method	6842	13500	53550	115459	61909
Gondia	SRI Method	8600	15000	53550	145125	91575
	Traditional Method	6842	13500	53550	115459	61909

At Gondia district of Maharashtra, SRI method of cultivation in paddy (PKVHMT) enhanced the yield by 1100 kg/ha and also net returns by Rs.14000/ha than traditional method (3200kg/ha) .

Growth and yield attributes as influenced by various treatments

Character Treatments	Plant height(cm)	No. of productive tillers/ per plant	Panicle length (cm)	No. of grains per panicle
SRI Method	93	23.40	18.90	207
Traditional Method	88	15.20	10.00	191

3.19 Critical Irrigation to Improve the Yield of Rainfed Cotton

Major Climatic Vulnerability: Drought

Background information

Cotton is one of the important rainfed crops grown in Khamam district of Telangana state. The yield of this crop will be reduced due to variation of rainfall in terms of total quantity and distribution. Incidence of long dry spells either at flowering or boll formation stages affect the yields drastically.

Existing practice

Farmers grow the crop of cotton in black soils in khamam district either by dibbling or with the help of plough. They operate tyne or blade harrow to control weeds and also to create dust mulch to minimize the drought effects. This practice does not improve the yield considerably.

Resilience Technology/ Practice

Supplemental irrigation from rainwater collected through drip system at flowering and boll formation stages in rainfed cotton will improve the productivity and profitability considerably

Performance

Keeping the situation in view, KVK of Khammam district selected the village of Nacharam as a part of imparting technologies for climate resilience. The farmers shown keen interest to improve the productivity of rainfed crops by constructing farm ponds and using the rainwater collected for the yield improvement. As a Part of NICRA activity three farm ponds were dug in individual farmers with capacity of 14.61 lakh liter capacity for each demonstration were organized to create impact of life saving irrigation through drip on cotton and other crops. Supplemental irrigation both at flowering and boll formation through drip system in cotton (Mallika-II) gave additional boll yield of 250 kg/ha and also increased the net income by Rs 8250/ha compared to cotton grown with rainfed situation. The rain fed cotton gave the kapas yield of 2000 kg/ha with the net income of Rs36000/ha. Similarly, Two irrigations with farm pond water doubled the fodder yield of the multicut fodder variety as against rainfed environment (10 t/ha)

Up scaling

The technology of creating / improving water resources through farm ponds can be promoted through watershed projects, MGNREGS, Department of Agriculture, Tribal development Projects NGOs and related agencies implementing rural development activities.

3.20 Enhancing Resilience through Improvement in Conveyance Efficiency

Major Climatic Vulnerability: Floods

Background information

One of the reasons for gap between potential created and utilized under canal irrigation systems is the lack of maintenance of conveyance channels which became silted up. As a result, tail end villages do not get the intended irrigation water supplied and often the envisaged benefits cannot be realized. As part of NICRA interventions, emphasis was on clearing of conveyance channels for providing irrigation to target areas.

Resilience practice / technology

NICRA village Matsyapuri in West Godavari district (Andhra Pradesh) receives an average annual rainfall of 1185 mm with frequent floods which submerge croplands resulting in crop failure. There are two irrigation channels, namely Mentepudi channel and VWS channel which are the major irrigation water source covering 640 ha (Mentepudi channel 400 ha and VWS channel 240 ha). Rice is the major crop cultivated in this village by 300 farmers. Over the years, these channels became nearly defunct due to silting and wild growth resulting in reduced capacity to supply irrigation water to tail end areas in the village. It also led to flooding of nearby fields during monsoon. Renovation and deepening of these two irrigation channels was taken up under NICRA project during 2012-13.

Impact and up scaling

At Matsyapuri village of West Godavari, as a result of this intervention, rice cultivation could be taken up by farmers in the tail end area. It also helped in efficient disposal of rainwater by avoiding flooding and submergence of crops at times of intense rainfall events. There was heavy rainfall in the first week of November 2012 due to *'Neelam'* cyclone and excess flood water was disposed-off safely. This prevented submergence of fields adjacent to the canals. It was noticed that there was flood water only up to a height of 42 cm in command area under the deepened channels and there was no overflowing of flood water. In other untreated areas submergence was up to 122 cm height and the crop was completely submerged due to flood water. This resulted in avoiding yield loss to the extent of 41.3 q/ha with MTU-1061, 33.8 q/ha with BPT-5204 and 26.3 q/ha with MTU-7029 in paddy areas under the renovated channels whereas the actual yield was only 15 q/ha in untreated areas that suffered submergence.

3.21 Assessment of Drought Tolerant Varieties of Groundnut for Scarce Rainfall Zone of Andhra Pradesh

Major Climatic Vulnerability: Drought

Background information

Drought is recurring problem in scarce rainfall zones like Anantapur of Andhra Pradesh. Groundnut is an important rainfed crop grown in this region. The productivity of this crop is low and uncertain. Hence there is need to assess the drought tolerant varieties like K-6, Narayani, IGGV-91114 and K-9 to improve the productivity.

Existing Practice

Farmers in this region are sowing local bunch variety like TMV-2 that has lost purity. As result farmers are realizing Sub-optimum yields and economic returns.

Improved Technology

Acharya N.G Ranga Agriculture University, (AP) is recommending improved drought tolerant varieties like K-6, K-9, Narayani and ICGV-91114 for rainfed conditions due to their drought tolerance, early duration and high pod yield. The pods are larger than local bunch and fetch higher price in market.

Performance

Groundnut is a major crop grown in adopted NICRA villages of the district. In order to popularize the improved drought tolerant varieties, assessment of improved varieties like K-6, K-9 and Dharani was done along with local check TMV-2 in 10 ha area involving 20 farmers during 2011, 2012 and 2013 in cluster of Chamaluru village under rainfed environment.

Performance of Different Drought Tolerant Varieties Of Groundnut

Year	Varieties	Pod Yield (kg/ha)	Fodder Yield (kg/ha)	Cost of cultivation (Rs/ha)	Gross income (Rs/ha)	Net income (Rs/ha)	B:C ratio
2013	K-6	377	1389	20150	27226	7076	1.35
	K-9	305	527	20150	24562	4412	1.22
	Dharani	433	1556	20150	28151	8001	1.40
2012	K-6	968	2112	46095	29000	16595	1.5
	K-9	1175	2400	55952	31000	24952	1.8

During kharif 2013, Dharani variety recorded higher pod yield (423 kg/ha) followed by K-6 (398 kg/ha) and K-9 (326 kg/ha). However, Higher BC ratio realized with Dharani (1.40) closely followed by K-6 (1.35) and K-9 (1.22). During 2012, improved variety K-9 recorded additional pod yield by 207 kg/ha and also additional returns (Rs 8357/ha) than K-6 under rainfed condition.

Impact and Up scaling

In Anantapur district, K-6 has spread in 2.5 lakh ha and K-9 has spread approximately in 1.0 lakh ha area. These varieties can be further popularized through the efforts of KVKs, Department of Agriculture, NGOs and other agencies by focusing seed village concept on participatory mode.

3.22 Assessment of Drought/Stress Tolerant Varieties for Stable Productivity in Rainfed Environment

Major Climatic Vulnerability: Drought

Background information

Climatic risk is an integral part of agriculture and in each season farmers are encountering production risks such as weather, pest and diseases and technology etc. Managing crops for excessive and deficit rainfall such as improved crops and cultivars, cropping systems and other management practices is necessary for stable profitability in rainfed areas. Among the factors of production, improved cultivars play an important role in enhancing the productivity in rainfed environment.

Existing practice/Technology

Many farmers in rainfed areas are often growing crops/varieties by virtue of their conviction. These crops/varieties are not able to fit in the growing environment. Sometimes varieties normally recommended for given regions are not performing well because of rainfall aberrations particularly with dry spells in their growth periods. Farmers are experiencing crop failures in some years.

Resilient Technology/Practice

Keeping this situation in view, demonstrations of location specific best cultivars for climate resilient agriculture along with local checks were organized in six districts of Andhra Pradesh, two districts of Telangana and seven districts of Maharashtra states as a part of National Initiative on Climate Resilient Agriculture (NICRA) initiated by Indian Council of Agricultural Research (ICAR) in 2011.

