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Productive and Profitable Management of Rainfed Lowland Rice Area Through Intensive Cropping and Efficient Water Use

GOURANGA KAR, RAVENDER SINGH, HARSH NATH VERMA

WATER TECHNOLOGY CENTRE FOR EASTERN REGION

(Indian Council of Agricultural Research)

Chandrasekharpur, Bhubaneswar - 751023, India

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PREFACE

The challenge before the rainfed rice farmers of eastern India is to transform rainfed farming into more sustainable and productive system through efficient use of existing natural resources. This calls for integrated and holistic development of rainfed area by promoting effective in-situ water utilization, rainwater conservation for providing supplemental irrigation to second crops and proper residual soil moisture management. The medium and lowland rainfed rice area constitutes 12.9 mha in eastern India which are relatively heavier in texture, slightly acidic to neutral in soil reaction and have better moisture holding capacity though able to support a good second crop are mostly kept fallow after rice, except in some areas where relay cropping with lathyrus, blackgram etc. is being practised. During the rainy season, on such land, rice is grown with traditional cultivation practices and most of the rice varieties under cultivation are of comparatively longer duration and consequently, land does not become available when sufficient residual soil moisture is found in the field (November). Water becomes scarce for growing second crops in rainfed medium and lowland rice fallow during dry season (winter season) but the land can be brought under double cropping with proper utilization of carry-over residual moisture and runoff recycling. In addition to carry-over residual soil moisture in shallow lowland, water table contribution to supply crop water use to second crop may be important because soil upward flux or groundwater contribution to crops, dependent on water table depth. Keeping the importance of above aspects in view, the present study was aimed at improving productivity of rice during rainy season with improved cultivation practices and growing of second crop through runoff recycling and residual soil moisture management in rainfed medium and lowland rice fallow.

We take this opportunity to extend our deep sense of gratitude and indebtedness to the Director General, Deputy Director General (Natural Resources Management) and Assistant Director General (IWM), ICAR for their encouragement and guidance to carry out the study.

The authors are extremely helpful to World Bank authority for providing fund to execute on-farm research work through National Agricultural Technology Project. We are thankful to the Scientific Advisory Panel of Rainfed Agro-Ecosystem of NATP, Chairman Dr. J. S. Kanwar and its Director Dr. H. P. Singh, Dr. Y. S.Ramakrishna and members who designed the technical programme and monitored it. We sincerely thank PPSS Dr. B. Venkateswarlu and Dr. K. P. K. Vittal who undertook the responsibility of implementation of the programme through financial and technical support, facilitating the process of execution of World Bank funded NATP project. We also take this opportunity to extend our deep sense of gratitude and indebtedness to Dr. I.C.Mahapatra, former Vice Chancellor, OUAT, Bhubaneswar for reviewing the manuscript critically and making necessary suggestions of improving it. Authors sincerely thank Dr. R. S. Tripathy, lead PI, IGKV, Raipur for his proficient guidance and constant encouragement during the study period. We are grateful to different programme leaders, scientists of WTCER, Bhubaneswar for providing laboratory facilities for soil and plant analysis.

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EXECUTIVE SUMMARY

For profitable and productive management of rainfed lowland rice ecosystem through intensive cropping and efficient water use, different on-farm trials were conducted in a representative rainfed district of eastern India, i.e., Dhenkanal, Orissa. In this study on-farm adoptive trials were conducted to improve productivity of rainfed medium and lowland rice during *kharif* (rainy season) and to grow second crops after rice during *rabi* (winter) season through residual soil moisture management, limited irrigation scheduling after harvesting excess rainwater and utilizing soil water upward flux.

Though several on-station research were carried out to improve the productivity and cropping intensity of such land, the productivity of rice on these lands is low (average 2 t ha^{-1}). Vast rainfed medium and lowland rice area (about 12 mha) in the region remains fallow after rice because of poor adoption of improved technology.

Two types of medium land rainfed rice eco-system *viz.*, medium land with shallow water table and deep water table were selected for developing suitable rice based cropping system. In the medium land with deep water table rice cultivar of 120 days (Lalat) was grown from 1999-2002 with improved and farmers' management practices. Study revealed that 87.2 - 95.8% higher yield was obtained with improved practices than that of farmers' practices. During 1999-00 and 2000-01 after harvesting of rice on such land, five winter crops *viz.*, maize, sunflower, groundnut, wheat and potato were grown during *rabi*/ dry season with limited irrigation from harvested rainwater of existing pond in the village. With four supplemental irrigation, water use efficiency of 13.8, 3.85, 3.39, 5.85 and 28.7 kgha^{-1} mm^{-1} was obtained in maize, groundnut, sunflower, wheat and potato (tuber), respectively. The net return of Rs. 33,565, Rs. 47,940, Rs. 28,800, Rs. 30,650, Rs. 17,660 and Rs. 27,340 per hectare was obtained from rice-maize (grain), rice-maize (cob), rice-groundnut, rice-sunflower, rice-wheat, rice-potato, respectively with 4 irrigation to second crops. During *rabi*/ dry season of 2001-02 and 2002-03, five other winter crops *viz.*, linseed, safflower, mustard, chickpea and pea were grown by utilizing limited irrigation from harvested rainwater. Study revealed that with three irrigation, Rs. 17,765, Rs. 30,155, Rs. 19,690, Rs. 25,135, Rs. 22,885 per hectare net return was obtained from rice-linseed, rice-safflower, rice-chickpea, rice-pea and rice-mustard, respectively. The crop growth parametrs like leaf area index, biomass, rooting depth of different winter crops were measured with different levels of irrigation.

On the other hand, in medium land with shallow water table 37 - 58.1%, 36.9 - 55.6%, 34.4 - 52.7% and 38.1 - 51.9% of crop water requirements were satisfied through soil upward flux (capillary contribution) in groundnut, blackgram, greengram and chickpea, respectively. As a result with one or even no irrigation, economic yield was obtained from these crops in rainfed rice fallow with shallow water table. Study revealed that with one irrigation to second crops on such land, Rs. 29,375, Rs. 25,355, Rs. 23,085, Rs. 20,530 per hectare net return was obtained from rice-groundnut, rice-blackgram, rice-greengram and rice-chickpea, respectively. Whereas, net return from rice with farmers' management practices was only Rs. 6980 ha^{-1}.

In lowland rainfed area, rice (cv. Gayatri) yield of 5.31 and 4.85 t ha^{-1} was obtained under improved management practices in 2001-02 and 2002-03, respectively. Whereas under farmers' management 3.25 and 3.05 t ha^{-1} yield was obtained in two respective study years, which was 59-63 % higher than that of farmer's practices.

In rainfed lowland, rice fallow with farmer's traditional relay cropping system, only 350, 300, 400 and 220 kg ha^{-1} yield was obtained in lathyrus, blackgram, pea and chickpea, respectively. With two ploughings 68.5 %, 106.6 %, 67.5 % and 122.7 % higher yield was obtained in lathyrus, blackgram, pea and chickpea respectively over traditional relay cropping system. The total net return of Rs. 18,220 ha^{-1}, Rs. 21,620 ha^{-1}, Rs. 22,370 ha^{-1} and Rs. 19,670 ha^{-1} was obtained from rice-lathyrus, rice-blackgram, rice- pea, rice-chickpea, respectively when sowing was done after two ploughing.

Experiments on integrated nutrient management revealed that substitution of 25% NPK with Dhaincha (*Sesbania rostrata*) as green manures incrased rice grain yield by 35-48% in different study years over full inorganic fertilizers because green manures might have supplied other nutrients also.

The different recommended technologies based on on-farm research were disseminated by organizing farmers' fair, field days, farmers' training programme. The farmers of the study district have started to adopt the recommendations and the success story was also covered by different national and regional news papers.

1. INTRODUCTION

The rainfed area which constitutes about 63 % (89 mha) of the cultivated area of India accounts for only 40 % of the total food production, whereas 37 % (53 mha) of the irrigated area contributes 60 % to the national food basket.

Eastern India (Orissa, West Bengal, Chhatisgarh, Assam, Jharkhand and eastern Uttar Pradesh) is the rice dominated area of the country which covers 63.6% of the total rice area of India. About 78.7% (21.1 mha) of rice farming in the region is rainfed and only 21.3% (5.7 mha) is irrigated. Out of total rainfed rice area (26.8 mha) in the region, about 16% of the rice area (4.3 mha) is rainfed upland, 48% (12.9 mha) is rainfed medium and lowland (0-50 cm water depth) and the remaining 14.7% (3.9 mha) is deepwater or very deep water. For food and livelihood, farmers of the region are heavily dependent on the medium and low land rainfed rice ecosystem which constitutes 48% of the total rice area of eastern India. Though several on-station research were carried out to improve the productivity and cropping intensity of such land, the productivity of rice on these lands remained low (average 2 t ha^{-1}) and vast rainfed rice area (about 12 mha) in the region remained fallow after rice and adoption of technology being poor. The possible reasons are many. Farmers are either unaware of the new technology due to lack of proper extension activities or farmers are averse to the changes because they cannot afford the high input required by the new technology. The new technology has been developed for 'maximum productivity, rather than for 'maximum profit'. To overcome these problems, demand driven, problem solving and participatory on-farm research were conducted to increase productivity and cropping intensity of medium and lowland rainfed rice area of eastern India.

During rainy season, rice is grown on such land with traditional cultivation practices and most of the rice varieties under cultivation are of comparatively longer duration, not harvested at physiological maturity and consequently land does not become available when sufficient residual soil moisture is found in the field (in the November). Intensive cultivation and application of only inorganic fertilizers have deteriorated the soil physical properties of such land

and also sole inorganic fertilizer application created nutrient imbalance in soil, particularly micronutrients. As a result, farmers achieved less yield from rainfed lowland rice ecosystem. But integrated nutrient management (inorganic fertilizer + green manures/FYM or locally available compost etc.) not only supply the balanced plant nutrients but also improve soil health. Medium and lowlands are relatively heavier in texture, slightly acidic to neutral in soil reaction and have better moisture holding capacity, though able to support a good second crop with residual moisture and are mostly kept fallow after rice because water becomes scarce for growing second crops in rice fallow during winter (*rabi*/dry) season. But the land can be brought under double cropping through proper utilization of carry-over residual moisture, runoff recycling with improved soil and water management practices. In addition to carry-over residual soil moisture in shallow lowland, water table contribution to supply crop water use to second crop may be important in rainfed regions because soil upward flux or groundwater contribution to crops dependent on water table depth.

Besides, 80% of total annual rainfall (1000-2000 mm) of eastern India occurs within 4 southwest monsoon months (June to September) and most of it is not accessed and put into beneficial use before it evaporates or flows into sinks. Higher amount of rainfall with heavy downpour results in substantial runoff and flood in southwest monsoon period (rainy season) whereas, in other season (winter season) agricultural droughts of varying intensities limit the crop production potential of the region. In this pattern of rainfall, efficient capture and retention of rainfall during rainy season is essential to increase cropping intensity and productivity of rainfed rice area.

Keeping the urgent need of enhancing productivity and cropping intensity of rainfed, medium and low land rice area of eastern India through judicious use of existing natural resources, the present multidisciplinary research problem was conceptualized.

Approaches to increase productivity and cropping intensity of rainfed medium and lowland rice ecosystem include (i) technologies for enhancing the productivity and profitability of rainfed rice on such land during (*kharif*/rainy) season (ii) rain water harvesting during (*kharif*/rainy) season and its recycling during (*rabi*/winter) season to stabilize yield of second crops in rice fallow (iii) residual soil moisture management and precision agriculture.

1.1 Definition of medium and low land rainfed rice ecosystem

The rainfed medium and lowland rice ecosystems are defined as the ecosystems, which are bunded with accumulation of water depth of 0-50 cm (0-25 cm depth of water in rainfed medium land and 25-50 cm depth in rainfed lowland) but dependant on seasonal rainfall. Consequently, the water regime is variable during the life cycle of rice in such land and water may be in excess during the peak of the wet season, or in deficit during no rainfall. The lack of control of the water ragime subjects the crop to extreme contrasts. The root system of rainfed rice may be developed in anaerobic conditions, but in subsequent drought, the shallow roots may face the challenge of extracting water and nutrients from deeper layers later in the season. Presently, rainfed medium and lowlands are monocropped and only one crop (rice) is taken during rainy season (*kharif*), though second crops (legumes, oilseeds etc.) can be grown during *rabi*/dry season (winter) through effective in-situ residual soil moisture utilization, runoff recycling and better crop-water management practices.

2. REVIEW OF LITERATURE

Based on the hydrology and topography of the land, rice area of the eastern India is divided into different ecologies *viz.*, rainfed upland, rainfed lowland, irrigated and hill rice. Out of total rainfed rice area in the region, 48 % (12.9 mha) is under rainfed lowland, which is dominated by rice during rainy season (Singh and Hossain, 2000) and in other seasons, the land remains fallow.

Increased water use efficiency of field crops in the dry season was possible through proper irrigation scheduling by providing only the water that matches the crop evapotranspiration and providing irrigation at critical growth stages (Norwood and Dumler, 2002, Hunsaker *et al.*, 1996). Quantifying the root length growth is necessary for knowledge about water and nutrient extraction pattern of different crops at different depths, (Merril 1992; Merril 2002). Some earlier workers (Sarker *et al.*, 2000, Zaman *et al.*, 2000, Das 2000, Prasad *et al.*, 2000, Singh *et al.*, 2000) attempted to increase productivity and cropping intensity of rainfed rice area of eastern India with supplemental irrigation to second crops like wheat, barley, rajmash, sunflower, etc. in rice fallow, but the feasibility of growing some non-cereal crops in rice fallow is to be studied.

Field Water balance is commonly used to measure total water use or actual crop evapotranspiration (ETa) when lysimeter facilities are not available and it is found that ETa increases with the increase in number of irrigation from one to adequate (Prihar and Sandhu, 1987). Much is known about the crop water uses or water use efficiency of wheat using field water balance and/or lysimeter study in field experimental plots at various agro-ecological conditions of India (Prihar *et al.*, 1976; Singh and Sinha, 1987; Singh 1989; Sharma *et al.*, 1990; Tyagi *et al.*, 2000). But still actual water use and water use efficiency of some winter crops in eastern India are to be studied.