Performance

Aurangabad

Farmers normally grow long duration local varieties of pigeon pea and cotton (170-185 days) in Shekta village of Aurangabad district in Maharashtra under rainfed conditions. These varieties quite often experience moisture stress during various stages of growth leading to low yields. NICRA team organized demonstrations of improved varieties along with local checks in pigeonpea, cotton, maize, soyabean and green gram crops from 2011-13. Farmer's varieties were severely affected due to moisture stress due to their long duration.

- Improved variety of greengram **BM2002-1** gave on average of higher seed yield by 200 kg/ha and also net income (Rs 7640/ha) over local Kopargao variety. An increase of Rs1269/ha was realized with improved variety of greengram BM2002-1 over local genotype (Rs12700/ha)
- Improved variety of **BDN-711** gave higher seed yield of 300 kg/ha and net returns of Rs11000/ha as compared to local variety (850 kg/ha). The BDN-711 is found to be drought tolerant, shorter in duration by 20-25days, resistant to sterility mosaic, determinate in habit, lower branching and higher seeds/pods (3.5) than local.

- Improved variety of onion of **AFLR** produced additional bulb yield of 600 kg/ha and also additional net income of Rs 56500/ha as compared to local variety in 2013. The local variety of onion gave the bulb yield of 2300 kg/ha).

- Improved variety of chickpea **Akash** increased the seed yield (300 kg/ha) and also net income (Rs 3610/ha) over local variety (2300 kg/ha). Local variety of onion realized the net income of Rs157500/ha.

- Improved variety of **Netravathi (NAIW-1415)** produced 1000 kg/ha as against of local (800 kg/ha) in 2013. While in 2011, improved variety of wheat of Lok-1/HD2189 produced enhanced seed yield by 700 kg/ha over local (3100 kg/ha). This variety realized additional net income of Rs 7714 over local (Rs13562/ha).

- Improved variety **Parbhani moti** in rabi sorghum registered an increased seed yield by 200kg/ha and also net returns of Rs 2200 as compared to local Dagdi (400 kg/ha) in 2013. The local variety gave the net income of Rs 250/ha for grain only. In 2011, Parbhani Moti produced1100 kg/ha as against of 800 kg/ha in respect of Dagdi. This improved variety has oval shaped cob and bulky in size, bright shiny, pearly in color, tolerant to drought, dual purpose (meant for both grain and fodder) and good fodder quality.

- Improved variety of soybean **(MAUS-71)** recorded seed yield of 1500 kg/ha and also net income of Rs 29900/ha in 2013; The local variety JS335 in soyabean gave the seed yield of 1180 kg/ha and also recorded the net income of Rs 21100/ha.

- In Nandurbar, the improved variety of chickpea, Digvijay was found drought tolerant and gave the higher seed yield (245 kg/ha) and net income (Rs 11410/ha) compared to traditional variety which gave the seed yield of 1295 kg/ha with net income of Rs 29360/ha. The average number of pods/plant is 44 and 100 grain weight is 28.5. This variety gave bold grain since it escaped terminal drought.

Impact and Up scaling

Effortts can be made to promote drought tolerant varieties on a large scale in different districts of three states by encouraging seed production though seed village concept, National Seeds Corporation, State Seeds Corporations and also private agencies for stable production and profitability. Linkages with concerned State Agricultural Universities need to be developed by respective Krishi Vigyan Kendras and other seed development agencies to procure breeder and foundation seeds for large scale production of certified seed.

3.23 Drought Tolerant Varieties of Pigeonpea and Chickpea in Black Soils

Major Climatic Vulnerability: Drought

Background information

Pigeonpea and chickpea are important pulses gown in scarce rainfall zone of Rayalaseema region. Among the crops Pigeonpea is often grown as mixed crop with sorghum or pearl miller or with groundnut. Sometimes it is grown as sole crop during kharif season in both red and black soils in rainfed environment. At present farmers are growing long duration varieties (>200 days) during crop season. These varieties are often facing severe moisture stress (Drought) during terminal growth stages either at flowering or pod formation stages. There is need to grow medium duration varieties of pigeonpea to avoid terminal moisture stress. Chickpea is grown under residual moisture in black soils. Traditionally farmers are growing Annaegiri variety. This variety often faces drought during pod formation stages.

Resilient technology

The medium duration varieties like PRG-158 are suitable to these circumstances instead of growing long duration varieties like LRG-30 which matures in 180-200 days. It is tolerant to fusarium wilt disease. While in chickpea, the improved varieties like JG-11, Swetha, Digvijay, Jaki-9218 and NBeG-1 are having 100-105 days duration varieties. These varieties showed tolerance to wilt.

Performance

Keeping this situation in view, NICRA team working in Yagantipalle village in Kurnool district, conducted demonstrations with improved variety PRG-158 as against traditional variety LRG-30 in 20 farmers fields in 8 ha area with participation of farmers during kharif season. In rabi season, the improved variety NBeG-1 was compared with traditional variety JG-11, Recorded yields of pigeonpea and chick pea crops both in improved and traditional varieties through crop cutting survey in 2011-13.

Among the varieties of pigeonpea, the improved variety on an average recorded additional seed yield by 236 kg/ha and also additional net income by Rs 7542/ha compared to the traditional variety LRG-38. The farmers who cultivated the traditional variety realized the mean yield of 906 kg with net income of Rs15784/ha.

Impact and up scaling

The improved varieties can be extended in black soils of Anantpur, Kadapa and Kurnool districts in Rayalaseema region. Further these varieties can be popularized through KVKs, Agriculture Technology Management Agency (ATMA), Non-Government Organizations to bring more areas under cultivation.

3.24 Real Time Assessment of Paddy Varieties in Flood Prone Areas

Major Climatic Vulnerability: Floods

Background information

Flooding is a major challenge for rice production in the country. Heavy and intense rainfall events cause flash floods due to overflow of rivers and canals or sometimes tidal movements in coastal areas. Continuous high rainfall in a short span leading to water logging and heavy rainfall with high speed winds in a short span due to cyclonic storms cause inundation of paddy fields and lodging of the crop at grain filling and maturity stages causing huge losses to the farmer. Floods due to heavy rainfall in upstream areas in often lead to spate of rivers causing flooding of adjacent crop lands. Further, flood is a recurrent phenomenon in coastal Andhra Pradesh. The problem is accentuated due to poor or non-existent drainage and in some cases due to the topography of the land which impedes fast drainage from crop lands. Apart from improving drainage and other preventive measures, farmers can adopt flood tolerant varieties that can withstand inundation for an extended period and reduce the risk from flood damage

Existing technology

Paddy is an important crop grown in coastal Andhra Pradesh. The crop many times experienced floods in coastal area of Andhra Pradesh. As result the crop underwent denudation at different growth stages resulting lodging, immersion of panicles in flood water, germination of grain and finally great loss in yields.

Resilient Technology

Rice varieties Swarna-sub1, MTU-1010, MTU-1001 and MTU-1140 are high yielding with good grain quality apart from possessing submergence tolerance and perform better under flood situation. Demonstration of these varieties in flood-prone areas showed that Swarna-sub1, a variety developed by IRRI and CRRI, Cuttack and released in 2009, could tolerate submergence up to two weeks and could perform significantly better compared to other improved and local cultivars. MTU-1010 is a short duration, dwarf variety resistant to lodging and can withstand moderate wind velocity. This attribute of lodging resistance saves from not only loss in grain but also straw yield which is the main source of dry fodder. MTU-1140 is also a promising, non- lodging variety comparable in grain quality to BPT-5204.

Performance

Keeping this situation in view, demonstrations on assessment of paddy varieties tolerant to floods was undertaken in in selected villages of sirsuwada in Srikakulamdistrict of Andhra Pradesh These demonstrations were organized as a part of National Initiative on Climate Resilient Agriculture (NICRA) initiated by Indian Council of agricultural Research (ICAR) from 2011

During 2012, highest inundation was noticed at maturity stage of the crop growth due to rains received during 1-5, November 2012 and over flowed to the fields through Canal/Gedda water. The variety, PLA 1100 had recorded higher yield (5840 kg/ha) followed by RGL 2537 (5650kg/ha) and Indra (5460 ha) when compared to that of check varieties (BPT 5204/ Swarna/MTU 1001) (4860 to 5100/ha) which showed severe lodging.

The rainfall of 1613 mm was received in the same village during 2013. Direct sown paddy at seedling stage was inundated nearly for 5 days and the crop failed in high inundated area. Medium duration varieties of paddy were affected at panicle initiation stage and the crop was slightly lodged. Boot leaf was twisted and crop was submerged in water. Long duration varieties were at maximum tillering to panicle initiation stage when the flooding took place.

Among the varieties tested PLA-1100 performed better followed by MTU-1061, and RGL-2357 at different levels of inundation. In low inundated areas PLA-1100 performed better and reduced loss compared other varieties followed by MTU-1061 (Indra). MTU-1140 is having non-lodging characters and has 5 days more duration than BPT-5204, the plant height is also more than BPT-5204, as a result the panicle is not inundated during the time of flood.

3.25 Assessment of Paddy Varieties in Flood Prone Areas

Malor Climatic Vulnerability: Floods

Background information

Floods are major climatic constraint in influencing the yields of paddy in west godavari district in Andhra Pradesh. The resent experience of floods for the last two years affected the productivity 0f this crop considerably.

Existing Technology

The major paddy variety grown in this area during Kharif season is Swarna (MTU-7029) in 2012. It is prone to lodging during heavy rains. During the first week of November heavy rains were occurred in this area due to Neelam cyclone and most of the fields were submerged and crops were damaged

Resilient Technology/Practice

The improved varieties MTU-1061, MTU-1064andMTU-1140 are found tolerant to floods

Performance

Keeping this problem in view, demonstrations with flood tolerant varieties along with locals checks were carried out in selected NICRA village of Mastyapuri village during 2012 and 2013 in farmers fields .. It was observed that the local Swarna variety was completely (100%) lodged due to heavy rains where as the MTU-1061variety was not lodged due to Helen cyclone in 2012. The MTU -1061 variety yielded 9.08% more than the Swarna variety. This may be due to non lodging nature of the MTU-1061 variety.

In 2013, a heavy rainfall of 352 mm and 25 mm received during the months of October and November and caused floods in the village. The major paddy variety grown in this area during Kharif season was swarna (MTU-7029). Which is prone to lodging during heavy rains. During the first week of November heavy rains were occurred in this area due to Neelam cyclone and most of the fields were submerged and crops were damaged. Among the varieties.MTU-1061(Indra) wad found higher tolerance to submergence than traditional var. of Swarna. It was observed that Swarna variety was completely lodged due to heavy rains received where as MTU-1061 variety was not lodged. The var. MTU-1061 gave additional grain yield of 469 kg/ha and net income of Rs9625/ha than local Swarna (5156 kg/ha). The improved variety has 17 productive tillers and 32 hills/sq.m. The improved variety RP Bio 226 gave 4353 kg of grains /ha while Local BPT-5204 gave grain yield of 4101kg/ha during kharif MTU-1121 gave higher grain yield (949 kg/ha) than local MTU-1010 (5935 kg/ha) during rabi. MTU-1140 was non lodged during Heavy rains and Helen cyclone of Kharif 2013

Up scaling

These tolerant varieties can be promoted in other areas through seed village concept through KVKs, State Agricultutal University and other seed production agencies to minimize the effect of floods.

3.26 Promotion of Salt/Stress Tolerant Genotypes

Major Climatic Vulnerability: Drought, Heat Wave

Existing Practice

Most of the farmers in the NICRA village, Nacharam of Khammam district are cultivating Paddy as kharif season crop. The soils in surrounding mandals of Nacharam are saline in nature. The farmers are realizing low yields because of salinity and also due to short duration varieties.

Resilient Technology

The short duration and salinity tolerant paddy variety Siddi (WGL-44) is of 140 days duration, with fine grain, short duration. It was tolerant to gall midge and tolerant to lodging during crop growth period

Performance

Under NICRA (National Initiative on Climate Resilient Agriculture) project. Krishi Vigyan Kendra, Wyra, Khammam, organized farmer participatory on-farm assessment trials along with local check in NICRA village during 2013-14.

The results of demonstrations in farmers fields showed that improved variety Siddi (WGL-44) gave additional grain yield of 350 kg/ha and also additional net income (Rs 4725/ha) compared to the local check.

Performance of Siddi variety compared to farmers practice

Treatments	Seed yield (kg/ha)	Fodder Yield (kg ha)	Cost of cultivation (Rs/ha)	Gross income (Rs/ha)	Net income (Rs/ha)	B:C ratio
Farmers practice	5250	15000	52000	70875	18875	1.36
Siddi (WGL-44)	5625	18750	48500	75938	27438	1.5

Up scaling

Salinity tolerant varieties of paddy (siddi) can be promoted in saline soils of different taluks of Khamam and Nalgonda districts where paddy is grown.

3.27 Contingent Crops for Delayed Onset of Monsoon in Scarce Rainfall Zones

Major Climatic Vulnerability: Drought

Existing Practice

Groundnut an important crop gown in kharif under rainfed environment in Anantapur district. The optimum sowing window of groundnut to obtain higher yields is second fortnight of July. However, in the district, delayed onset of monsoon is common due to which, either fields are kept fallow or sown with groundnut which results in low yields.

Resilient Technology

If south west monsoon is delayed beyond first week of August, instead of ground nut, sowing of contingency crops like horsegram, foxtail millet/pearlmillet/yellow sorghum, cowpea can be preferred

Performance

Keeping this situation in view, NICRA team organized demonstrations of alternative crops of foxtail millet (Suryanandi) and yellow sorghum (AJ-140) with traditional crop of Groundnut (K-6) with 25 farmers covering 0.4 ha each. Sowing of test crops were done in second fortnight of August in 2013. The yields of crops were recorded through crop cutting surveys. The results showed that under late sowings, Setaria realized higher net returns (Rs.7500/ha) and BC ratio (1:3) whereas, groundnut crop realized negative net returns of Rs 2190/ha with a BC ratio of 0.89. Alternatively, yellow sorghum (AJ-140) can be equally suitable as an alternative crop under delayed sowing conditions of groundnut. The demonstrations organized in NICRA village of Anantapur clearly showed that yellow sorghum gave the net returns of Rs17203/ha; while ground nut under delayed sowings resulted negative net returns of Rs-2190/ha.


Up scaling

Under delayed onset of monsoon, Foxtail-millet (Suryanandi) can be popularized alternative to groundnut through Krishi Vigyana Kendras, ATMA and Watershed development projects. Efforts can be made for large scale production of foxtail millet (Suryanandi) by the Department of Agriculture and Seed Village programmes to meet contingent situation.

3.28 Assessment of Crop Diversification for Higher Profitability in Rainfed Area

Major Climatic Vulnerability: Drought

Background information

Diversification of agriculture with more competitive with high value commodities is one of the important stategy to overcome many of the challenges in rainfed agriculture. Diversification can be used as a tool to augment farm income, employment, alleviate poverty and to conserve precious soil and water resources. Rainfed areas can be benefited more as a result of agricultural diversification in favour of high value crops by substituting inferior coarse cereals. Agricultural diversification is also contributing to employment opportunities in agriculture and increasing exports. The need is to suitably integrate production and marketing of high value commodities through appropriate institutions. Market reforms in developing and strengthening desired institutions through required legal changes would go a long way in boosting agricultural growth, augmenting income of small farm holders and promoting exports.