In addition to carry-over residual soil moisture in shallow lowland, water table contribution to supply water to second crop may be important in rainfed regions (Sepaskhah *et al.* 2003). Grismer and Gates (1998) reported that under arid condition, water table could supply as much as 60-70 % of crop water requirements. Sepaskhah *et al.* (2003) suggested a simple equation relating groundwater contribution to water table depths, q^0= a x bD, where, q^0 is the ratio of groundwater contribution (Gc) to actual evapotranspiration (ETa). This equation adequately describes the dependence of upward flow rates (Gc) on water table depths (D). The parameters "a" and "b" are empirical constants that depend on soil hydraulic properties. Similar studies were made by Shih and Rahi (1984) on lettuce crop and by Wallender *et al.* (1975) on cotton. Jhorar *et al.*, 2001 observed 153 to 203 mm soil upward flux in wheat crop grown in shallow water table (1.10 to 1.65 m). Where the water table is deep, there is need of irrigation for optimum crop production while the shallow water table can supplement irrigation through water movement to root zone (Jat and Das, 1978).

Several research workers observed the beneficial effects of integrated nutrient management in rice based cropping system. Inorganic nitrogen sources, when applied in combination with organics are better utilized than inorganic alone (Saravana *et al.*, 1987; Budhar *et al.*, 1991 and Rajput, 1995). Puste *et al.*, (1999) found application of 75% of the recommended dose of fertilizer (N:P:K:: 60:30:30 kg ha^{-1}) along with 10 tha^{-1} FYM or crop residues produced the highest grain-yield (3.26 tha^{-1}) of rice during *kharif* (rainy season) and subsequently seed yield of linseed, safflower and niger during *rabi* (winter season).

2.1 Prodcution constraints identified through diagnostic survey for low productivity and cropping intensity in medium and low land rainfed rice area

The present production constraints for low productivity and cropping intensity of rainfed medium and lowland rice areas are categorized under the following heads.

2.1.1 Biophysical Constraints

- Delay in the onset of southwest monsoon often leading to delayed and prolonged transplanting and sub-optimum plant population.
- By growing the crop in bunded fields to impound rainwater, farmers sought to capture the advantages of the irrigated system for weed control and nutrient availability. But lack of control of the water regime subjects the crop to extreme contrasts. Intermittent moisture stress occurs due to low and erratic rainfall in Chhatisgarh and eastern Uttar Pradesh. Flash floods, waterlogging/submoisture occurs due to poor drainage, high rainfall and low-lying physiography in West Bengal, Assam and some parts of Jharkhand, Orissa.
- The drought-submergence-drought conditions in rainfed lowland rice ecosystem create adverse conditions for extracting water and nutrients from deeper layers.
- Low fertility due to low and imbalanced use of fertilizers. Accumulation of toxic decomposition products in ill-drained soils, encouraging problems of iron toxicity.
- Heavy infestation of weeds (*Echinochloa crus-galli, Cyperus difformis, Commelina benghalensis*), pests (leaf folder, plant hopper caseworm, stem borer) and diseases (bacterial leaf blight sheath blight, sheath rot, stem rot, blast, brown spot).
- The 80% of total annual rainfall is confined to four southwest monsoon months (June-September) only, as a result the non availability of water during dry season (*rabi*/winter) mainly restricts the cultivation of second crops in rainfed rice fallow.

2.1.2 Technological Constraints

- Poor crop stand due to broadcast seeding, resulting in uneven germination of rice during wet season (*kharif*).
- Continuous use of traditional long duration varieties due to the non-availability of improved seeds.
- Imbalanced dose of fertilizers, lack of integrated nutrients, weed or pest management practices.
- Near absence of green manuring or green leaf manuring and lack of availability of organic matter/compost.
- No corrective measures for Zn deficiency or the toxicity.
- No proper application of technology for utilizing carry-over residual soil moisture to grow second crops during post-rainy (*kharif*) season (*rabi*, winter).
- Non harvesting of lowland rice at physiological maturity, delayed harvesting causes shortening of period for growing second crops utilizing carry-over residual soil moisture. Land does not become available when sufficient residual soil moisture is found in the field.
- Lack of concept about soil water upward flux under shallow ground water situation which may contribute significant amount of soil moisture to second crops in rice fallow.

- In rainfed lowland areas, especially with puddled transplanted conditions, establishment of succeeding crops in the cropping pattern is a major problem faced by farmers.
- Though in some areas lathyrus, blackgram, mustard etc. are grown after rice in rainfed low land rice fallow but that too, under exclusively relay cropping/utera system. The practice is to broadcast seeds on the soil surface with or without fertilizer atleast 12-15 days before harvesting of rice. The poor germination and uneven plant stand results in very low productivity of second crops (1-2 q ha^{-1}) in rainfed medium and lowland rice fallow.

2.1.3 <u>Socio-economic constraints</u>

- Non-availability of inputs and high yielding varieties at proper time due to non- synchronous delivery of credit, input and technology.
- Dominance of marginal and small farmers, lack of resources and low literacy levels for adopting improved cultivation or technology. Traditional cultivation results in low yield of rice with low cropping intensity in rainfed medium and lowland rice area.
- Non-availability of proper production and protection technology for improved rainfed farming in medium and lowland rice ecosystem.
- High cost of cultivation compared to value of produce and distressed sale of rice at non-remunerative prices.
- Lack of modern agricultural implements like tractor/power tiller, seed drill, seed cum fertilizer drill on custom hiring for ensuring timely agricultural operation reducing drudgery of farmers.

2.1.4 <u>Administrative/Institutional constraints</u>

- Lesser minimum support price than market prices or wholesale market price indicating that the farmers are not getting the real price for their produce, which they should otherwise get.
- Non-synchronous delivery of credit, input and improved water and crop management technology, as a result of which farmers get very little time for precision farming.
- Poor linkages between research-extension-farmers-market. Lack of field demonstration or frontline demonstration of improved production and protection technology.
- Inadequate extension literature, non-functional village extension agents, near absence of mini but many small demonstrations.
- Improper implementation of crop insurance scheme.

Keeping the above constraints and prospects of rainfed lowland rice ecosystem in view, the following options may be prioritized for improving productivity of rice during wet *(kharif)* season (June to November/December) and for growing other crops after rice during *(rabi)* season (November/December to March/April).

3. PRIORITIES TO IMPROVE PRODUCTIVITY AND CROPPING INTENSITY OF RAINFED LOWLAND RICE AREA

3.1 Technology Option

- Ensuring optimum plant population of rice during wet/*kharif* season through appropriate crop establishment practices and in case of direct seeding, seed should be placed at proper depth.

- Application of balanced dose of fertilizers, integrated nutrient management practices including green manures, inclusion of legumes in the cropping system
- Keeping the field free from weeds upto 45 days after seeding/transplanting and adopting integrated weed management.
- Selection of suitable high yielding rice varieties (115-120 days duration in medium land and 145-150 days duration in lowland) and harvesting at physiological maturity to make available more residual soil moisture to second crops.
- Improved in-situ water management practices like checking of runoff water in community reservoirs, ponds or runoff interception trenches for harvesting of excess water during wet (rainy *kharif*) season.
- Enhancement of profile recharge by improving in-filtration through deep ploughing, summer ploughing etc.
- Growing of second crops after rainy (wet/*kharif*) season rice as per the suitability of soil moisture, runoff water for recycling, groundwater table situation, soil texture, economic situations of the farmers.
- Development of proper seeding/tilling methods for establishment, better growth and development of second crops which will overcome the problems associated with utera-cropping system.
- Conservation of carry-over residual soil moisture for enhancing water use efficiency of succeeding crops. Locally available organic mulch material may be used for this purpose.
- Adoption of integrated pest management like growing of resistant variety, crop rotation, biological controls etc. and using agro-chemicals only when absolutely necessary.

3.2 Policy option

- Proper linkage should be developed among research scientists, extension specialists, farmers and markets for proper adoption of technology and fetching good return.
- Synchronization of credit, input and technology under one umbrella at Panchayet level which will ensure precision farming by saving farmers' valuable time and energy.
- Incentives to be provided for development and establishment of small scale processing mills at village Panchayat level for producing value added products from diversified cropping system like processed 'dal' from pulses, 'oil' from oilseeds and 'pop corn', 'corn flakes', 'flour from maize etc. The maize grain can also be used as poultry feed in integrated farming system.
- All pulses, oilseeds or low water requiring cereals-millets should be covered under minimum support price.
- Implementation of crop insurance scheme by the Government for all oilseeds, pulses and low water requiring cereals and pulses.
- Trifurcation of existing Technology Mission, each on oilseeds, pulses and maize etc.

4. NATURAL RESOURCES OF THE STUDY AREA

Keeping the above constraints and priorities for improving productivity and cropping intensity of medium and lowland rice area in view, some of the research and policy options were prioritized and on-farm adaptive research was conducted in one of the representative rainfed districts of Orissa i.e. Dhenkanal. Orissa. (Figure-1). According to NARP classification (1979), the study area belongs to Mid Central Table Land Zone of Orissa. The cropping intensity of the district is low (only 145 %). In regard to crop husbandry practices during rainy season, 96 % of the cultivated area is dominated by rice (*Oryza sativa* L.) and rest 4 % is under different crops like groundnut, maize, greengram, sesamum etc.

Photo-1: Dr. I.C.Mahapatra(ex-Vice Chancellor, OUAT), Dr. P.K. Mahapatra (HOD, Agronomy, OUAT), Dr. H.N. Verma, Dr. G. Kar (P.I.) discussing bio-physical constraints of the study village

Photo-2: Dr. H.N.Verma (Director, WTCER) and Dr. G. Kar (P.I.) collecting the opinion of farmers for improving productivity of rainfed rice area

Photo-3: Dr. R.S.Tripathy, Director, IGKV, Raipur suggesting some strategies for the successful adoption of improved technologies

During *rabi* (dry/winter season, November to March), the vast rainfed rice area remains fallow inspite of having favourable natural resources, human labour and market option. The spatial distribution of different natural resources of the study area has been prepared using GIS tool and are depicted in Fig. 2, 3, 4, and 5. (*Hardcopy map source : NATMO, Calcutta*)

5. NORMAL WEATHER

The normal weather conditions of the study area are given in Table-1(a). The mean monthly maximum temperature ranges from 46.2 °C in May to 29.4 °C in December. On the other hand, mean minimum temperature varies between 24.6 °C in July to 9.0 °C in December. The mean total annual rainfall is 1440 mm and 80% of it occurs during the southwest monsoon period (June- September). The reference crop evapotranspiration of the region varies from 8.7 mm in May to 3.3 mm in December. The mean date of onset of effective monsoon (OEM) was found to be 15th June and southwest monsoon generally ended on 27th September. The earliest and latest probable dates of OEM were found to be 1st and 20th June respectively, the earliest and latest probable dates of monsoon withdrawal were worked out to be 15th September and 05th October, respectively (Kar *et al.*, 2003). The pre-monsoon shower may occur between 16th-19th weeks, making off-season tillage and preparation of seed beds for rainy season rice feasible then. Rainfed rice can successfully be gown in medium and lowland from the 25th - 38th week at 70 % (dependable) probability level. The weekly water balance of the study region reveals that total annual potential evapotranspiration (PET) and actual evapotranspiration (AET) were 1536.4 mm and 800.4 mm, respectively.

Figure-1: Location of experimental site

Fig.-2: Existing land use map of study district (Dhenkanal)

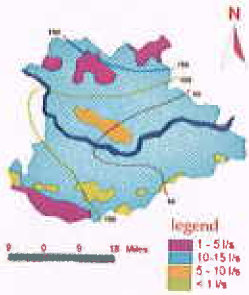


Fig.-3: Ground water potential map of study district (Dhenkanal)

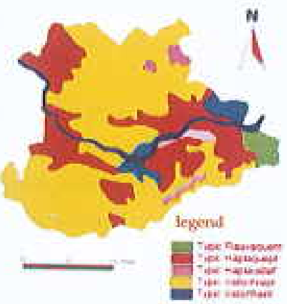


Fig.-4: Soil map of study district (Dhenkanal)

Fig.-5: Rocks and minerals of study district (Dhenkanal)

5.1 Computation of runoff depth for assessing rain water harvesting potential in the region

The *kharif*/wet (rainy) season of the region is confined to Southwest Monsoon period (June-September) within which 80% of total annual rainfall occurs. The excess rainfall is not accessed and put into beneficial use before it evaporates or flows into sinks but efficient capture and retention of excess rainfall during the rainy season is essential for creating supplemental irrigation source to the second crops in rice fallow during dry / *rabi* (winter) season. The SCS runoff curve number method has been employed for computing runoff depth to assess water harvesting potential of the region.

$Q = \frac{(P - 0.2\,S)^2}{P + 0.8S}$, $P \geq 0.2S$, where Q = actual direct runoff, P = total storm rainfall,

S = potential maximum retention. P,Q and S are expressed in the same units e.g. centimeters or inches or milimiters

$S = \frac{2540}{CN} - 25.4$, In which CN is the runoff curve number (dimensionless) and S is in centimetres.

Table 1 (a) : Mean monthly major weather parameters of study area, Dhenkanal (Lat. 20^0 40' N. Long. 85^0 36' E., Height. 139 m. above m.s.l)

Month	TMAX (°c)	TMIN (°c)	MH (%)	AH (%)	RET (mm)	Rain (mm)	Wind (km/hr)	Av. VP (mb)	Av. AP (mb)
January	30.9	9.7	75	47	3.5	15.5	4.8	14.05	999
February	36.5	10.0	70	38	4.6	17.2	5.8	14.3	997
March	38.7	12.7	66	33	6.1	25.4	6.6	15.3	994
April	44.6	20.6	64	34	7.8	37.5	8.1	19.7	991
May	46.2	21.5	65	39	8.7	64.8	9.6	24.3	986
Jun	42.0	23.6	73	60	6.7	263.6	9.3	27.85	983
July	35.7	24.6	82	77	4.7	369.1	8.2	30.05	984
August	38.0	23.4	83	79	4.6	281.6	7.2	30.35	985
September	33.6	23.4	83	77	3.7	220.6	6.3	29.9	988
October	33.8	18.6	80	67	4.4	93.6	5.5	25.7	994
November	32.2	11.5	74	53	3.6	25.2	4.5	18.2	998
December	29.4	9.0	73	48	3.3	4.5	5.0	14.4	1000

Source: Climatological Table, IMD, New Delhi (based on 1951-1980 data)
**Reference evapotranspiration (RET) was computed using FAO Penman-Monteith method (1998)*
MH = morning humidity, AH = afternoon humidity, VP = vapour pressure, AP = atmospheric pressure, mb=millibar

Table 1 (b) : Runoff (mm) at different probability levels with actual runoff (mm)

Month	Runoff at probability (mm)				Actual runoff (mm) during study years			
	10%	25%	50%	75%	1999	2000	2001	2002
Jun	150	131	89	81	145	104	124	95
July	153	169	129	101	153	145	228	104
August	201	153	139	97	123	99	137	93
September	195	161	141	102	153	102	134	95
Total	699	614	498	381	432	451	625	387

The runoff was collected in an existing pond of the site during the wet season (*kharif*) and recycled to provide supplemental irrigation to second crops in rainfed rice fallow in dry season (*rabi*). The computed runoff at different probability levels with actual runoff during the study years (1999-2002) area given in Table 1(b).