Existing technology

The rice is the major crop grown in Katangtola and Chandanitola villages in Gondia district during kharif. The farmers were facing high cost of production and low remuneration in rice production

Resilient Technology/Practice

Vegetable cultivation in paddy growing area

Performance

Keeping this, in view alternate cropping system was demonstrated in farmers field with bottle gourd crop was taken up by KVK Godia with drought tolerant variety Warad along with micro irrigation system. The crop was sown in the first week of June 2012 in 0.35 ha and total yield obtained 22 quintals. The net income was Rs. 33,500 by cultivation of bottle gourd where as with rice crop it was only Rs.7,500 per hectare. Keeping this, in view alternate cropping system was demonstrated in farmers field with bottle gourd crop was taken up by KVK Godia with drought

tolerant variety Warad along with micro irrigation system. The crop was sown in the first week of June 2012 in 0.35 ha and total yield obtained 22 quintals. The net income was Rs. 33,500 by cultivation of bottle gourd where as with rice crop it was only Rs. 7,500 per hectare.

Up scaling

The technology of crop diversification can be promoted through the efforts of state horticulture mission, horticultural development officers and NABARD agency and also by National Banks in risk prone paddy growing areas of Gondia district.

3.29 Profitable Intercropping Systems for Scarce Rainfall Zone of Maharashtra

Major Climatic Vulnerability: Drought

Background information

Farmers in Aurangabad district grow sole and mixed crops of pearl-millet, cotton, soybean in kharif and sorghum and safflower in rabi season in rainfed situation. The productivity and profitability of these crops are relatively low due to aberrant weather conditions and poor crop management.

Resilient Technology

Intercropping of soyabean and pigeonpea (4:2), pearlmillet and pigeonpea (3:3), pigeonpea+greengram (1:2), Cotton+greengram (1:1) and Rabi sorghum+safflower (3:3) are recommended by MAU, Pabhani for stabilized productivity and income in black soil region of Aurangabad.

Performance

Keeping these situations in view, NICRA team of KVK, Aurangabad organized farmer participatory on–Farm assessment studies in selected Shekta village during 2011-13. The farmers adopted soybean and pigeon pea intercropping system (4:2) which on an average resulted in higher net income of Rs 11281/ha compared to the sole pigeonpea. Similarly, intercropping of pearl millet+ pigeonpea

(3:3) gave net economic advantage of 126 per cent over sole pearl millet. The farmers of NICRA village realized the additional net income by Rs12791/ha through intercropping of pearl-millet and greengram (1:2) intercropping than sole pigeonpea crop. Adoption of cotton+greengram (1:1) system by the farmers resulted to achieve higher net returns by Rs18765/ha than sole cotton. During rabi season farmers realized the additional net returns (Rs 8755/ha) than sole rabi sorghum (Rs 4850/ha). Among various systems cotton + grengram system recorded highest net returns followed by pigeonpea+soybean system.

Impact and up scaling

These sytems can be further popularized through Front Line Demonstrations, National Food Security Mission (NFSM), RKSY, SGDA and Watershed programmes in similar domains of solapur, Aurangabad, Jalgaon and Nandurbar areas of Maharashtra.

3.30 Soybean + Pigeonpea (3:1) Intercropping System

Major Climatic Vulnerability: Drought

Existing practice

Soyabean pigeonpea and maize are principal crops grown in Nandurbar district of Maharashtra. The farmers in this region generally cultivate soybean either as sole or mixed crop with pigeonpea in shallow black to medium black soils or even red soils during kharif under rainfed condition. The erratic rainfall in this area results in low productivity and stable profitability.

Resilience Technology

The technology comprises Soybean (JS-9305) + Pigeon pea (ICPL-87) in row ratio (3:1) sown at 45cm between crops @ seed rate of 50 kg/ha and pigeonpea is 10 kg/ha. The fertilized dose of 30 kg N/ha and 35 kg P/ha can be given as basal dose. Weeding and hoeing can be done up to 30 days after sowing of component crops.

Performance

The KVK Nandurbar as a part of NICRA activity conducted farmers participatory assessment trail in Umarani village from 2011-13 in15 farmers fields in 6 ha area. The results indicated that intercropping of soybean and pigeonpea (3:1) gave mean additional net returns of Rs11352/ha over sole soybean (Rs14213/ha). This system also helped in covering the land during early stages and conserved soil moisture.

Impact and up scaling

In soyabean cultivated areas of Nandurbar and other areas of similar domains if this system is adopted even in 10000 ha, there will be the net income benefit of Rs 142.0 crores. This system can be widely demonstrated and popularized by converging through Dry Land Farming Mission (DLFM) of Maharashtra, NFSM, RKVY, KVK and other extension agencies. Co-ordinator KVK, Nandurbar.

3.31 Sustainable Pearlmillet and Mothbean Intercropping

Major Climatic Vulnerability: Drought

Existing practice

Pearl-millet is an important crop grown in rainfed areas of Ahmednagar district of Maharashtra. The rainfall in this village is 351mm as against the normal rainfall of 450 mm. The productivity of this crop many times fluctuates due to vagaries of monsoon especially dryspell at the grain formation stage.

Resilient Technology

Intercropping of mothbean with pearlmillet (1:2) ensures stable income in rainfed condition.

Performance

Pearl millet is mainly cultivated in light to medium soils in Nirmal Pimpri village in Ahmednagar district of Maharashtra. Intermittent droughts are common during growth period of the crop affecting vegetative and tillering stage of the crop leading to poor harvest. Hence KVK introduced inter cropping of moth bean with pearl Intercropping of mothbean with pearlmillet (1:2) millet (1:2) to get stable returns in rain fed environment. Mothbean acts as mulch crop and helps in conservation of moisture besides minimizing weed intensity. There were two subsequent dry spells of 26 days duration during crop growth period. Sole pearl millet crop showed stunted growth in some places and dried completely.

Moth been crop covered the inter row spaces, acted as mulch and conserved moisture. Intercrop of pearl millet with mothbean gave higher yield by 9.77 % (17.18 q/ha) compared sole pearl millet (15.62 q/ha) and realized higher net income of Rs. 7500/ha compared to the sole pearl millet Rs.3398/ha.

Impact and up scaling

This practice can be extended in other similar domains where pearl-millet is predominantly grown in rainfed situation. The seeds of component crops can be promoted through seed village concept, KVKs and other private agencies.

3.32 Soil Test based Fertilizer Application in Cotton

Major Climatic Vulnerability: Drought

Existing practice

Cotton is an important crop grown in black soils of Nalgonda district of Telangana state. Farmers are using excessive nitrogen fertilizers which often leading to nutrient imbalance. This practice led to reduction in cotton yields and increased incidence of pests and diseases.

Resilience Technology

Balanced use of nutrients on soil test basis results in saving of fertilizer and reduces the cost of production in rainfed lands

Performance

Considering the importance of soil test based fertilizer application, KVK of Nalgonda district collected 86 soil samples from NICRA villages of Nandhyala gudem of Atmakur (S) mandal. These samples are dried and screened through 2 mm sieve and analyzed at soil testing laboratory, KVK Gaddipally. p^H of the soil samples is in the range of 6.51 to 7.5 and EC of all 84 samples is less than 1 dsm^{-1} and EC of 2 samples ranging between 1 to 2 dsm^{-1}, which is normal for crop growth. All soil samples are having low organic carbon content. The available nitrogen is low in all the samples i.e less than 280 kg/ha and the available P_2O_5 is low in 51 samples and high in 11 samples. The available potassium status is low in 42 samples and medium in 44 samples.

Demonstrations were conducted with fertilizer recommendation based on results of soil testing and also in traditional farmers method in cotton with 30 farmers covering 0.4 ha area each. Based on the results of two years, soil test based fertilizer application in cotton gave the additional net benefit of Rs 16375/ha as compared to the farmers method of nutrient application (Rs 43385/ha).

Up scaling

The technology of soil test based fertilizer application for different crops can be promoted through the soil testing laboratories established either at Mandal/District level and also through SAUs/KVK/ICAR institutes or other agencies like ICRISAT.

3.33 Improvement of Paddy Productivity in Alkaline Soils

Major Climatic Variability: Drought and Irrigation

Existing Technology

About 30% soils in Kurnool and Anantapur regions of Andhra Pradesh are saline soils. The productivity of crops in these soils are limited due to presence of excess salts specially sodium and chlorine. Due to drought and dry conditions, the water evaporates from the soil surface leading to the precipitation of salts as a result soils are becoming saline. Paddy grown in these soils are recording very low yields.