6. WATER AND IRRIGATION REQUIREMENTS OF MAJOR WET (*KHARIF*) AND DRY (*RABI*) SEASON CROPS IN THE REGION

Studies of crop water requirements under local conditions provide the base to improve crop planning and efficient irrigation management in many field crops. For most agricultural crops, a relation can be established between evapotranspiration and climate by the introduction of the crop coefficient (Kc) which is the ratio of crop evapotranspiration (ETc) to reference evapotranspiration (ETo) (Doorenbos and Pruitt, 1979).

The reference crop evapotraspiration, ETo, was calculated to the FAO Penman-Monteith equation, ETo is the evapotranspiration rate from a hypothetical reference crop with an assumed crop height (12 cm), a fixed crop surface resistance (70 sm^{-1}) and albedo (0.23), closely resembling the evapotranspiration from an extensive surface of green grass cover that is of uniform height, actively growing, completely shading the ground and with adequate water supply. The FAO-Penman-Monteith equation, which is considered as latest standard method, has been used in this study for calculation of ETo (mm per day) (Allen *et al.*, 1998):

$$ETo = \frac{[0.408\Delta(R_n - G) + \gamma\, 900/(T + 273)\, U_2(e_s - e_a)]}{\Delta + \gamma\,(1 + 0.34\, U_2)}$$

Where Rn is the net radiation at the crop surface (MJ m^{-2} per day), G is the soil heat flux (MJ m^{-2} per day). T is the average air temperature (^0C), U_2 is the wind speed at 2 m height (ms^{-1}), (e_s-e_a) is the vapor pressure deficit (KPa). Δ is the slope of vapor pressure curve (KPa $^0C^{-1}$), and 900 is the conversion factor.

The water requirements of different important crops of the region were computed by multiplying the crop coefficient with reference evapotranspiration through CROPWAT 4.0 model and are depicted in Table-2. Irrigation requirements of crops were determined by subtracting the water requirements from effective rainfall. Crop coefficient curve was obtained by plotting Kc against crop age (Doorenbos and Pruitt, 1975). Effective rainfall was computed using USDA Soil Conservation Services methods.

7. MATERIALS AND METHODS FOR CONDUCTING ON-FARM TRIALS

7.1 Increasing productivity and cropping intensity of mediumland rainfed rice area of eastern India.

Based on water table depth, medium land rainfed rice area of the region can be divided into two categories *viz.*, (i) medium land with deep water table (ii) medium land with shallow water table. Presently both categories of land are dominated by rice during wet (rainy, *kharif*) season and remain fallow during dry (winter, *rabi*) season inspite of having favourable natural resources (rainfall, soil, hydro-geomorphology, topography) and labour. In the land with deep water table, capillary contribution is less, moisture depletion is very fast after harvesting rice, as a result growing of second crop in rice fallow on such land without supplemental irrigation is risky.

Table-2 : Computed water and irrigation requirements of some important crops in the study area

Crop	Crop water requirement (mm)	Effective rainfall (mm)	Irrigation requirement (mm)
Rice (autumn)	532	459.5	72.5
Rice (winter)	661	533.2	127.8
Rice (summer)	798	121.22	676.78
Maize (*kharif*/wet season)	405	512.8	0
Maize (winter/dry season)	386	30.5	355.5
Groundnut (*kharif*/wet)	464	526.5	0.0
Groundnut (*rabi*/dry)	441	31.69	409.31
Blackgram (*kharif*/wet)	405	496.5	0.0
Blackgram (*rabi*/dry)	381	24.5	356.5
Greengram (*rabi*/dry)	371	24.0	347.0
Linseed	286	17.89	268.11
Safflower	435	30.44	404.56
Mustard	365	21.4	343.6
Chickpea	359	30.5	328.5
Sunflower	430	49.5	380.5
Potato	508	29.3	478.7
Wheat	440	49.1	390.9
Pea	359	27.99	331.01
Pigeonpea (*kharif*/wet)	467	582.2	0.0
Cowpea (*kharif*/wet)	389	478.5	0.0
Sesamum (prewinter)	249	54.4	194.6
Horsegram (prewinter)	238	32.1	205.9
Sugarcane	1809	815.49	993.51
Millet (*kharif*/wet)	371	579.1	0.0

On the other hand in shallow medium land capillary rise is known to be a major source of meeting the water requirement of crops. Sepaskhah *et al.* (2003) suggested a simple equation relating groundwater contribution to water table depths, q0= a x bD, where, q0 is the ratio of groundwater contribution (Gc) to actual evapotranspiration (ETa), "a" and "b" are empirical constants that depend on soil hydraulic properties, D is the water table depth.

7.1.1 Increasing productivity and cropping intensity through rice based cropping system in medium land with deep ground water table utilizing limited irrigation.

Place of on-farm trial : Arnapurnapur village, Dhenkanal

Experiment-1: Improving productivity of rice during wet (rainy/*kharif*) season and performance evaluation of winter crops (maize, groundnut, sunflower, wheat, potato) in rainfed medium land rice fallow during dry (*rabi*)season with limited irrigation

Treatments :

During wet/*kharif* (rainy) season :
Rice (cv. Lalat) with improved (IP) and farmers' management (FP) practices

During dry/*rabi* (winter) season :
Crops: Maize (MZ), groundnut (GN), sunflower (SN), wheat (WH), potato (PO)
Irrigation: Two (I_2), three (I_3) and four (I_4) (from recycling of harvested rainwater in village pond)

- **Management practices adopted during *kharif* (rainy) season to improve productivity of rice**

The rice (*Oryza sativa* L.) variety 'Lalat' (120 days duration) was grown during wet/*kharif* (rainy) season in two study years following both improved and farmers' management practices to measure the increase in yield through improved practices over farmers' practices. The farmers' practices consisted of broadcasting, sowing, no control of pest and diseases, no intercultural operation or gap filling, and application of basal dose of 30:30:0 fertilizer (N:P:K) etc. Whereas, under improved practices transplanting was done with the spacing of 15 x 10 cm and gap filling was done at 20 days after transplanting. Weed was controlled through integrated weed management technique (Butachlor @ 1.5 lit/ha at 5 days after transplanting, DAT+one hand weeding at 35 DAT). Fertilizer was given in the ratio of 60:40:40 (N:P:K), 50 % N and full dose of P and K were applied as basal and rest 50 % N was applied during maximum tillering stage. Need based plant protection measure was also taken.

Photo-4: Growing of rainfed rice in medium land with traditional practices(bueshening)

Photo-5: Growing of rainfed rice in medium land with improved practices (transplanting with 10x15 cm spacing)

- **Management practices adopted during *rabi* (winter) season to increase cropping intensity**

During 1999-00 and 2000-01, five winter crops *viz.*, maize (cv. Novjyot), groundnut (cv. TMV-2), sunflower (BSH-1), wheat (cv. Sonalika), potato(cv. Kufri Jyoti),were sown during dry (*rabi*) season utilizing limited irrigation from harvested rainwater and carry-over residual soil moisture on 22th November, 1999 and 19th November, 2000 after the harvest of rainy season rice (cv. Lalat). (Layout is given in Fig. 6). The excess rainfall (runoff) was collected during rainy season in the existing village pond and recycled during dry (*rabi*) season for providing supplemental irrigation at critical growth stages (Table 4). Irrigation treatments were two, three or four irrigation and in each irrigation, 60 mm of water was applied through gated pipe from harvested rain water of existing pond. Plots were bordered to prevent runoff. The package of practices of growing these winter crops in rice-fallow is given in Table -4. The maximum root length, leaf area index and above ground dry biomass of different crops with different levels of irrigation were also recorded. The soil water content was measured gravimetrically once a week and soil water uptake pattern of different crops was studied based on moisture depletion at different layers.

	Rice with Improved Practice (I.P.)					Rice with Farmers' Practice (F.P.)				
I_2	MZ	SN	WH	PO	GN	MZ	SN	WH	PO	GN
I_3	GN	MZ	SN	WH	PO	GN	MZ	SN	WH	PO
I_4	GN	PO	MZ	SN	WH	GN	PO	MZ	SN	WH

Fig.-6: Layout of experimental plot of Experiment-1

Overall water use efficiency (WUE) was determined by dividing the grain yield by the water used (sum of soil water at planting - soil water at harvest + irrigation water + effective rainfall) and expressed as kg $ha^{-1}mm^{-1}$.

Table-3: Irrigation scheduling at different growth stages of winter crops (maize, groundnut, sunflower, wheat, potato) during 1999-00 and 2000-01

Irrigation treatments	Crops				
	Maize	Groundnut	Sunflower	Wheat	Potato
Two	Tassel initiation + grain filling	Peg initiation + pod development	50% flowering + grain filling	Crown root initiation (CRI) + jointing	Stoloniza-tion + tuberization
Three	Early vegetative + tassel + initiation + grain filling	Flowering + pod development + grain filling	Bud initiation + 50% flowering + seed development	Crown root initiation (CRI) + jointing + milking stage	Stoloniza-tion + tuberization + tuber bulking
Four	Early vegetative + tassel + initiation + silking + grain filling	Branching + pegging + pod develop-ment + seed filling	Secondary branching + Bud initiation + 50% flowering + seed development	Crown root initiation (CRI) + tillering + jointing + milking stage	early vegetative + tuberization + 50 % tuber formation + tuber bulking

Table-4: Package of practices for growing winter crops in medium land rice fallow during 1999-00 and 2000-01.

Crop	Variety	Spacing (cm xcm)	Fertilizer dose (N:P:K)	Date of sowing		Date of harvest	
				1999-00	2000-01	1999-00	2000-01
Maize	Novjot	60 x 30	80:40:40	22.11.99	19.11.00	18.03.00	16.03.01
Groundnut	TMV-2	30 x 20	20:40:40	22.11.99	19.11.00	23.03.00	20.03.01
Sunflower	BSH-1	45 x 30	60:60:30	22.11.99	19.11.00	26.03.00	25.03.01
Wheat	Sonalika	20 x 10	80:50:40	22.11.99	19.11.00	20.03.00	16.03.01
Potato	Kufri Jyoi	45 x 20	120:60:120	22.11.99	19.11.00	10.03.00	07.03.01

<u>Exeriment-2</u>: **Improving productivity of rice during *kharif* (rainy) season and performance evaluation of winter crops (linseed, safflower, mustard, chickpea and pea) during dry (*rabi*) season with limited irrigation**

<u>Treatments :</u>

During wet/*kharif* (rainy) season :
Rice (cv. Lalat) with improved (IP) and farmers' management (FP) practices

During dry/*rabi* (winter) season :
Crops: Linseed (LN), safflower (SF), chickpea (CP), pea (PE), mustard (MU)
Irrigation: One (I_1), two (I_2), and three (I_3) (from recycling of harvested rain water)

- **Management practices adopted during *rabi* (winter) season to increase intensity**

During 2001-02 and 2002-03, another five winter crops *viz*., linseed (*Linum usitatissimum* L.), safflower (*Carthamous tinctorious* L.), mustard (*Brassica juncea* L.), chickpea (*Cicer arietinum* L.) and pea (*Pisum sativum* L.) were sown on 17th November, 2001 and 13th November, 2002 after harvest of rainy (wet/*kharif*)season rice (cv. Lalat). (Layout of the trial is given in Fig. 7). Irrigation treatments were one, two, or three irrigations and in each irrigation 60 mm of water was applied through gated pipe from harvested rain water of existing pond. (Table 5). The package of practices of growing these crops is given in Table 6.

	Rice with Improved Practice (I.P.)					Rice with Farmers' Practice (F.P.)				
I_1	LN	SF	MU	CP	PE	LN	SF	MU	CP	PE
I_2	PE	LN	SF	MU	CP	PE	LN	SF	MU	CP
I_3	CP	PE	LN	SF	MU	CP	PE	LN	SF	MU

Fig.-7: Layout of experimental plot of Experiment-2

Table-5: Irrigation scheduling at different growth stages of winter crops (linseed, safflower, mustard, chickpea, pea) during 2001-02 and 2002-03.

Irrigation treatments	Crops				
	Linseed	Safflower	Mustard	Chickpea	Pea
One	50% flowering	50% flowering	50% flowering	50% flowering	50% flowering
Two	50% flowering + grain filling	Secondary branching + seed formation	50% flowering + siliqua development	50% flowering + grain filling	50% flowering + seed pod development
Three	Secondary branching + 50% flowering + grain filling	Secondary branching + 50% flowering + seed formation	Secondary branching + 50% flowering + siliqua development	Branching + flowering + grain filling	Secondary branching + 50% flowering + pod development

Table-6: Package of practices for growing winter crops in medium land rice fallow during 2001-02 and 2002-03.

Crop	Variety	Spacing (cm xcm)	Fertilizer dose (N:P:K)	Date of sowing		Date of harvest	
				2001-02	2002-03	2001-02	2002-03
Linseed	Sekhar	30 x 10	40:20:20	17.11.01	13.11.02	25.02.02	24.02.02
Safflower	Bhima	30 x 10	40:20:20	17.11.01	13.11.02	18.03.02	12.03.03
Mustard	Pusa Bold	30 x 15	20:40:40	17.11.01	13.11.02	16.03.02	14.03.03
Chickpea	Pragati	30 x 15	20:40:40	17.11.01	13.11.02	10.03.02	11.03.03
Pea	Rachna	30 x 15	40:30:20	17.11.01	13.11.02	09.03.02	04.03.03

7.1.2 Increasing productivity and cropping intensity of medium land with shallow ground water table utilizing soil upward flux and supplemental irrigation.

Experiment-3: Exploring possibility of growing second crops in medium rainfed rice fallow with shallow water table utilizing soil upward flux and supplemental irrigation.

Place of on-farm trial : Noagao, village, Dhenkanal

Treatments :

During wet *kharif* (rainy) season :
Rice (cv. Lalat) with improved (IP) and farmers' management (FP) practices

During dry *rabi* (winter) season :
Sub plots:Crops- Groundnut(GN), blackgram (BG), greengram (GG), chickpea (CP),
Main plots: Irrigation- No (I_0), one (I_1) and two (I_2) (runoff recycled water was used for irrigation)

- **Management practices adopted during dry/*rabi* (winter) season to increase cropping intensity**

After harvesting of rice, four crops *viz.*, groundnut (*Arachis hypogea* L.), blackgram (*Vigna mungo* L.), greengram [*Vigna radiata* (L.) Wilczek] and chickpea (*Cicer arietinum* L.) were sown on 10th November, 2001 and 18th November 2002 in two study years utilizing residual soil moisture, soil upward flux and supplemental irrigation(Layout of trial is given in Fig. 8). Rice (cv. Lalat) was grown on that land during wet/*kharif* (rainy) season with both improved and farmers' management practices. The irrigation treatments during dry/*rabi* (winter) season consisted of no, one and two irrigations. One irrigation was given at pod formation stage and two irrigations were given at flowering and seed filling stages of all the crops and no irrigation treatment was kept as control. The 60 mm water was applied during each irrigation. The crops were grown following standard agronomic package of practices (Table 7).