Resilience Technology

Use of gypsum (3.0 t/ha) before sowing or top dressing of gypsum@500 kg/ha reduces the alkalinity and improves the productivity of paddy.

Performance

Low yields in paddy are problematic in NICRA villages; Yagantipalle of Kurnool and Chamaluru of Anatapur districts. NICRA teams in Anantapur and Kurnool districts organized need based demonstrations in farmers fields with and without use of gypsum in alkali soils. Demonstrations of gypsum application in paddy fields were organized with 50 farmers covering 20 hectares' area in Anantapur and with 20 farmers covering 5 hactares area in Kurnool districts of Andhra Pradesh. The yield of paddy in improved and local checks was recorded by NICRA teams.

Ten demonstrations were organized on reclamation of sodic soils with gypsum at Yagantipalle village of Banaganapalle Mandal. The initial soil pH ranged from 9.02 to 9.16 and after reclamation the range is from 8.61 to 8.78. After reclamation cultivation of paddy was taken up. The average yield of paddy in demonstration plots was high (5920 kg/ha) compared to control plots (4852 Kg/ha). The results indicated that there is 22.02 percent yield increase in demonstration plots over the control plots. An amount of Rs 8735/ha was realized as additional income in demonstrations due to yield increments.

KVK, Reddipalli supplied gypsum to the farmers cultivating paddy in saline soils under NICRA scheme. Grain yield enhanced by 47% under top dressing of gypsum compared to control. Higher B:C ratio (2.69) was realized in fields top dressed with gypsum compare to control (2.09).

Up scaling

This practice can be promoted through State Department of Agriculture, Extension Agencies, KVKs and other projects like SFDA for stabilized yields of paddy.

3.34 Improvement in Soil Quality through Green Manuring with Dhaincha

Major Climatic Vulnerability: Drought

Existing Technology

Paddy is an important crop grown under irrigation in Khammam district of Telangana state. The productive of paddy in problematic soils is low due to presence of excess salts like chlorine or sodium or carbonates.The fertility in these soils can be improved by adoption of improved management practices like gypsum application or with incorporation of green materials.

Resilient Technology/practice

Incorporation of in-situ green leaf materials like Dhaincha orgypsum application on long term basis will improve the soil quality and thus eventually paddy yields.

Performance

Farmers of NICRA village getting high cost of cultivation due to the low fertile and saline soils and using more fertilizers during their crop growth period, Understanding the farmers problem about the low fertile and salinity, demonstrations were organized in 22 ha with active participation of 12 farmers under NICRA (National Initiative on Climate Resilient Agriculture) project. During 2012-14. The results showed that incorporation of Dhiancha helped in reclamation of low fertile saline soils. Farmers who adopted green manuring with Dhaincha was useful to reduced the fertilizers by15-20 % compared to other farmers.

3.35 In Situ Incorporation of Biomass and Crop Residues for Improving Soil Health

Major Climatic Vulnerability: Drought, High Temperature Stress, Flood and Heat Wave

Existing Practice

Generally, farmers burn crop residues like stalks of pigeonpea and cotton without recycling them. This is a great loss to the farmer as well to the land, as the land is deprived of biomass, which helps build precious soil organic carbon. This harmful practice is leading to increased CO_2 emissions besides depriving crop residue to the soil. Farmers resorted to burning of the crop residue as removing it involves higher cost for labour to uproot, chop and mix in the soil.

Resilient practice / technology

In order to encourage farmers to follow this practice, rotavator was introduced in the NICRA villages. The harvested crop stalks/stubbles are chopped into small pieces and incorporated *in-situ* into the soil with varying efficiencies depending upon the left over residue. The cost of implement was Rs 1.0 to Rs1.2 lakhs and field capacity of the rotavator is 5-6 ha/day. Rotavator helps in early seedbed preparation soon after harvesting of *kharif* crops for sowing of *rabi* crops. This not only requires low energy in tillage operation but also mixes and incorporates the stubbles of previous crop thoroughly into the soil. This improves the soil physical properties and hence, resulted in increased crop yield. Incorporation of green manuring crops such as dhaincha, moong and cowpea in wet conditions can be taken up to improve soil health.

Performance

On an average incorporation of cotton stalks in one hectare field adds about 124 Kg N, 36 Kg P_2O_5, with some quantities of Zn, S and other micronutrients into the soil. This results in saving of chemical fertilizers, labour and time. Residue or biomass incorporation improves water retention of soils and benefits the crop. This practice of *in situ* incorporation of crop residues can bring about reduction in harmful practice of residue burning which aggravates GHG emissions and air pollution. Rotavator use is gaining popularity in view of its multiple operation capabilities with greater efficiency. In NICRA villages the machine was made available through custom hiring centers for wider adoption by farmers of resource conservation practices for improvement of soil health and productivity.

Shri Sanjay Sawalkar, a farmer of Takali village, Amravati, Maharashtra cultivates about 2.4 ha of land out of which 0.8 ha is irrigated. He earlier practiced burning of cotton stalk after harvesting the crop. His average yield of seed cotton was 8.8 q/ha. In the next season tillage operations such as ploughing and harrowing with tractor mounted implements cost him Rs.2500/ha. Under the NICRA project he hired the rotavator from the custom hiring center for incorporating the crop residue in the field and spent around Rs.1750/ha for the operation. His average productivity in subsequent years increased by 2.7 q/ha.




Up scaling

In NICRA villages, *in situ* incorporation of paddy, wheat and cotton residues and biomass of green manuring crops was demonstrated in farmers fields across several districts of NICRA centers of Aurangabad, Amravati, Baramati, Gondia in Maharashtra, Kurnool in Andhra Pradesh and Nalgonda in Telagana states.

3.36 Performance of Seed Drills in Pigeonpea and Chickpea

Major Climatic Vulnerability: Drought

Existing practice

Pigeonpea and chickpea are important pulses grown in black soils of kurnool district of Andhra Pradesh. Traditionally these crops are sown with the help of gorru and bullocks. This involves high cost, less coverage and less precision and also low plant stand and poor yields.

Resilient Technology

Use of tractor mounted planter/seed drill reduces the cost of sowing, increases the coverage and also increases the precision. This tool improves the plant stand and eventually crop yields. These tools are developed and promoted by Acharya N.G. Ranga Agricultural University and also Central Research Institute for Dryland Agriculture (CRIDA) Hyderabad.

Performance

Keeping the principle of timeliness and precision in view, demonstrations with the use of tractor mounted seeding device along with farmers method i.e sowing with gorru were assessed with test crops of pigeonpea (PRG-158 and LRG-41) and chickpea (Nandyala Sanaga) in NICRA village of Yagantipalle during 2012-13. Farmers with use of tractor mounted planter realized higher seed yield (176 kg/ha) and higher net income (Rs 4073/ha) in pigeonpea compared to the use of bullock drawn seed drill. Adoption of tractor mounted planter reduced the cost of cultivation by Rs1119/ha than bullock drawn Gorru (Rs 18200/ha).

Performance tractor mounted planter on productivity and profitability in pigeonpea (2012-14)

Seeding devices	Yield (kg/ha)	Cost of cultivation (Rs/ha)	Net income (Rs/ha)	B:C ratio
Traditional gorru	1183	18200	27961	2.52
Tractor mounted planter	1259	17081	32044	2.88

Up scaling

The tractor mounted planter can be used in predominant rainfed crops like groundnut, chickpea and pigeonpea in similar domains of Kurnool, Anantapur and Kadapa districts to get economic and yield gains in Andhra Pradesh. This instrument has the field capacity of 6 to 7 ha/day which enables covering large area in short span of time. The use of this instrument can be further popularized through custom hiring centers, KVKs and ATMA etc.,

3.37 Tractor Drawn Ananta Groundnut Planter for Scarce Rainfall Zone of Andhra Pradesh

Major Climate Variability: Drought

Existing Practice

Farmers use four-row bullock drawn local gorru for sowing of groundnut in this zone. The seed are dropped manually through seed bowl (Jadigam) which has four circular holes connected to a furrow through seed tubes. The manual dropping mechanism fails to ensure uniform seed rate and good plant stand. A pair of bullocks will complete 2 ha area in a day of 8 hours for sowing of groundnut with 4 tyne local seed drill. It costs about Rs 1200/- including hire charges of the bullocks and wages for 3 men labour. The field capacity of this drill is about 0.75 to 0.5ha/day.

Resilient Technology

The 8 row tractor drawn Ananta groundnut planter operates mechanically with a metering system. The inclined disc plate seed metering mechanism maintains correct seed to seed and requires recommended seed rate of 90 to 100 kg/ha. A 5cm width blade is fitted behind furrow openers to cover the furrows after the seed placement. The spring type cultivator fecilitates sowing stonyand slopy soils. The cost of the planter is approximately Rs 4500.

Performance

In order to enhance the vigor of seedlings, timely operations, precision of seeding, demonstrations were conducted in NICRA village of Anantapur planted from 2011-14. The traditional seed drill operated by the farmers was included as a check. The yield and economics of these seeding devices was recorded by the team members in all three years. The results over three years showed that farmers who used Ananta planter realized additional pod yield (176 kg/ha) and additional net income (Rs 5708/ha) and reduced the cost of cultivation by Rs 1150/ha than traditional seed drill.

Up scaling

The Ananta groundnut planter can be promoted in red soils of Anantapur. Kadapa and Kurnool districts of Rayalaseema region through custom hiring center, ATMA, watersheds, Food Security Mission and other developing projects of State and Central Governments.

3.38 Drum Seeding of Rice for Water Saving and Timeliness in Planting

Major Climatic Vulnerability: Drought and Floods

Existing Practice

Farmers cultivating transplanted rice in irrigated areas even though their area is dominated with rainfed agriculture. Labour availability in rice is one of the major bottleneck for timely transplanting in Paddy. The cost for transplanting is increasing day by day and thus profitability in this crop is diminishing. Water shortage at the time of transplanting leads to delayed transplanting and use of over aged seedlings with limited tillering capacity.

Resilience Technology

Drum seeding technique involves direct seeding of pre-germinated paddy seeds and drums made up of fibre material to dispense seeds evenly in lines spaced at 20 m apart in puddled and levelled fields. About 35 to 40 kg paddy seed is soaked overnight in water and allowed to sprout. The sprouted seed is air-dried in shade for sometime (<30 minutes) prior to sowing, for easy dispensing of seedlings through holes in the drum seeder. Excess water in puddled field is drained out ensuring the soil surface is moist enough. Drums are filled with sprouted seeds (3/4 th) and pulled across the field maintaining a steady speed for even sowing. Drum seeding in one ha area can be completed in 5 to 6 hours time by three persons compared to transplanting operation which requires about 30 to 40 man days.

Performance

Rice is the major crop in Nacharam village in Khammam district. Farmers cultivate long duration (145–160 days) rice varieties like BPT-5204, WGL-482 and JGL-18047. These varieties are usually sown in the nursery in mid June and transplanted in mid-July. Farmers use a seed rate of 75 kg/ha and face serious shortage of labour for manual rice transplanting. Initially in 2012, direct sowing with drum seeder was introduced to five progressive farmers in the village in 3 ha area and sowing was taken up during 2^{nd} and 3^{rd} week of July. Cost of cultivation came down by Rs10000/ha. Yield obtained ranged between 42 to 54 q/ha compared to 3500 to 4600 kg/ha with transplanted paddy. Increase in grain yield ranged from 13 to 28%. In 2013, farmers took up direct seeding both in *kharif* and *rabi* seasons. Drum seeded paddy was applied four irrigations (two less than transplanted paddy). Advantage in net income due to drum seeding ranged from Rs 13000-14000/ha in both the seasons and B:C ratio was higher (2.3 to 2.9) with drum seeding compared to transplanted paddy (1.5 to 2.0).

Up Scaling

Drum seeding on an average increased the yield 9 to 29% besides reducing the cost of cultivation by reducing the labour. The technology of drum seeding can be extended/ promoted through custom hiring services by establishing custom hiring centers by the rural trained youth. There is need to provide financial support to the rural youth through NABARD or with national Banks or Integrated rural development agencies or SFDA or TADA in the district.


3.39 Mechanical Transplanting of Paddy

Major Climatic Vulnerability: Floods

Existing Practice

Majority of the farmers in rice growing areas do transplanting with manual labour. This practice is costly. Further labour availability for transplanting is a problem when water release from canals or tanks was delayed. Many times the yield of paddy is reduced due to delay in transplanting because of labour scarcity. Thus traditional method of Mannual transplanting in paddy involves high cost, less coverage and less precision.

Resilient Technology

Mechanical method of transplanting by Cobatto/drum seeder machine helps in timely farm operations also helps to escape the crop from heavy rains at the early crop growing stages. This machine helps to reduce the cost of sowing/transplanting of paddy besides helping in precision.

Performance

Matsyapuri village in West Godavari district was adopted by KVK under NICRA project and it is at the tail end of irrigation channels and sowings were getting late due to late release of canal water which was resulting in delayed harvesting and harvesting was coinciding with the rains exposing the crop to the risk of losses. The team of KVK, Undi organized farmers participatory demonstrations in 15 ha area with involvement of 5 farmers. The comparisons included in demonstrations are use of cobalt machine transplanting/drum seeder and manual transplanting. Machine transplanted field was less lodged compared to manual transplanting. The cost of cultivation was also reduced by Rs 5750/ha.

Direct sowing of paddy with drum seeder and also direct broadcasting method was promoted in the village, so that nursery raising and transplanting time could saved and also avoid transplanting shock there by advancing crop duration by around 15 days. Yield of transplanted paddy was affected to an extent of 50% due to late release of canal water. Further the canal water was by and large in advocate during the period from panicle initiation to flowering stage. The other problems such as grain shattering due to low temperatures before harvesting and rains at the time of threshing also caused yield reduction. But in direct sown of paddy field, the harvesting was 15 days earlier than the transplanted paddy. This helped the crop escape from the rains at the time of threshing. As a result the yield was 15.4% more than transplanted paddy. This also saved costs in raising nursery and transplanting. The cost of cultivation was reduced @ Rs 6250/ha and saving irrigation water up to 40%. The farmers were impressed and coming forward to adopt the direct sown paddy method of cultivation with drum seeder and broadcasting during rabi season.

Up scaling

The transplanting machines like drum seeder or with other mechanical method of transplanted can be promotes through rural development agengies like NABARD and other National Banks and also agencies involved for rural development like SFDA.

3.40 Use of Planter for Higher Yields and Cost Reduction in Soybean

Major Climatic Vulnerability: Drought

Existing practice

Soybean is an important crop grown in rainfed black soils of Baramati district of Maharashtra. Traditionally farmers in this region sow the crop with bullocks which involves high cost, less coverage and less precision. Delayed sowing of soybean beyond first week of July results in severe yield reduction of the crop.

Resilient Technology

Improved method of seeding with tractor drawn planter increased the coverage and precision and also helps soybean for timely sowing in kharif season.

Performance

The KVK team of Baramati district organized farmers participatory on-farm assessment trails with use of tractor mounted planter and farmers method of bullock drawn seeding in 10 ha area with soybean as a test crop during 2011-13.

The results showed that use of tractor drawn planter reduced the time to cover one ha by 2.20 hours than traditional bullock sowings. The labour saved due to use of tractor mounted sprayer was 8 persons/ha. The total cost of seeding with bullock drawn methods was Rs 2250 as against of Rs 1750 with tractor mounted seed planter.

Up scaling

These implements can be promoted through SFDA, Watersheds and projects related farm machinery and other development projects like Dryland development of Maharashtra in similar domains/districts.