	Rice with Farmers' Practice				Rice with Improved Practice			
	I.P.				F.P.			
I_0	GN	BG	GG	CP	GN	BG	GG	CP
I_1	GG	GN	BG	GM	GG	GN	BG	GM
I_2	GG	CP	GN	BG	GG	CP	GN	BG

Fig.-8: Layout of experimental plot of Experiment-3

Table-7: Package of practices of growing second crops in medium rainfed rice fallow with shallow water table

Crop	Varieties	Spacing (cm x cm)	Speed rate (kg ha^{-1})	Fertilizer dose (N:P:K)
Groundnut	TMV-2	30 x 10	80 (kernel)	20:40:40+250 kg zypsum ha^{-1}
Blackgram	T-9	30 x 15	20	20:40:40
Greengram	K-851	30 x 10	25	20:40:40
Chickpea	Pragati	30 x 15	80	20:40:40

The actual water use (AWU) of second crops was computed using the following relationship on the assumption that runoff and deep percolation were negligible.

$$AWU\ (mm) = ER + I + \Delta S \pm \int_{t_1}^{t_2} Fz\, dt$$

Where, ER= effective rainfall (mm), I= applied irrigation (mm), ΔS= change in soil water storage or profile depletion (mm), Fz = vertical flux (mm day^{-1}) across the root zone depth (1.2 m).

To determine ground water contribution, the vertical flux was estimated using Darcy' equation $F_z = -K(\theta)\ \delta H/\ \delta Z$

Where, K= hydraulic conductivity (mm day^{-1}) corresponding to an average soil-water content, (q) during the period considered, and dH/dZ is the average hydraulic gradient during that period.

The hydraulic conductivity in the field was determined using the internal drainage method, as described by Rose *et al.*, (1965), Hillel (1971) and Maesschalck *et al.*, (1979).

Volumetric soil water content was measured at depths of 0.15, 0.30, 0.45, 0.60, 0.90 and 1.20 m using gravimetric method. Soil-water storage (S) between depths Z1 and Z2 was calculated as

$$S = \int_{Z_1}^{Z_2} \theta\ \delta Z$$

Changes in S between successive measurement times and for each soil layer were determined graphically. Tensiometer readings were taken simultaneously with soil-water content and at the same depths. From these readings, hydraulic head was calculated and plotted against soil depth. Hydraulic gradient (δH/δZ), which determines the magnitude and indicates the direction of water movement, was then computed for the different depths and time.

Water use efficiency (WUE) was calculated as follows.

$$\text{WUE (kg ha}^{-1}\text{ mm}^{-1}) = \frac{\text{Crop yield (kg ha}^{-1})}{\text{Actual amount of water used (mm)}}$$

7.2 Development of rice based cropping system to increase cropping intensity and productivity of rainfed lowland rice ecosystem.

Experiment-4: Increasing productivity and cropping intensity of rainfed lowland rice ecosystem through alternate seeding/tilling methods.

Despite of sufficient soil moisture in lowland rainfed rice area, winter season mostly remains fallow. In some areas, lathyrus is grown as second crop after rice, which is exclusively under utera system with very less productivity of 100 to 200 kg ha^{-1}. Therefore, a study was undertaken to advocate alternative seeding/tilling methods for growing diversified crops in lowland rainfed rice area after harvesting of rice.

Place of on-farm trial : Arnapurnapur village, Dhenkanal

Treatments :

During wet/*kharif* (rainy) season :
Rice (cv. Gayatri) with improved IP) and farmers' management (FP) practices

During dry/*rabi* (winter) season :
Main plots - Crops: Lathyrus(LY), blackgram (BG), chickpea (CP), pea (PE)
Sub plots -Tilling/seeding methods: Relay(R), one tillage (**T1**), two tillage(**T2**), conventional tillage(C) and zero tillage(Z).

- **Management practices adopted during *kharif* (rainy) season to improve productivity of rice**

The rice (*Oryza sativa* L.) variety 'Gayatri' (150 days duration) was grown during rainy season of two study years following both improved (IP) and farmers' management practices (FP) to measure the incrase in yield through improved practices over rarmers' practices. The farmers' practices consisted of broadcasting sowing, no control of pest and diseases, no inter-cultural operation or gap filling, and application of basal dose of 30:30:0 fertilizer (N:P:K) etc. Whereas, under improved practices transplanting was done with the spacing of 20 x 10 cm and gap filling was done at 20 days after transplanting. Weed was controlled through integrated weed management technique. Fertilizer was given in the ratio of 80:40:40 (N:P:K), 50 % N and full dose of P and K were applied as basal and rest 50 % N was applied during maximum tillering stage. Need based plant protection measure was also taken.

- **Management practices adopted during dry/ *rabi* (winter) season to increase intensity through alternate seeding/tilling methods.**

Four crops *viz.*, Lathyrus, blackgram, chickpea and pea were grown after rice as per the layout, given in Fig. 9. The package of practices for growing crops are given in Table 8.

	Rice with Farmers' Practice				Rice with Improved Practice			
	I.P.				F.P.			
R	LY	BG	PE	CP	LY	BG	PE	CP
T1	PE	LY	BG	CP	PE	LY	BG	CP
T2	BG	PE	CP	LY	BG	PE	CP	LY
Z	LY	BG	CP	PE	LY	BG	CP	PE
C	PE	CP	LY	BG	PE	CP	LY	BG

Fig.-9: Layout of experimental plot of Experiment-4

Table-8 : Package of practices and date of sowing-harvesting of different crops in low land rainfed rice fallow

Crop	Variety	*Spacing	Date of sowing			Date of harvesting		
		(cm x cm)	1999-00	2000-01	2001-02	1999-00	2000-01	2001-02
Lathyrus	Nirmal	30 x 10	R:13.12.99 O:27.12.99	R:11.12.00 O:26.12.00	R:13.12.01 O:25.12.01	R:12.3.00 O:23.3.00	R:10.3.01 O23.3.01	R:14.3.02 O:20.3.02
Blackgram	T-9	30 x 15	R:13.12.99 O: 27.12.99	R:11.12.00 O:26.12.00	R:13.12.01 O:25.12.01	R:14.3.00 O:21.3.00	R:14.3.01 O:25.3.01	R:15.3.02 O:26.3.02
Pea	Rachna	30 x 10	R:13.12.99 O:27.12.99	R:11.12.00 O:26.12.00	R:13.12.01 O:25.12.01	R:16.3.00 O:23.3.00	R:15.3.01 O:24.3.01	R:14.3.02 O:23.3.02
Chickpea	Pragati	30 x 15	R:13.12.99 O:27.12.99	R:11.12.00 O:26.12.00	R:13.12.01 O:25.12.01	R:23.3.00 O:29.3.00	R:19.3.01 O:23.3.01	R:17.3.02 O:28.3.02

** Spacing is maintained for other than relay cropping (relay cropping was broadcasted), R=Relay; O=other methods*

<u>Experiment-5</u>: **On-farm trial on integrated nutrient management in lowland rice field to improve productivity of rice and its subsequent effects on winter crops.**

A field experiment on integrated nutrient management practices was carried out during three years (2000-01, 2001-02, 2002-03) at Arnapurnapur village, Dhenkanal Orissa. The low land rice cv. Gayatri was transplanted with 20 x 10 cm spacing and nutrient in the ratio of 80:40:40 (N_2:P_2O_5:K_2O)was supplied through integrated nutrient sources. The treatments consisted of different quantities of recommended dose of NPK fertilizers alone and/or different kinds of organic matter *viz.*, T1-25% NPK through Dhaincha +75% NPK through inorganic fertilizers, T2-25% NPK through FYM +75% through inorganic fertilizers, T3-25% NPK through press mud +75% NPK through inorganic fertilizers, T4 - Entire recommended dose through inorganic fertilizers, T5-Farmers' practice (control). The soil was clay loam in texture with moderate status of nitrogen (0.068%) and organic carbon (0.67%) and available P_2O_5 and K_2O were 17.5 and 133 kg ha^{-1} with pH 6.6. The Dhaincha (*Sesbania rostrata*) was sown in the month of May in the separate field. After 45 days of sowing, Dhanicha plants were uprooted and incorporated in the soil of experimental plot. The Dhanicha green leaf manure had 2.79, 0.42, 1.12 and 23.8 percent N,P,K and organic carbon, respectively. While, other organic manures, P_2O_5 through single super phosphate and K_2O through Muriate of Potash were incorporated in the plot on the same day of green manuring and nitrogen through urea was applied in 3 splits ($^1/_2$ at 4 days after transplanting, ¼ at tillering, ¼ at panicle initiation) The press mud was collected from local sugar factory (M/s. Shakti Sugar Ltd., Dhenkanal) which had 24%, 1.1, 2.15 and 1.14 percent organic carbon, N, P, K, respectively. On the other hand FYM had 0.40, 0.25, 0.15 and 4.4 percent organic carbon, respectively.

During post rainy (dry/*rabi*) season three crops *viz*., pea, blackgram, and greengram were taken on residual fertility in each plot after harvest of rice.

8. FIELD EXPERIMENTAL FINDINGS

8.1 Development of suitable rice based cropping system to increase cropping intensity and productivity of medium land rainfed rice ecosystem

8.1.1 <u>Increasing productivity and cropping intensity of medium land with deep water table utilizing limited irrigation from harvested rainwater</u>

<u>Experiment-1</u>: Improving productivity of rice during wet/*kharif* (rainy) season and performance evaluation of winter crops (maize, groundnut, sunflower, wheat, potato) in rainfed medium land rice fallow with limited irrigation

- **Soils of experimental site and water table depth**

The soils throughout the experimental area were relatively homogeneous, the upper layer (0-0.15 m) was sandy loam in texture whereas the next two layers (0.15-0.30 m and 0.30-0.45 m) were sandy clay loam in nature (Table 9). The bulk density was 1.55 mg m^{-3} at 0-0.15 m soil depth and it increased with depth, at 0.90-1.2 m layer it was 1.62 mg m^{-3}. The pH was slight to moderately acidic and no salt problem was detected in the soil profile. The organic carbon content was relatively higher (0.60%) at upper layer (0-0.15 m) while at deeper layer it was only 0.07%. The soil fertility was very low with Olsen P and available K (NH4OAc-K) was 7.4 mg P kg^{-1} and 75 mg K kg^{-1} of soils respectively. The water content at field capacity was 0.220 m^3m^{-3} at 0-0.15 m layer and the highest water content was 0.266 m^3m^{-3} at 0.45-0.60 m soil depth. The available water content was 0.108, 0.124, 0.146, 0.148, 0.140 and 0.131 m^3m^{-3} at 0-0.15 m, 0.15-0.30 m, 0.30-0.45 m, 0.45-0.60 m, 0.60-0.90 m and 0.90-0.120 m soil depth, respectively. The graphical relationship between matric potential and soil water content, hydraulic conducivity vs. soil water content and soil water diffusion vs. soil water content are given in Fig. 10(a), 10(b) and 10(c), respectively.

The water table depth was measured throughout the year through pizometric observations and pooled data of two years are presented in Fig. 11. Study revealed that the water table ranged between 6.8 m in May to 2.1 m in October and the site was considered as medium rainfed rice land with deep water table depth.

- **Enhancement of rice yield and net return during (rainy) season with improved practices over farmers' practices.**

Study revealed that (Fig.12) rice (cv. Lalat) yield of 4.51 and 4.01 tha^{-1} was obtained under improved management practices in 1999 and 2000, respectively (average of 5 farmers). On the other hand under farmers' practices 2.41 and 2.05 t ha^{-1} yield was achieved in two respective years. It is revealed that 87.1 to 95.6 % higher grain yield was obtained with improved practices over farmers' practices (Fig. 12). It has been also observed that due to dry spell in 2000, rice yield was adversely affected, as a result 12.4 and 17.5 % less grain yield was obtained under improved and farmers, practices, respectively in that year.

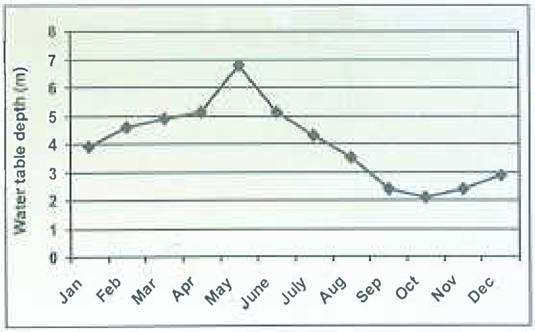


Fig. 11: Variation of water table depth in different months of the year

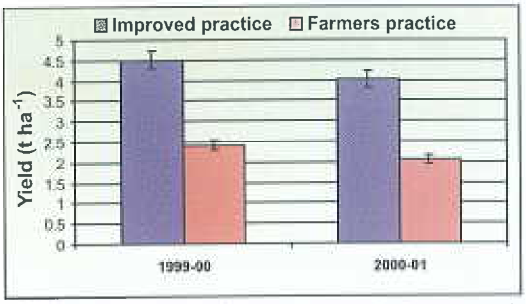


Fig.-12: Grain yield of rice (cv. Lalat) with improved and farmers' management practices

- **Crop growth with supplemental irrigation**

The second crops were sown in the third week of November as early as possible after harvesting rice, to enable these to make full use of carry-over residual profile soil moisture.

Table-9 : Important soil properties of medium rainfed rice land with deep ground water table.