3.41 Fodder Cultivars to Tackle Fodder Scarcity

Climate Vulnerability: Drought In Rainfed Areas

Existing practice

Adequate supply of fodder either green or dry is crucial to the livelihoods of farmers involved in animal husbandry. Livestock producers meet their fodder requirements through a combination of crop residues, grazing on community and private property resources (CPRs & PPRs), cultivable fallows and crop lands after harvest apart from cultivation of forage crops to a limited extent. In general, livestock farmers do not make special efforts for forage and pasture management during drought years. This leads to severe fodder crisis, which ultimately forces distress sale of valuable animals for slaughter. Early season drought reduces the area under fodder crops, whereas mid-season drought impacts fodder availability especially during lean period. Terminal drought has much less effect on fodder production but it affects the availability of seed material for the succeeding year. The most significant effect on fodder crops during drought conditions are reduced forage yields and greater extent of lignification due to low soil moisture. Further, grazing on such areas severely damages the crop stand and affects their revival even if some rains are received during later period. This is essential for targeted increase in production through feeding and to take up appropriate measures required to provide better nutrition to animals during drought period. The critical need is to build proper feed and fodder reserves to tackle the shortages in low rainfall years.

Resilient practice/Technology

Short and medium duration fodder cultivars of several crops that can withstand up to 2-3 weeks of exposure to drought in rainfed areas were demonstrated in NICRA villages. These include: Sorghum (Pusa Chari Hybrid-106 (HC-106), CSH-14, CSH-23 (SPH-1290), CSV17; Bajra (CO-8, TNSC-1, APFB-2, Avika Bajra Chari (AVKB-19), Maize (African tall, APFM-8). These cultivars can be sown immediately after the rains under rainfed conditions in arable lands during *kharif* season and are ready for cutting by 50-60 days. Cultivars of *rabi* crops like Berseem (Wardan, UPB-110) and Lucerne (CO-1, LLC-3, RL-88) were demonstrated in NICRA villages as second crop with the available moisture during winter. Perennial fodders like APBN-1, CO-3 and CO-4 were also demonstrated under limited irrigated conditions.

Performance

Demonstration on potentials of improved varieties of fodder crops were conducted in different NICRA villages of Andhra Pradesh, Telangana and Maharashtra states. Improved varieties of Tanjania grass, SSG-1 and APBN-1 gave 3-4 times higher productivity compared to traditional cultivars in NICRA villages of Khammam and Nalgonda districts respectively in Telangana state. Improved variety SSG-59-3 in Anantapur district of Andhra Pradesh gave 12 t/ha of additional fodder over traditional variety (106 t/ha). Similarly multicut variety Rasila and Devagan (Ahmednagar), African Tall in maize (Amravati) and Lucerne RL-8 recorded double yields over their respective locals in NICRA villages of Maharashtra. The multicut perennial fodder varieties like Co-4, DHN-6, and Jayant were useful to supplement fodder during summer with little irrigation in Ahemadnagar district of Maharashtra.

Up scaling

Availability of suitable varieties of fodder seed for delayed planting situation is a serious constraint for implementation of contingency plans in districts experiencing deficit rainfall. Solution lies in the promotion of seed production of short duration cultivars (cutting at 50-60 days duration) and medium duration varieties (60-75 days). Effective linkages and coordination among the state animal husbandry department and state veterinary universities is highly desirable for implementation of a successful seed production plan well in advance. Strengthening of scientific storage infrastructure is warranted. Scope exists for promotion and up-scaling of short and medium duration varieties of fodder in the rainfed areas in Andhra Pradesh, Telangana and Maharashtra states.

3.42 Fish Production Technology to Reduce Mortality in Coastal Areas

Major Climatic Vulnerability: Floods

Existing Technology

The farmers of Matsyapuri village are practicing aquaculture and they were incurring heavy losses by fish farming due to sudden mass mortality of fish during monsoon season. Farmers used to think this is because of some disease and applied medicines for the fish without any effect.

Resilient Technology/Practice

When the climate is cloudy or rainy, fish wander near the surface of water and die. This is the indication of reduced dissolved oxygen (D.O) levels (< 5 PPM) in the fish ponds. Fish wander near the surface of water due to suffocation. At this stage immediately dissolved oxygen levels need to be increased to minimum 5 PPM and above by application of prescribed chemicals or changing water or turning (recycling) water.

Performance

At this stage KVK scientists created awareness among the fish farmers that fish wander near the surface of water due to increased water P^H (> 8.5), reduced dissolved oxygen levels (< 5 PPM) or accumulation of ammonia in the pond water. When the climate is cloudy or rainy, fish wander near the surface of water and die. This is the indication of reduced dissolved oxygen levels (< 5 PPM) in the fish ponds. Fish wander near the surface of water due to suffocation. At this stage immediately dissolved oxygen levels need to be increased to minimum 5 PPM and above by application of prescribed chemicals or changing water or turning (recycling) water. For this water quality monitoring kits were supplied to 20 farmers of around 40 ha of fish pond area during Aug-Sep 2011 and conducted method demonstrations on checking and maintaining water quality of fish pond on daily basis. The farmers started adopting the technology and there was no report of mass mortality till date during rainy and cloudy weather conditions, in the fish ponds where quality of water is maintained. Mass mortality of fish in the fish ponds was reported where the above technology was not used.

3.43 Captive Rearing of Fish Seed-A Livelihood Opportunity in Flood Prone Areas

Climate Vulnerability: Floods, Cyclone

Existing practice

Availability of quality stock size fingerlings of freshwater fish species for stocking in tanks has been a limiting factor for fish production in the panchayat/community tanks. Fisher folks face difficulty in procurement of quality fingerlings in required numbers which have to be transported over long distances which often results in poor survival besides increasing the cost of fingerlings. Changes in rainfall pattern cause uncertainty in releasing fish seed on time into community tanks and sometimes results in loss of stocked fish seed due to floods.

Resilient Practice/ Technology

Captive rearing of fish seed i.e. rearing of early stages (Spawn to fry and fry to fingerling stages) through appropriate feed and health management in nursery pond was demonstrated in Sirusuwada village of Srikakulam district, Antdhra Pradesh. Required training for captive rearing was provided to the fisher folk by the KVK.

Impact

Sri Chekka Sanyasi and three other fishermen of Sirusuwada (NICRA village) practiced fresh water fish culture with Indian Major Carps in Jagannatha Naidu tank spread over an area of 25 acres during August-September and about 8 acres water spread during February-March. Earlier these farmers used to stock the tank with fish seed at fry stage of 2-3 cm size brought from the local fish seed farm which resulted in poor survival and inappropriate stocking ratios. Cost of fingerling of size 6-8 cm was high (Rs 1.5 to 3.0). During 2013-14, few farmers were identified and trained in nursery rearing of fish seed at fry stage in nursery pond. They were supported with fish seed at fry stage and the feed material. About 25000 numbers of fish seed at fry stage were released on 8thAugust, 2013 in 25 x 25 Sq.mt nursery pond. Rearing to fingerling size was done for 29 days and harvested on 6 th September to release into the village tank. The main learning for the fishermen was on acclimatization of fish seed before stocking and feed made up of rice bran and groundnut cake (1:1 ratio) and on regular sampling for monitoring the growth and health of fish seed. By this technology farmers saved about Rs.10500 on cost of fish seed. This attracted other farmers to adopt the technology in the village.

Economics of captive rearing of fish seed

Particulars	Cost (Rs)
Cost of fish seed (25000 No's)	9500
Feed cost	1500
Labour charges	1000
A) Total cost for captive rearing per month	12000
B) Cost of fingerling at market price @ Rs1.50 for 15000* fingerlings	22500
Net saving (B-A) (Rs/unit)	10500

**calculated based on survival of fish seed to fingerling size in nursery pond estimated @60%*

3.44 Village Level Seed Banks to Combat Seed Shortages

Climate Vulnerability: Drought, Flood

Existing practice

Seed shortage of suitable crop varieties is an important limitation faced by farmers to implement contingency crop plans to tackle aberrant rainfall situations. In vulnerable areas, farmers tend to dispose-off the entire produce as grain and therefore depend on external sources for seed supply in the next season. In crops where the seed multiplication ratio is low, seed rate and seed cost are high (e.g. soybean and groundnut) and this dependence entails significant investment towards seed cost at the start of the season. Early season drought and need for re-sowing will exacerbate the hardship faced by farmers.