(a) Particle size analysis

Soil depth (m)	Particle size distribution (%)				Textural class	Bulk density (mg m^{-3})
	Coarse sand	Fine sand	Silt	Clay		
0.0-0.15	27.5	25.5	30.0	17.0	sl	1.55
0.15-0.30	30.0	22.2	25.8	22.1	scl	1.55
0.30-0.45	22.8	23.2	25.0	29.2	scl	1.58
0.45-0.60	27.2	18.4	27.4	27.0	scl	1.60
0.60-0.90	24.4	19.2	22.4	33.9	cl	1.60
0.90-1.20	26.6	16.0	23.6	33.8	cl	1.62

(b) Important soil chemical properties and fertility status

Soil depth (m)	pH	EC (ds m^{-1})	Organic carbon(%)	Olsen P (mg P kg^{-1} soil)	NH_4 OAc-K (mg K kg^{-1} soil)
0.0-0.15	6.1	0.23	0.60	2.9	75
0.15-0.30	6.0	0.18	0.53	2.3	35
0.30-0.45	5.8	0.18	0.35	2.1	50
0.45-0.60	6.6	0.20	0.20	<1.0	60
0.60-0.90	6.1	0.13	0.13	1.7	105
0.90-1.20	6.5	0.23	0.07	<1.0	70

(c) Water retention properties

Soil depth (m)	θ_s (m^3m^{-3}) at 0.01 MPa	θ (m^3m^{-3}) at 0.33 MPa	θ (m^3m^{-3}) at 1.5 MPa	Available water content (m^3m^{-3})
0.0-0.15	0.283	0.220	0.092	0.128
0.15-0.30	0.203	0.227	0.103	0.124
0.30-0.45	0.334	0.269	0.113	0.154
0.45-0.60	0.341	0.276	0.118	0.158
0.60-0.90	0.321	0.261	0.111	0.150
0.90-1.20	0.309	0.279	0.117	0.162

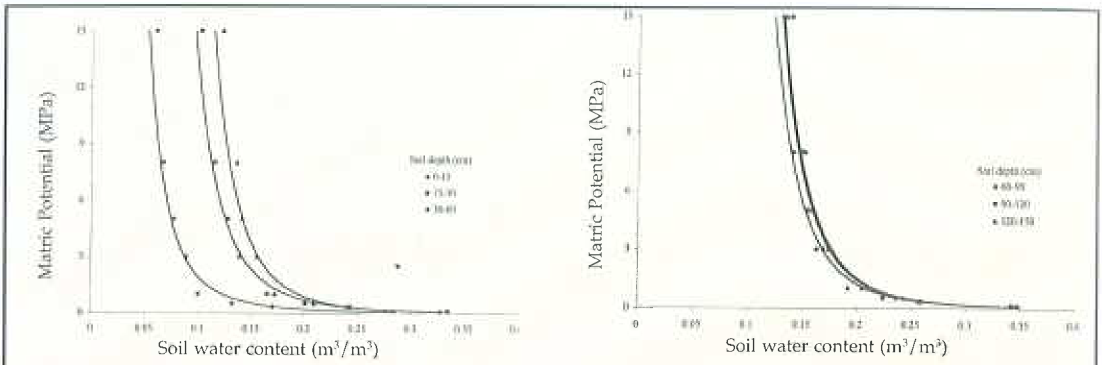


Fig. 10(a): Matric potential vs. water content relationship in medium land soil with deep water table

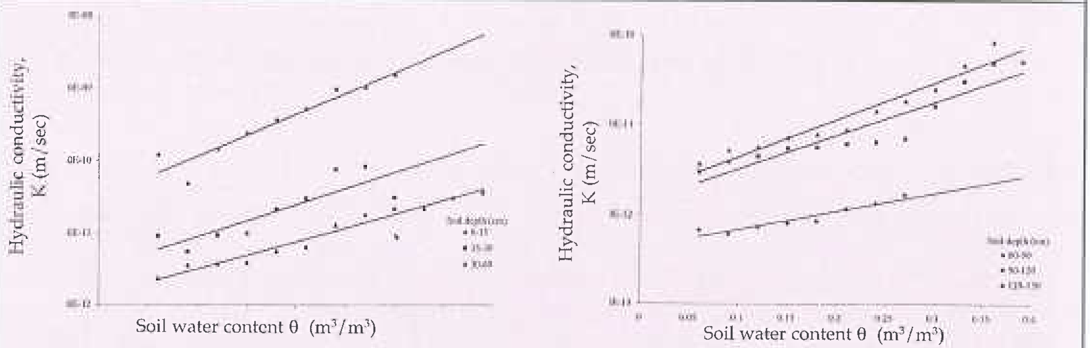


Fig. 10(b): Hydraulic conductivity as a function of water content in medium land soil with deep water table.

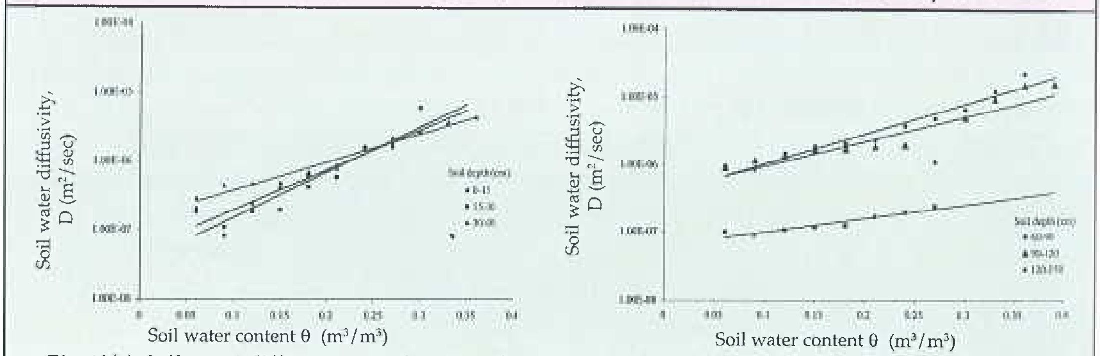


Fig. 10(c): Soil water diffusivity as a function of water content in medium land soil with deep water table.

Two main crop growth parameters like above ground dry biomass and leaf area index were measured and the pooled data of two study years (1999-00 and 2000-01) are presented in Fig. 13 and 14, respectively. Study revealed that with two irrigation, mean above ground biomass of 600, 785, 808, 448 and 446 g m^{-2} was achieved in maize, groundnut, sunflower, wheat and potato, respectively (pooled data). The 20.0, 37.1, 56, 53 and 28 % peak above ground biomass was enhanced in respective five crops when three irrigation was applied over two irrigation. With four irrigation at 45.2, 75.3, 105.0, 87.3 and 54.3 % maximum biomass was increased over two irrigation in maize, groundnut, sunflower, wheat and potato, respectively.

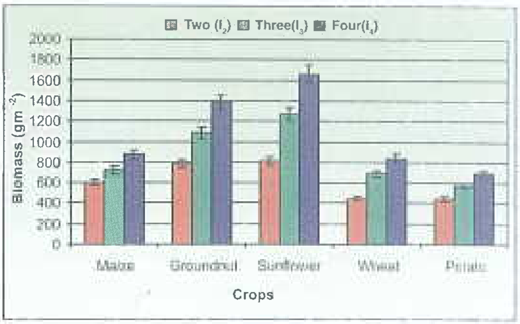


Fig. 13: Maximum above ground dry biomass of maize groundnut, sunflower, wheat and potato (pooled data of 1999-2000 and 2000-01)

Highest leaf area index was observed with four irrigation with the mean values being 5.3, 5.8, 6.9, 4.8 and 5.0 in maize, groundnut, sunflower, wheat and potato respectively. The 69, 65, 78, 81 and 84 % maximum leaf area index was enhanced with the application of four irrigation over two irrigation in respective five crops.

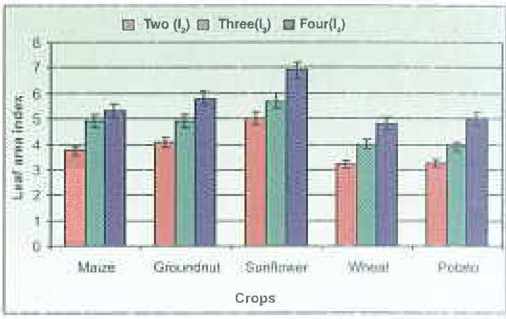


Fig. 14: Peak leaf area index (LAI) of maize, groundnut, sunflower, wheat and potato (pooled data of 1999-2000 and 2000-01)

- **Grain yield with supplemental irrigation**

Study revealed that supplemental irrigation had a significant effect ($P < 0.001$) on grain yield of winter crops (Table 10) and with two supplemental irrigation, mean yield of 1845, 785, 905, 1420, 8050 kg ha^{-1} was obtained in maize, groundnut, sunflower, wheat and potato (tuber) respectively. The 59 %, 29 %, 33 %, 58 %, and 19 % higher yield was obtained in respective (five) crops when three irrigation was applied. With increase of another irrigation i.e. with four supplemental irrigation 214 %, 89 %, 78 %, 81 % and 54 % yield was enhanced in maize, groundnut, sunflower, wheat and potato respectively over two irrigation.

- **Field water use and water use efficiency (WUE)**

The amount of water use is directly proportional to the amount of water supplied in the soil profile. The total water use of 334, 348, 395, 340 and 355 mm was measured by the maize groundnut, sunflower, wheat and potato, respectively when only two irrigation was applied. With four irrigation, the total water use was 438, 444, 476, 440 and 432 mm in respective five crops. Among all the crops the highest water was used by sunflower crop, it might be due to its deep root system as compared to other crops. Study revealed that (Table 10) with two supplemental irrigation,

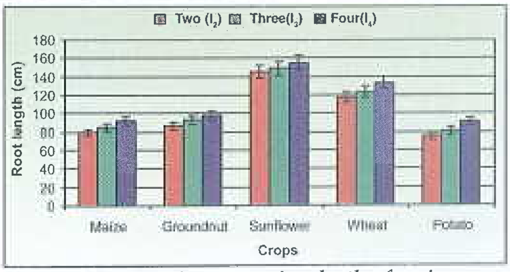


Fig.-15 : Maximum rooting depth of maize, groundnut, sunflower, wheat,potato (pooled data of 1999-00 and 2000-01) water use efficiency (pooled data of two years) of 4.95, 2.24, 2.29, 4.08 and 22.7 kg ha^{-1} mm^{-1} was achieved by maize, groundnut, sunflower, wheat and potato (tuber) respectively.

The WUE increased by 46 %, 14 %, 22 %, 38 %, and 7 % when three irrigation was applied over two irrigation in maize, groundnut, sunflower, wheat and potato, respectively. With four supplemental irrigation WUE of 13.8, 3.58, 3.60, 6.31 and 28.7 kg ha^{-1} mm^{-1} was obtained in respective five crops.

Table-10: Yield and water use efficiency (pooled data of two years) of different crops with limited irrigation scheduling during 1999-00 and 2000-01

Crop	Grain yield (kg ha^{-1})				Water use (mm)				Water use efficiency (kg $ha^{-1}mm^{-1}$)			
	I_2	I_3	I_4	S.E.$_m$(±)	I_2	I_3	I_4	S.E.$_m$(±)	I_2	I_3	I_4	S.E.$_m$(±)
Maize (grain)	1845	2950	5805	1179.7	334	385	438	30.0	4.95	7.25	13.8	2.58
Maize (cob), No/ha	40000	43000	49400	2772.0	-	-	-	-	-	-	-	-
Groundnut	785	1020	1590	207.2	348	395	444	27.7	2.24	2.57	3.58	0.32
Sunflower	905	1205	1715	205.7	395	429	476	23.4	2.29	2.81	3.60	0.31
Wheat	1420	2250	2780	345.0	348	390	440	28.8	4.08	5.76	6.31	0.57
Potato(tuber)	8050	9650	12400	1270.2	355	394	432	22.2	22.7	24.5	28.7	1.77

Photo-6: Collection of excess rain water (runoff) during wet/kharif (rainy) season in the village pond

Photo-7(a): Performance of sunflower with two irrigation from harvested rainwater

Photo-7(b): Bumper yield of sunflower with four irrigation from harvested rainwater

Photo-8: Wheat crop with three irrigation from harvested rainwater

Photo-9(a): Potato with two supplemental irrigation

Photo-9(b): Potato with three supplemental irrigation

Photo-9(c): Potato with four supplemental irrigation

- **Maximum rooting depth studies and water extraction pattern of different crops**

The characterization of maximum rooting depth is necessary to appraise the water and nutrition uptake pattern of different crops. The maximum rooting depth of different crops in rainfed rice fallow was measured and average results of two years are presented in Fig. 15. The water uptake of different crops from different depths was also studied and percent of total water use was extracted at different depth has been given in Table 11. Of the five crops studied, sunflower was found to be deep-rooted and it withdrew 30 to 40 mm more water than other crops. Sunflower, with its tap root-organized root growth system, was found the most deeply rooted and had the capability of extracting subsoil water at greater depths than all other crops studied. This crop extracted 18 - 20 % and 14 - 16% of total water use at 0.60-0.90 and 0.90-1.20 m depth, respectively (Table-11). Results of two years revealed that root length was more with four irrigation which was interpreted as response to availability of soil water.

Table-11: Percentage (%) of total extracted water at different soil depths by maize, groundnut, sunflower, wheat and potato (pooled data of 1999-00 and 2000-01)

Soil depth(m)	Maize			Groundnut			Sunflower			Wheat			Potato		
	I_2	I_3	I_4	I_2	I_3	I_4	I_2	I_3	I_4	I_2	I_3	I_4	I_2	I_3	I_4
0-0.30	43.2	38.9	42.1	39.8	40.7	40.3	28.8	30.1	30.3	39.0	39.5	40.3	39.5	41.2	45.2
0.30-0.60	35.0	36.1	37.9	32.1	32.7	35.1	27.7	26.8	26.9	32.8	33.3	32.9	34.7	36.3	35.2
0.60-0.90	15.9	16.9	15.4	20.5	30.4	21.8	18.1	18.2	20.1	17.1	17.7	17.6	17.9	15.3	14.0
0.90-1.20	4.8	7.0	4.4	5.5	4.1	2.9	16.1	16.1	14.0	9.0	7.4	6.2	7.7	7.1	5.5

With four irrigation average maximum rooting depths were 92, 98, 155, 133 and 91 cm in maize, groundnut, sunflower, wheat and potato respectively which was, 16 %, 13 %, 6 %, 13 % and 21% higher than that of twice irrigated crops because of wet subsoils (Fig. 15). The variation of rooting depth in different crops was positively correlated with soil water extraction during both the years.

- **Economics of rice-maize/groundnut/sunflower/wheat/potato cropping system with limited irrigation to second crops**

The net return from first and second crop were computed and are presented in Table-12. Since maize cob was more remunerative and had better market prospects, economics of rice (improved)-maize(cob) was also computed. Study revealed that from first crop rice (pooled data of two years) Rs. 13540 ha^{-1} and Rs. 8480 ha^{-1} net return was obtained with improved and farmers' practices, respectively. With two irrigation to second crops Rs. 14765 ha^{-1}, Rs. 18140 ha^{-1}, Rs. 15530 ha^{-1}, Rs. 18635 ha^{-1}, Rs. 15540 ha^{-1} and Rs. 19640 ha^{-1} net return was obtained from rice-maize(grain), rice-maize(cob), rice- groundnut, rice-sunflower, rice-wheat, rice-potato, respectively when rice was grown with improved management. With four irrigation Rs. 33565 ha^{-1}, Rs. 47940 ha^{-1}, Rs. 28800 ha^{-1}, Rs. 30650 ha^{-1}, Rs. 17660 ha^{-1} and Rs. 27340 ha^{-1} net return was obtained from rice-maize (grain), rice-maize(cob), rice-groundnut, rice-sunflower, rice-wheat, rice-potato respectively. Therefore, with four supplemental irrigation the net return was obtained in the order of sole rice (farmers' practices)<sole rice (improved practices)<rice-wheat<rice-potato<rice-groundnut<rice-sunflower<rice-maize(grain) <rice-maize(cob).

Table-12: Net return from different crop combinations (pooled data of 1999-00 and 2000-01)

Crop Combination	*Net return from first crop (Rs ha^{-1})	Net return from second crop (Rs ha^{-1})			Total return (Rs ha^{-1})		
		I_2	I_3	I_4	I_2	I_3	I_4
Rice-maize(grain)	13540	1225	6250	20025	14765	19790	33565
Rice-maize(cob)	13540	4600	13000	34400	18140	26540	47940
Rice-groundnut	13540	1990	7780	15260	15530	21320	28800
Rice-sunflower	13540	5095	7875	17110	18635	21415	30650
Rice-wheat	13540	-	2500	4120	13540	15940	17660
Rice-potato	13540	6100	8800	13800	19640	22340	27340
Mono-cropped rice (farmers' practice)	6920	-	-	-	6920	6920	6920

** Net return includes value of straw yield of rice.*

Photo-10: Winter maize with three supplemental irrigation

Photo-11: Groundnut with three supplemental irrigation

Photo-12: Director, WTCER, Dr. H.N.Verma is interacting with a farmer of Arnapurnapur village, Dhenkanal regarding sustainability of rice based cropping system

Photo-13: Farmers' satisfaction with bumper yield of sunflower with limited irrigation (four)

<u>Experiment-2</u>: Performance evaluation of winter crops (linseed, safflower, mustard, chickpea and pea) during dry/*rabi* season with limited irrigation

- **Enhancement of rice yield and net return during wet/*kharif* (rainy) season with improved practices over farmers' practices.**

Study revealed that (Fig.16) rice (cv. Lalat) yield of 4.45 and 3.95 t ha^{-1} yield was obtained under improved management practices in 2001 and 2002, respectively (average of 5 farmers). On the other hand under farmers practices 2.23 and 1.95 t ha^{-1} grain yield was achieved in two respective sowings. It is revealed that 102-104 % higher yield was obtained with improved practices over farmers practices. It is also observed due to dry spell in 2002, rice yield was affected, as a result 12.6 and 14.3 % less yield was obtained under improved and farmers' practices, respectively in that year.

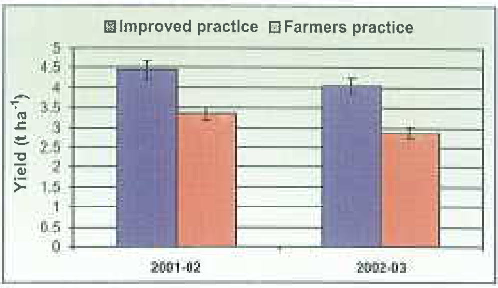


Fig. 16: Grain yield of rice (cv. Lalat) with improved and farmers management practices

- **Crop growth with supplemental irrigation**

Two main crop growth parameters like maximum above ground biomass and leaf area index were computed and are presented in Fig. 17 and 18, respectively. Study revealed that (Fig.17) with one irrigation, mean above ground biomass of 355, 575, 258, 402 and 395 g m^{-2} was achieved in linseed, safflower, chickpea, pea and mustard, respectively (pooled data of two years). The 40 %, 16 %, 48 %, 54 % and 50 % above ground biomass was enhanced in respective five crops when two irrigation was applied. With three irrigation above ground biomass of 509, 872, 542, 649 and 812 g m^{-2} was obtained in linseed, safflower, chickpea, pea and mustard, respectively.

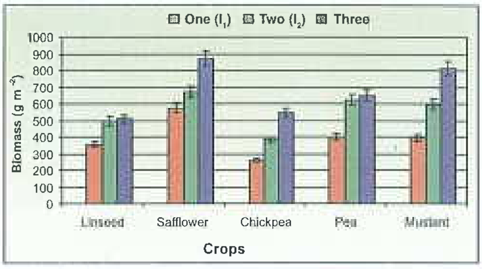


Fig. 17: Maximum above ground dry biomass of different crops (linseed, safflower, chickpea, pea mustard) as influenced by irrigation levels (pooled data of 2001-02 and 2002-03)

Highest leaf area index was observed with three irrigation with the mean values being 3.7, 5.7, 4.15, 5.75 and 5.35 in linseed, safflower, chickpea, pea and mustard, respectively, which was 68 %, 40 %, 80 %, 76 %, and 84 % higher over one irrigation in respective five crops.

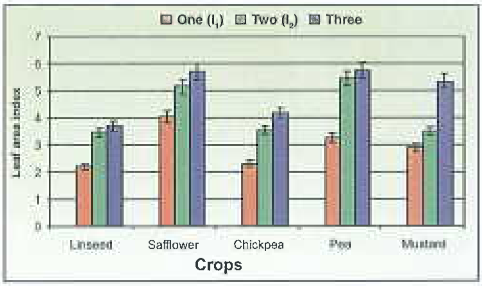


Fig. 18: Peak leaf area index (LAI) of linseed, safflower, chickpea, pea and mustard as influenced by irrigation levels (pooled data of 2001-02 and 2002-03)

- **Grain yield with supplemental irrigation**

Study revealed that supplemental irrigation had a significant effect ($P < 0.001$) on grain yield of winter crops (Table 13). With one supplemental irrigation, mean grain yield of 212, 392, 165, 331 and 246 kg ha^{-1} was obtained in linseed, safflower, chickpea, pea and mustard, respectively. With increase of another irrigation i.e. with two supplemental irrigation 69 %, 48 %, 65 %, 57 % and 55 % grain yield was enhanced in linseed, safflower, chickpea, pea and mustard, respectively over one irrigation. With three irrigation 845, 1258, 765, 1168, 938 kg ha^{-1}

grain yield was obtained in linseed, safflower, chickpea, pea and mustard, respectively which was 298 %, 220 %, 363 %, 252 %, and 281 % higher over single irrigation in respective five crops. Study also revealed that the yield difference was not significant in linseed and pea between two and three supplemental irrigations, so, three irrigation may not be economical for growing these crops. Therefore, under limited water situation, linseed and pea can be tried with two supplemental irrigation. On the other hand, in safflower, chickpea and mustard, yield was enhanced significantly with three supplemental irrigation over two irrigation. So these crops can be grown with three supplemental irrigation in rainfed medium land rice fallow.

Table-13: Yield and water use efficiency (pooled data of two years) of different crops with limited irrigation scheduling during 2001-02 and 2002-03

Crop	Grain yield (kg ha^{-1})				Water use (mm)				Water use efficiency (kg ha^{-1}mm^{-1})			
	I_1	I_2	I_3	S.E.$_m$(±)	I_1	I_2	I_3	S.E.$_m$(±)	I_1	I_2	I_3	S.E.$_m$(±)
Linseed	212	701	845	191.5	227	279	325	28.3	0.93	2.51	2.59	0.54
Safflower	392	762	1258	213.0	319	363	413	27.1	1.23	2.11	3.04	0.43
Chickpea	165	475	765	145.7	259	295	340	23.4	0.65	1.61	2.25	0.38
Pea	331	787	1168	189.5	292	334	394	29.5	1.45	2.90	2.96	0.49
Mustard	246	547	938	200.3	279	321	381	29.5	0.88	1.71	2.45	0.45

- **Field water use and water use efficiency (WUE)**

Study revealed that (Table-13) with one irrigation, under rainfed condition, the highest water use efficiency (pooled data of two years) was achieved in pea (1.45 kg ha^{-1} mm^{-1}), followed by safflower (1.23 kg ha^{-1} mm^{-1}) and linseed (0.93 kg ha^{-1} mm^{-1}). It might be due to short duration and low water requirements of linseed and pea and tap root system of safflower, which allowed it to draw moisture from lower soil strata after good establishment with initial rainfall.

The WUE increased by 169 %, 71 %, 147 %, 100 %, 94 % when two irrigation was applied over one irrigation in linseed, safflower, chickpea, pea and mustard respectively. With three supplemental irrigation, the highest efficiency was achieved by safflower followed by pea and linseed with the mean values being 3.04, 2.96 and 2.59 kg ha^{-1} mm^{-1}, respectively. Study revealed that enhancement of WUE from two to three irrigation was not significant in case of linseed and pea which might be due to increased water application resulting in increased crop water use without a corresponding increase in the yield of linseed and pea. On the other hand,

Photo-14: Linseed with two irrigation

Photo-15: Linseed with three irrigation

Photo-16: Safflower with two irrigation

Photo-17: Visit of Dr. R.S.Tripathy (Director, IGKV) and Dr. H.N.Verma (Director, WTCER) to experimental site of limited irrigation

WUE was increased significantly from two to three irrigation in safflower, chickpea and mustard. Therefore, to achieve higher WUE for these three crops, at least three supplemental irrigation were required in medium land rice fallow with deep water table.

- **Maximum rooting depth studies and water extraction pattern of different crops**

The maximum rooting depth of different crops in rainfed rice fallow was measured and average results of two years are presented in Fig. 19. The water uptake of different crops from different depths was also studied and percentage of total water use was extracted at different depth has been given in Table-14. Among the crops studied, linseed was a shallow rooted one

Photo-18: Pea with two irrigation

Photo-19: Pea with three irrigation

Photo-20: Mustard with two irrigation

Photo-21: Mustard with three irrigation

Photo-22: Chickpea with three irrigation

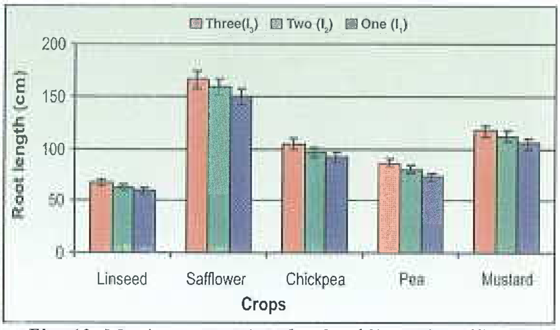


Fig.-19: Maximum rooting depth of linseed, safflower, chickpea, pea and mustard as influenced by irrigation levels (pooled data of 2001-02 and 2002-03)

(maximum depth 0.67 m) that extracted about 90% soil moisture from 0-0.60 m layer. The shallow rooting behavior of linseed crop will be advantageous for well adaptation to improved moisture conditions of the surface soil. Of the five crops studied, safflower withdrew maximum water following mustard and both the crops were shown to withdraw 44 to 88 mm more water than other crops. Safflower, with its tap root and organized root growth system, was found the most deeply rooted and had the capability of extracting subsoil water at greater depths than all other crops studied under the experiment. This crop extracted 20-22.8 % and 17-18.4 % of total water use at 0.60-90 and 0.90-1.20 m, respectively. Xerophytic spine attributes of safflower contributed to good drought and heat tolerance and produced 392 and 762 kg ha^{-1} grain yield with one and two irrigation, respectively though crop fulfilled 68.6 % and 78.4 % of its crop water requirements with one and two irrigation, respectively. Results of two years, revealed that greatest total rooting length was more in thrice irrigated plots than that of under single irrigation which was interpreted as response to soil water availability in subsoils.

With three irrigation average maximum rooting depths were 166 cm, 117 cm, 104 cm, 86 cm and 67 cm for safflower, mustard, chickpea, pea and linseed, respectively which was 13.5, 10.6, 14.2, 17.8 and 11.4 % higher than that of single irrigated crops because of more wet subsoils. The variation of rooting depth in different crops was positively correlated with soil water extraction pattern during both the years. There was considerable difference in potential among the crops for using water and nutrients at deeper positions in the soil profile.

Among two pulses (pea and chickpea) chickpea had the ability to extract soil moisture from deeper layers and 11-12 % and 7-10 % of total water extracted from 0.60-0.90 m and 0.90-1.20 m depth, respectively. For linseed and pea, total crop water requirements were matched when two irrigation were applied and about 90-92 % of crop water was extracted by these crops from 0-0.60 m soil layers owing to their shallow root system (Table 14).

- **Economics of rice-linseed/safflower/chickpea/pea/mustard cropping system with limited irrigation to second crops**

From pooled data of two years it is revealed that from first crop (rice), Rs. 13315 ha^{-1} and Rs 6360 ha^{-1} net return was obtained with improved and farmers' practices, respectively (Table-15). When one irrigation was applied to second crops and rice was grown with improved management, Rs. 13315 ha^{-1}, Rs 15803 ha^{-1}, Rs. 13315 ha^{-1}, Rs. 13789 ha^{-1} and Rs. 13505 ha^{-1} net return

Table-14: Percentage of total extracted water at different soil depth (pooled data of two years)

Soil depth(m)	Linseed			Safflower			Chickpea			Pea			Mustard		
	I_1	I_2	I_3	I_1	I_2	I_3	I_1	I_2	I_3	I_1	I_2	I_3	I_1	I_2	I_3
0-0.30	45.1	45.4	48.5	29.4	29.1	29.3	41.8	44.1	47.3	46.0	48.1	51.1	35.2	36.4	35.6
0.30-0.60	46.6	48.3	46.9	24.6	25.3	25.5	37.5	35.1	34.1	38.2	37.9	37.1	32.1	32.6	32.8
0.60-0.90	5.01	3.98	3.42	22.4	22.8	20.0	11.5	11.1	9.0	8.9	7.3	6.6	17.9	18.9	18.6
0.90-1.20	3.76	2.46	1.06	18.4	17.5	17.0	7.1	7.8	9.4	6.8	6.5	5.2	14.7	11.9	13.2

Table-15: Net return from different crop combinations (pooled data of 2001-02 and 2002-03)

Crop Combination	*Net return from first crop (Rs ha^{-1})	Net return from second crop (Rs ha^{-1})			Total return (Rs ha^{-1})		
		I_1	I_2	I_3	I_1	I_2	I_3
Rice-linseed	13315	-	3510	4450	13315	16825	17765
Rice-safflower	13315	2488	7088	16840	15803	20403	30155
Rice-chickpea	13315	-	2625	6375	13315	15940	19690
Rice-pea	13315	465	6805	11820	13780	20120	25135
Rice-mustard	13315	190	4205	9570	13505	17520	22885
Monocropped rice (farmers' practice)	6360	-	-	-	6360	6360	6360

** Net return includes value of straw yield of rice.*

was obtained from rice-linseed, rice-safflower, rice-chickpea, rice-pea, rice-mustard respectively. With three irrigation Rs. 17765 ha^{-1}, Rs.30155 ha^{-1}, Rs. 19690 ha^{-1}, Rs. 25135 ha^{-1}, Rs. 22885 ha^{-1} net return was obtained from rice-linseed, rice-safflower, rice-chickpea, rice-pea and rice-mustard respectively. Therefore, with three irrigation, the net return was achieved in the order of: rice (farmers' practice)<rice(improved)<rice-chickpea<rice-mustard<rice-pea<rice-safflower.