Resilient Practice / Technology

Good quality seed enhances vigour, ensures better germination, exhibit good genetic quality, yield potential and respond positively for both biotic and abiotic stresses. Availability of good seed is the biggest constraint among the farming community in the villages. Seed banks play an important role to meet the challenge of improved seed production by the farmers' right in the village and make them available to the neighboring farmers in same or surrounding villages. Keeping this situation in view, the concept of seed bank was initiated in different NICRA centers.

Performance

Participatory village level seed production of short duration, drought and flood tolerant varieties was demonstrated in several NICRA villages with the support of KVKs in rice, soybean, groundnut, greengram, finger millet, foxtail millet and pigeonpea. Breeders seed/foundation seed was sourced from research farms for multiplication in farmers fields and the quality seed so produced was mostly used in the village and nearby villages. Farmer to farmer sale as truthful seed was the means of spread. The basic steps followed in establishment of village seed banks are:

- Identification of seed problems related to supply, demand of various crops for seed production through base line survey
- Creation of awareness programmes on village seed Banks and participatory seed production at village/cluster of NICRA villages
- Constitution of village level committee to seed banks for proper functioning and monitoring the progress of work
- Identification of commodity groups for farmers. i.e. formation of crop based voluntary groups for seed production of demand driven crops
- Imparting skills to the participatory seed producers through KVKs

- Procurement of breeder/foundation seeds from SAUs/ICAR institutes in advance before starting the activity of seed production
- Agreement between participatory seed producers and seed bank in terms of selling/depositing seed at fixed price at village level
- Monitoring the progress of seed production in the village by already set committee of the Bank
- Distribution/selling of demand driven seeds after verifying the quality to the customers
- Organizing village level seed bank committee to monitor the progress of work and solve the issues/services at least twice/thrice in a year.
- Presentation of performance of seed bank to the members of village seed Bank at least twice in a year

Outcome/Impact

Nalgonda

In Nalgonda district, the farmer groups with facilitation of KVK scientists procured foundation seeds of pigeon pea (PRG-158), green gram (LGG-460), maize (SIRI-4546) from the research organizations like ANGRAU and ICAR during 2012-13. Need based training to the farmers was provided by the KVK. Spot guidance was also provided to the farmers during crop season. Farmer groups in the village produced 5.4 tons of PRG-158 (Redgram), 3.8 tons of LGG-460 (green gram), 13 tons of SIRI (Maize). All the improved seed produced by the growers stored in a place by following suitable storage methods. They fixed the price after considering cost of production and sold to the farmers of the village and also to the farmers from neighboring villages.

Ahmednagar

The base line survey and PRA exercises made earlier in NICRA villages of Ahmednagar district showed that availability of good quality seed (soybean and chickpea) is a problem in village. Soybean variety JS-335 has been sown year after year in this village. Farmers got awareness of a new variety JS-9305 which has the characteristics like drought resistance, wilt resistance, short duration, clubbed with good yield potential. KVK scientists interacted with the farmers and initiated discussion on how the problem of seed can be solved. Some farmers in the village came forward and showed interest to produce the good quality seed. Thus the concept of seed bank (*Gramina seed bank)* was initiated in the village in 2012-13. About 33 farmers became members of Gramina seed bank. They assessed the seed demand of improved varieties of crops. Farmers having interest for seed production were made into commodity groups of soybean and chickpea and trained in seed production techniques. KVK organization made efforts to bring foundation seed of JS-9305 (990 kg) and chickpea (990 kg) from the Agricultural University and State Seed Corporation agencies. The scientists of KVK provided spot guidance in the field. They produce 26.4t good quality soyabean seed of JS-3905 and also 28.05t of JAKI -9218 of chickpea. The committee procured1.5 tons of improved seed of soybean and 2.76 tons of chick pea and stored in seed bank. The seed producers of soybean and chickpea invested Rs.5.08 lakhs and realized 13.8 lakh with sale of improved seeds.

Nandurbar

The issue of seed bank was come out as a result of discussion in the Gram Sabha (NICRA village of Nandubar district) regarding availability of improved seeds within stipulated period. A committee of two VCRMC members has been constituted to look after the functioning of seed bank. The assessment of demand for improved seed was done in the VCRMC meeting. Procurement of improved varieties was done after assessment of the demand. Improved seed of ICPL-87 in pigeonpea (100 kg) and Digvijay in chickpea (300 kg) were procured from the Agricultural University and ICAR institutes. These seeds were given to the farmers of the NICRA village for seed production under the guidance of KVK. The centre realizes the amount of Rs.13300 due to the sale of seed from the seed bank. Thus the seed bank gained net income of Rs 2800.

Seed bank was established in this village in 2011. Mostly seeds of Jowar and wheat are produced under the seed bank activity. Seed processing and certification is done by KVK Pune. The Village Climate Risk Management Committee (VCRMC) established in 2011 is looking after this activity. The centre procured improved variety Phule Anuradha of sorghum (80 kg) and Netravati of wheat (160 kg) from research organizations of ICAR and SAU as per the demand of the farmers of the village. Four farmers from the village are involved in the seed production activity. The participating farmers produced and handed over 2.3 tones of improved seeds of wheat and sorghum to the seed bank

Mode of up scaling

Use of farm saved seed is predominantly the means of absorbing the risk associated with contingency situations arising on account of delay in onset of monsoon or in situations warranting re-sowing of crops due to failure of rains immediately after sowing in low rainfall areas. Under the technology demonstration component, NICRA KVKs conducted participatory demonstrations with identified varieties of crops in NICRA villages. Based on the performance of these varieties, seed production was encouraged at the village level. The crucial challenge for NICRA KVKs was to identify the appropriate varieties of crops suitable for meeting location specific contingency situations. Support from the central schemes for establishment and maintenance of seed banks by state seed corporations and the seed village scheme is to be tapped in the ensuing period.

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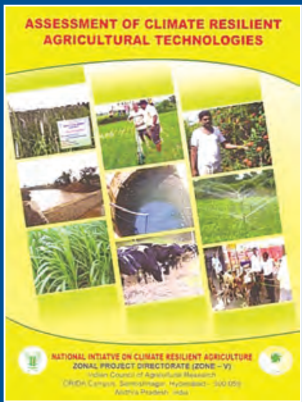

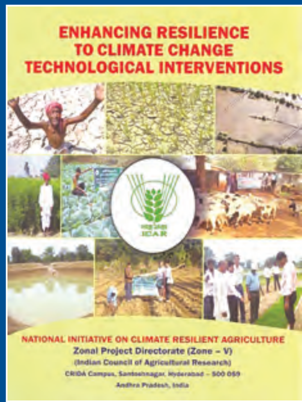

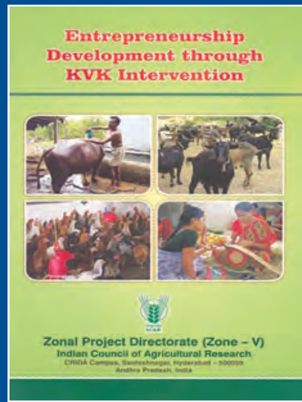

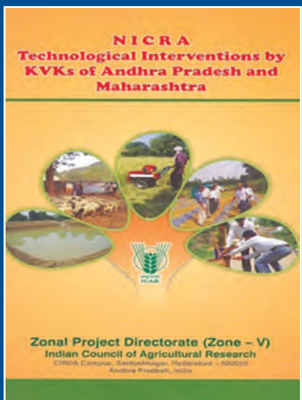

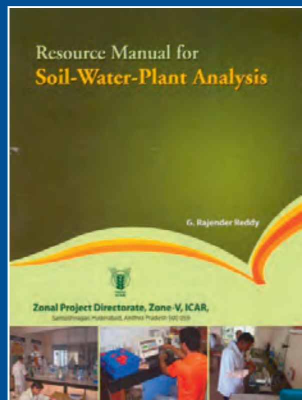

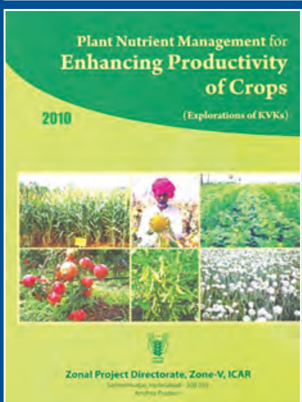

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