8.1.2 Increasing productivity and cropping intensity of medium land with shallow ground water table.

Experiment-3: Exploring possibility of growing second crops in medium rainfed rice fallow with shallow water table utilizing soil upward flux and supplemental irrigation.

- **Soils of experimental site and water table depth**

The important physical, physico-chemical and water retention properties of the soils (average of 6 profiles) at different depths are given in Table 16. Study reveals that texture of the soils varied from clay to sandy clay loam. Bulk density of soil varied from 1.52 to 1.64 (mgm^{-3}) and it increased with soil depth. The pH of the soil varied from 6.0 - 7.0 and electrical conductivity ranged between 0.14 to 0.38 dS m^{-1}. No salt problem was detected in the soil profile.

Organic carbon (%) content of the soil varied from 0.72 % in upper layer to 0.11% in lower layer. Available phosphorus (Olsen P) in the soil was less and varied from 1.0 to 2.9 mg P kg^{-1} of soils and potassium (K) content

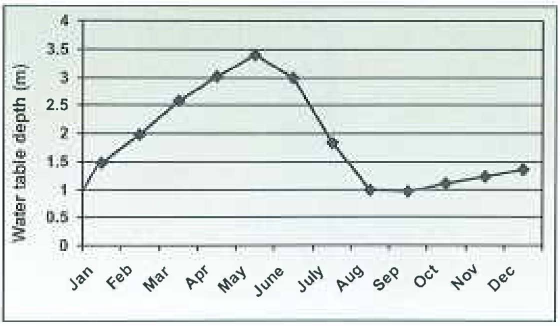


Fig.-20 : Variation of water table depth in the medium rainfed rice land with shallow ground water table (Place : Noagao, Dhenkanal)

Table-16: Important soil properties of experimental site with shallow ground water

(a) Particle size analysis

Soil depth (m)	Particle size distribution (%)				Textural class	Bulk density (mg m^{-3})
	Coarse sand	Fine sand	Silt	Clay		
0.00-0.15	18.8	19.8	24.1	37.3	cl	1.52
0.15-0.30	22.1	20.1	23.8	34.0	cl	1.53
0.30-0.45	25.3	23.2	23.3	28.3	scl	1.59
0.45-0.60	28.3	21.2	25.4	29.1	scl	1.61
0.60-0.90	25.1	19.7	21.4	33.8	cl	1.62
0.90-1.20	23.8	17.3	20.6	38.3	cl	1.64

(b) Water retention properties

Soil depth (m)	θ_s (m^3m^{-3}) at 0.01 MPa	θ (m^3m^{-3}) at 0.33 MPa	θ (m^3m^{-3}) at 1.5 MPa	Available water content (m^3m^{-3})
0.00-0.15	0.303	0.240	0.112	0.128
0.15-0.30	0.295	0.288	0.114	0.174
0.30-0.45	0.344	0.269	0.117	0.152
0.45-0.60	0.354	0.281	0.119	0.162
0.60-0.90	0.358	0.291	0.129	0.162
0.90-1.20	0.347	0.313	0.137	0.176

varied from 59 to 105 mg K kg^{-1} of soils. In general, soil was moderately acidic with low organic carbon and phosphorus and available K content was in medium range. Available water capacity of the soils varied from 0.128 to 0.176 $m^3 m^{-3}$.

The water table depth was observed using pizometer throughout the year and mean results of two years are presented in Fig. 20. Study revealed that water table was quite shallow which varied between 3.6 m in May to 0.96 m in September. During the second crop growing period (dry / *rabi* season) it ranged between 1.05 m - 1.63 m.

- **Enhancement of rice yield and net return during wet/*kharif* (rainy) season with improved practices.**

Study revealed that rice (cv. Lalat) yield of 2.38 and 2.11 t ha^{-1} was obtained under farmer's management practices in 2001-02 and 2002-03, respectively (Fig. 21). The 96.6 % and 96.2 % yield was enhanced under improved management practices in respective two years over farmer's management practices. In 2002, rice growth was affected due to dry spells, as a result 11.5 % and 11.3 % less yield were obtained in 2002 under improved and farmer's management practices, respectively. Under improved management practices 4.68 and 4.39 t ha^{-1} yield was obtained in 2001 and 2002, respectively (Fig. 21).

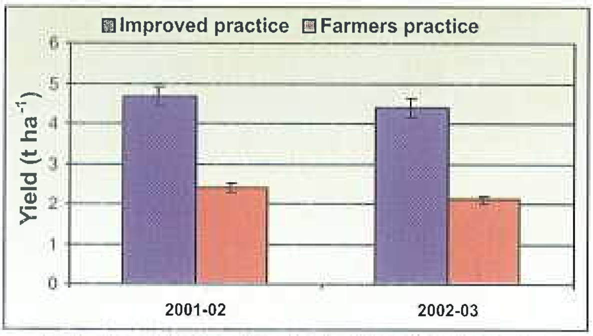


Fig. 21: Grain yield of rice (cv. Lalat) with improved and farmers management practices in medium rainfed rice land with shallow water

- **Actual water use and crop water requirements of second crops after rice**

The actual water use by four crops grown in rainfed medium land rice fallow with shallow water table was computed as per the methodologies mentioned in materials and methods. The crop water requirements of 441, 381, 371 and 359 mm were computed for groundnut, blackgram, greengram and chickpea, respectively (Table-2). In regard to actual water use, study revealed that 373, 397 and 441 mm total water was actually used by groundnut with no, one and two irrigation, respectively and blackgram crop utilized 337, 385 and 422 mm water with no, one and two irrigation, respectively. The greengram also used 324, 371, 409 mm soil moisture in three respective irrigation treatments. The actual water use by chickpea was 385, 391 and 439 mm with no, one and two irrigations, respectively. From the pooled data of both years, it was revealed that with one irrigation the crops met crop water requirements and produced good yield. Owing to shallow water table, the soil upward flux was high which contributed 58.1, 55.6, 52.7 and 51.9 % of crop water requirements with no irrigation in groundnut, blackgram, greengram and chickpea, respectively.

From the study it is revealed that if it is possible to sow the above mentioned crops in the second week of November (after harvest of rice) and one supplemental irrigation is provided at pod formation stage, crops will produce optimum yield during post rainy season (dry / *rabi)* in rainfed medium land rice area with shallow water table.

- **Soil upward flux (capillary contribution) from groundwater table to second crops**

Water flux for all the crops and with different irrigation levels was found to be in upward direction which might be due to the presence of shallow water table. Total upward flux of 217, 187, 171 and 204 mm was computed (from pooled data of two study years) for groundnut, blackgram, greengram and chickpea, respectively when no irrigation was applied. In case of groundnut, 37.1 - 58.1 % of actual water use was contributed by upward flux whereas contribution of upward flux to blackgram, greengram and chickpea was 36.9 - 55.6 %, 34.4 - 52.7 %, and 38.1 - 51.9 % of actual water use respectively, in different irrigation treatments (Table 17). The different upward flux was observed which might be due to the difference in growth duration, root water uptake pattern and evaporative demand of different crops. From the pooled data of two years, it was revealed that soil upward flux was reduced when irrigation was applied and twice-irrigated plots exhibited minimum upward flux across the root zone (1.20 m).

Photo-23(a) : Visit of Dr R.S.Tripathy (Lead PI) and Dr. H.N. Verma (Director, WTCER) to medium land experimental site with shallow water table

Photo-23 (b): Dr H.N.Verma interacting with a farmer regarding crop performance in medium land experimental site with shallow water table

Photo-24: Measurement of soil upward flux from groundnut

Photo-25: Measurement of soil upward flux from greengram

Photo-26(a &b) : Performance of rainfed chickpea in mediumland rice fallow with shallow water table

- **Productivity and field water use efficiency of second crops in rice fallow**

The productivity of second crops (kg ha^{-1}) was computed from the final harvest of crops and pooled data of both study years are presented in Table 17. Owing to higher soil upward flux and moderate available water capacity, reasonable yield was obtained even under rainfed condition with the mean values being 940, 716, 720 and 510 kg ha^{-1}, in groundnut, blackgram, greengram and chickpea, respectively. Study also revealed that 57.4 %, 51.6 %, 38.1 % and 42.0% yield was enhanced in groundnut, blackgram, greengram and chickpea, respectively when one irrigation was applied at pod formation stage as compared to no irrigation. With one irrigation 1480, 1086, 995 and 725 kg ha^{-1} yield, was obtained in groundnut, blackgram, greengram and chickpea, respectively. Whereas, with two irrigation, very less yield was enhanced (only 2-3 %) over one irrigation for all the crops. It might be due to the fact that one irrigation of 60 mm at pod formation stage was sufficient to meet the total crop water requirements of all the crops which was sown in the second week of November when sufficient amount of carry-over residual soil moisture was available in the field.

The field water use efficiency (kg ha^{-1} mm^{-1}) of all the crops was also computed and pooled data of two study years are presented in Table 17. Study revealed that water use efficiency (WUE) of 2.52, 2.12, 2.22 and 1.31 kg ha^{-1} mm^{-1} was achieved when no irrigation was applied in groundnut, blackgram, greengram and chickpea, respectively. With one irrigation 23.7 to 26.4 % WUE was enhanced over no irrigation with the values being 3.72, 2.82, 2.68 and 1.80 kg ha^{-1} mm^{-1} in groundnut, blackgram, greengram and chickpea, respectively.

Table-17 : Soil upward flux, grain yield and water use efficiency of second crops (two year's pooled data) in medium rainfed rice area with shallow water table depth (pooled data of two years).

Crop and irrigation treatment	Capillary contribution (soil upward flux), mm	Actual crop water use (mm) (PD+ER+UF)	% of actual water use contributed by soil upward flux	Grain yield (kg ha^{-1})	Water use efficiency ($kgha^{-1}mm^{-1}$)
Groundnut					
I_0	217	373	58.1	940	2.52
I_1	189	397	47.6	1480	3.72
I_2	164	441	37.1	1522	3.45
$S.E_m(\pm)$	15.30	19.91	6.06	187.39	0,36
Blackgram					
I_0	187	337	55.6	716	2.12
I_1	166	385	43.1	1086	2.82
I_2	156	422	36.9	1111	2.63
$S.E_m(\pm)$	9.13	24.60	5.49	127.70	0.20
Greengram					
I_0	171	324	52.7	720	2.22
I_1	149	371	40.1	995	2.68
I_2	141	409	34.4	1023	2.50
$S.E_m(\pm)$	8.96	24.58	5.40	96.67	0.13
Chickpea					
I_0	204	387	51.9	510	1.31
I_1	185	402	46.0	725	1.80
I_2	171	450	38.1	750	1.66
$S.E_m(\pm)$	9.56	19.00	3.99	76.17	0.14

I0= No irrigation, I1= One irrigation, I2=Two irrigation, 60 mm water was applied in each irrigation.
PD=Profile depletion (mm), ER = Effective rainfall (mm), UF = Soil upward flux (mm)

- **Economics of rice based cropping system in rainfed shallow medium land rice area**

The economics of rice based cropping system under improved management practices in the rainfed shallow lowland rice ecosystem was computed and the results of 2001-02 and 2002-03 are presented in Table 18. Study revealed that without any irrigation, Rs 22315 ha^{-1}, Rs 20395 ha^{-1}, Rs. 19743 ha^{-1} and Rs. 17805 ha^{-1} net return was obtained from rice-groundnut, rice-blackgram, rice-greengram and rice-chickpea, respectively (pooled data of two years). With one irrigation to second crops, Rs. 29375 ha^{-1}, Rs. 25355 ha^{-1}, Rs.23085 ha^{-1}, Rs. 20530 ha^{-1} net return was obtained from rice-groundnut, rice-blackgram, rice-grengram and rice-chickpea, respectively. Whereas, rainfed sole rice produced only Rs. 14155 $ha^{-1}$and Rs. 6980 ha^{-1} net return under improved and farmers' management practices, respectively. Study also revealed that with two irrigation, the net return did not significantly increase due to increase cost of irrigation and productivity of second crops was not enhanced propotionately with two irrigation over one irrigation.

8.2 Development of suitable rice based cropping system to increase cropping intensity and productivity of lowland rainfed rice ecosystem

Experiment-4: **Increasing productivity and cropping intensity of rainfed lowland rice ecosystem through alternate seeding/tilling methods.**

Table-18: Net return from different crop combinations in medium land with shallow water table depth

Crop Combination	*Net return from first crop (Rs ha^{-1})	Net return from first crop (Rs ha^{-1})			Total return (Rs ha^{-1})		
		I_0	I_1	I_2	I_0	I_1	I_2
Rice-groundnut	14155	8160	15220	15300	22315	29375	29445
Rice-blackgram	14155	6240	11200	11165	20395	25355	25320
Rice-greengram	14155	5580	8930	8980	19743	23085	23055
Rice-chickpea	14155	3650	6375	6250	17805	20530	20405
Monocropped rice (farmers' practice)	6980	-	-	-	6980	6980	6980

** Net return includes value of straw yield of rice.*

- **Soil properties of experimental site**

The upper two layers (0-0.30 m) were clay loam in texture, whereas next two layers (0.30-0.45 and 0.45-0.60 m) were sandy clay loam in nature (Table 19). The bulk density was 1.58 mg m^{-3} at 0-0.15 m soil depth and it increased with depth, at 0.90-1.20 m layer it was 1.65 mg m^{-3}. The pH was slight to moderately acidic and no salt problem was detected in the soil profile. The organic carbon content was relatively higher (0.82%) at upper layer (0-0.15 m) while at deeper layer it was only 0.21%. The soil fertility was very low with Olsen P and available K (NH4OAc-K) was 3.1 mg P kg^{-1} and 87 mg K kg^{-1} of soils. The water content at field capacity was 0.267 m^3m^{-3} at 0-0.15 m layer and the highest water content was 0.294 m^3m^{-3} at 0.45-0.60 m soil depth. The available water content was 0.144, 0.142, 0.150, 0.154, 0.152 and 0.194 m^3m^{-3} at 0-0.15 m, 0.15-0.30 m, 0.30-0.45 m, 0.45-0.60 m, 0.60-0.90 m and 0.90-0.120 m soil depth, respectively.

Table-19: Important soil properties of rainfed lowland rice experimental site

(a) Particle size analysis

Soil depth (m)	Particle size distribution (%)				Textural class	Bulk density (Mg m^{-3})
	Coarse sand	Fine sand	Silt	Clay		
0.00-0.15	24.1	21.1	23.8	31.0	cl	1.58
0.15-0.30	25.2	23.2	24.6	27.1	cl	1.58
0.30-0.45	23.8	26.8	26.3	23.1	scl	1.59
0.45-0.60	28.2	21.7	28.2	21.9	scl	1.61
0.60-0.90	26.3	20.7	24.3	28.7	cl	1.61
0.90-1.20	27.1	17.3	23.8	31.8	cl	1.65

(b) Water retention properties

Soil depth (m)	θ_s (m^3m^{-3}) at 0.01 MPa	θ (m^3m^{-3}) at 0.33 MPa	θ (m^3m^{-3}) at 1.5 MPa	Available water content (m^3m^{-3})
0.00-0.15	0.313	0.267	0.123	0.144
0.15-0.30	0.293	0.263	0.121	0.142
0.30-0.45	0.330	0.283	0.133	0.150
0.45-0.60	0.353	0.294	0.138	0.154
0.60-0.90	0.343	0.293	0.141	0.152
0.90-1.20	0.367	0.325	0.131	0.194

- **Enhancement of rice yield and net return during (rainy) season with improved practices over farmers' practices.**

Study revealed that rice (cv. Gayatri) yield of 5.31 and 4.85 t ha^{-1} was obtained under improved management practices in 2001-02 and 2002-03, respectively (Fig. 22). Whereas under farmers' management 2.75 and 2.45 t ha^{-1} yield was obtained in two respective study years, which was 93.0 % and 59.0 % higher than that of farmer's practices in 2001-02 and 2002-03, respectively. Due to the occurrence of dry spells in 2002, 9.4% and 12.2 % less yield was obtained in 2002 under improved and farmer's management practices, respectively.

- **Grain yield of dry/*rabi* (winter) season crops after wet/*kharif* (rainy) season rice with different seeding/tilling methods**

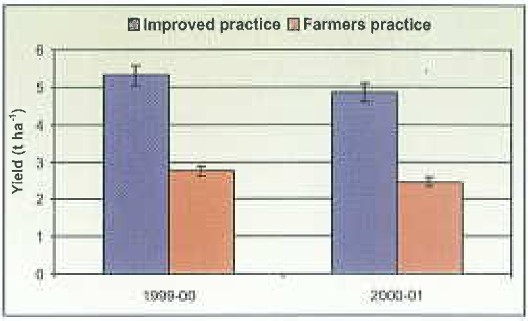


Fig.-22: Grain yield of rice (cv. Gayatri) with improved and farmers' management practices

Study revealed that tillage and seeding methods had a significant effect ($P < 0.001$) on grain yield of winter crops (Table 20) and the highest, mean yield of 590, 620, 670, 490 kg ha^{-1} was obtained in lathyrus, blackgarm, pea and chickpea, respectively when two ploughings were applied in different days and seeding was done after second ploughing. With farmer's traditional relay cropping system, only 350, 300, 400 and 220 kg ha^{-1} grain yield was obtained in lathyrus, blackgram, pea and chickpea, respectively. With two ploughings 68.5 %, 106.6 %, 67.5 % and 122.7 % higher yield was obtained in lathyrus, blackgram, pea and chickpea, respectively over traditional relay cropping system. On the other hand with conventional tillage only 430, 490, 510 and 270 kg ha^{-1} yield was obtained in four respective crops. It might be due to fast depletion of soil moisture by evaporation from the field due to repeated ploughing. As a result, less moisture was available in the field throughout the growing period in the conventional tillage treatment than that of other treatments.

Table-20: Yield (pooled data of three years) of different crops with different seeding/tilling methods in rainfed lowland rice fallow

Treatments	Crop yield (kg ha^{-1})				Water use (mm)				Water use efficiency (kg ha^{-1} mm^{-1})			
	Lathyrus	Black gram	Pea	Chick pea	Lathyrus	Black gram	Pea	Chick pea	Lathyrus	Black gram	Pea	Chick pea
R	350	300	400	220	303	323	305	329	1.15	0.92	1.31	0.66
T1	510	570	590	400	288	291	272	298	1.77	1.95	2.16	1.34
T2	590	620	670	490	272	280	291	285	2.16	2.21	2.30	1.71
Z	390	420	430	330	289	299	297	305	1.34	1.40	1.44	1.08
C	430	490	510	270	221	237	225	241	1.94	2.06	2.26	1.12
Mean	454	480	520	342	275	286	278	292	1.67	1.70	1.89	1.18
$S.E_m (\pm)$	35.17	46.11	40.82	38.93	11.65	11.54	11.69	11.86	0.15	0.19	0.17	0.14

R =Relay (farmers' practice), T1 = One ploughing and sowing on same day, T2 = Two ploughing in different days and sowing after second ploughing, Z = Zero tillage, C = Conventional tillage

- **Field water use and water use efficiency (WUE)**

Study revealed that (Table-20) the highest water use efficiency (pooled data of three years) was achieved when two ploughings were applied (T_2) with the mean values being 2.16, 2.21, 2.30 and 1.71 kg ha^{-1} mm^{-1} in lathyrus, blackgram, pea and chickpea respectively. On the other hand, under relay cropping the WUE was 1.15, 0.92, 1.31 and 0.66 kg ha^{-1} mm^{-1} , in respective four crops. The seasonal water use 272, 280, 291 and 285 mm of lathyrus, blackgram, pea and chickpea was computed, respectively when sowing was performed after two ploughings.

Photo-27: Blackgram under relay cropping in standing paddy

Photo-28: Blackgram with minimum tillage

Photo-29: Blackgram with two ploughing

Photo-30 (a): Chickpea under relay cropping in standing paddy.

Photo-30(b): Chickpea under relay at later stage

Photo-31: Chickpea with minimum tillage

Photo-32: Performance of pea under relay cropping

Photo-33: Performance of lathyrus under relay cropping .

- **Economics of rice based cropping system in lowland rainfed rice ecosystem with different seeding/tilling methods**

The economics of rice (under improved management) based cropping system (rice-lathyrus/blackgram/pea/chickpea) was computed and compared under different seeding/tilling methods (Table 21).

Study revealed that from first crop rice (pooled data of two years) Rs. 16320 ha^{-1}and Rs. 8400 ha^{-1} net return was obtained with improved and farmers' management practice, respectively. The total net return of Rs. 18570 ha^{-1}, Rs. 21620 ha^{-1}, Rs. 22370 ha^{-1} and Rs. 19670 ha^{-1} was obtained from rice-lathyrus, rice-blackgram, rice- pea, rice-chickpea respectively when two ploughing were applied in two different days, and sowing was done after second ploughing. With relay cropping only Rs. 500 ha^{-1}, Rs. 1200 ha^{-1}, Rs. 1800 ha^{-1} and Rs. 300 ha^{-1} net return was obtained from lathyrus, blackgram, pea and chickpea, respectively.

Experiment-5: Effect of integrated nutrient management on the grain yield of rice and subsequent winter crops in sequence in rainfed low land rice fallow.

- **Productivity of *kharif* rice during rainy season with different combination of nutrient sources.**

Grain yield of rice was significantly influenced due to application of fertilizer (NPK) in conjunction with different sources of organic matter (FYM, press mud or green manures) applied to rice. From pooled data of three study years, it is revealed that the highest yield (5380 kg ha^{-1}) of rice (cv. Gayatri) was obtained when 25% NPK fertilizer was supplied through green

Photo-34: Low land rice with inorganic fertilizer only

Photo-35: Substitution of 25% NPK with green manure

Photo-36: Substitution of 25% NPK with Pressmud

Photo-37: Substitution of 25% NPK with FYM

Photo-38: Organizing farmers' training cum field day on 19.03.2004 at Dhenkanal (Dr. I.C.Mahapatra, former VC, OUAT, chief guest on the occasion)

Photo-39: Large number of farmer's and agricultural officers of the district attended the training programme on 19.3.04

Photo-40: Organizing Brain storming session on 'Increasing cropping intensity rainfed rice area of eastern India' (Dr. D. Lenka, former Dean, OUAT, the chief guest on that occasion)

Photo 41: Dr. H.P. Singh, Former Director, CRIDA addressing the farmers during farmers fair organized by WTCER

Photo-42 : District Magistrate and Collector of the district, Mr. N. Mohanty speaking to the farmer's in a farmer's fair organized by WTCER

Photo-43: Dr. I.C. Mohapatra, Former Vice Chancellor, OUAT, Bhubaneswar addressing the farmers.

Photo-44: Visit of Dr. H.N.Verma (Director, WTCER) to the adoption site of winter maize at Arnapurnapur, Dhenkanal with harvested rainwater

Photo-45: Adoption of sunflower with harvested rainwater by farmers of Arnapurapur village, Dhenkanal in large area

Photo-46: Adoption of groundnut without irrigation in large area in rainfed rice fallow with shallow water table at Kingol, Dhenkanal

Photo-47: Adoption of groundnut without irrigation in large area in rainfed rice fallow with shallow water table at Noagao, Dhenkanal

Photo-48: Director, WTCER, Dr. H.N.Verma assessing the yield potential of rainfed blackgram adopted by a farmer in lowland rice fallow with shallow water

manures (Dhaincha). The second highest yield was obtained (5250 kg ha^{-1}) with 75% NPK through inorganic fertilizer + 25% NPK through press mud followed by combination of 75% NPK through inorganic + 25% by FYM. The 18.7% less yield was obtained when only inorganic fertilizer was applied (T4) than that of T1 treatment (75% inogranic + 25% Dhaincha). Whereas, with farmers' management practices (T5), only 2990 kg ha^{-1} rice grain yield was obtained.

- **Residual effects of different sources of nutrients on productivity of winter pulses**

After harvesting of rice with residual soil fertility, three pulses (pea, blackgram and greengram) were sown consecutively for three years during *rabi*/dry (winter season) on the same land. This was done to visualize the effect of NPK fertilizer and organic matter management of rice to the succeeding crops. All the three crops achieved highest (490, 463, 438 kg ha^{-1}), when they were raised in the plot, where 75% of the recommended doses of NPK along with Dhanicha were applied (T1) to rice. This treatment was almost statistically at par to all the crops with the treatments T2 (75% of the recommended doses of NPK+ FYM) and T3 (75% recommended doses + press mud), but significantly different from T4 (full inorganic fertiliser) and T5 (farmers' practices). The yield increment in T1 over T5 treatment was 108%, 139% and 193% from pea, greengram and blackgram, respectively.

- **Economics from different combinations of nutrients**

Study revealed that the highest total rice equivalent yield 7095 kg ha^{-1} was obtained with rice-pea combination, when rice was grown with 75% NPK through inorganic fertilizer and 25% through green manures, dhaincha (Table 22). The highest net return (Rs. 21380 ha^{-1}) was obtained from rice-pea in that treatment. The second highest net return was obtained in T3 treatment from rice-pea combination (Rs. 20792 ha^{-1}). Whereas, net return of Rs. 16916 $ha^{-1,}$ Rs. 16232 ha^{-1} and Rs. 16536 ha^{-1} was obtained from rice-pea, rice-greengram and rice-blackgram, respectively when only inorganic sources of nutrients were applied. Under farmers' management, only Rs. 8764 ha^{-1}, Rs. 8232 ha^{-1} and Rs. 7548 ha^{-1} net profit were obtained in three respective cropping systems.

Table-21: Net return from different crop combinations with different seeding/tilling methods

Crop Combination	*Net return from first crop (Rs ha^{-1})	Net return from second crop (Rs ha^{-1})				Total return (Rs ha^{-1})			
		Lathyrus	Black gram	Pea	Chick pea	Lathyrus	Black gram	Pea	Chick pea
R	16320	500	1200	1800	300	16820	17520	18120	16620
T1	16320	1600	5050	5350	2500	17920	21370	21670	18820
T2	16320	1900	5300	6050	3350	18220	21620	22370	19670
Z	16320	650	3050	3200	1700	16970	19370	19520	18020
C	16320	-	2850	3150	-	16320	19170	19470	16320
Mean	16320	930	3550	4150	1570	17250	19870	20470	17890
Monocroped rice (farmers' prictice)	8400	-	-	-	-	8400	8400	8400	8400

** Net return includes value of straw yield of rice.*

9. TECHNOLOGY DISSEMINATION PROGRAMME CONDUCTED

The different technologies for improving productivity and cropping intensity of medium and lowland rainfed rice eco-system generated based on on-farm research trials were demonstrated to the farming community by organizing different technology dissemination programmes.

- A workshop was organized at WTCER from 13-15th June, 2001 and during the workshop, a brainstorming session was organized on 'Increasing cropping intensity in rainfed rice area of eastern India', in which farmers, NGOs and experts from WTCER, OUAT, Bhubaneswar and other local ICAR institutes participated.

Table-22: Effect of integrated nutrient management on the grain yield of *kharif* (wet season) rice and subsequent winter crops (*rabi*/dry season) in sequence in rainfed low land rice fallow (Pooled data of 2000-01, 2001-02, 2002-03).

Fertilizer + organic matter treatment on rice	Grain yield ($kg\ ha^{-1}$)				Rice equivlent yield from the system ($kg\ ha^{-1}$)	*Net return ($Rs.ha^{-1}$) from the system
	Kharif rice	Winter crops				
		Pea	Greengram	Blackgram		
T_1 (25% NPK through Dhaincha)	5380	490	-	-	7095	21380
	5380	-	463	-	7001	21004
	5380	-	-	438	7023	21092
T_2 (25% NPK through FYM)	5080	480	-	-	6760	20040
	5080	-	428	-	6578	19312
	5080	-	-	405	6599	19396
T_3 (25% NPK through Press mud)	5250	485	-	-	6948	20792
	5250	-	433	-	6766	20064
	5250	-	-	395	6731	19924
T_4 (100% inorganic)	4530	414	-	-	5979	16916
	4530	-	365	-	5808	16232
	4530	-	-	361	5884	16536
T_5 (Farmers' practice)	2990	236	-	-	3816	8764
	2990	-	198	-	3683	8232
	2990	-	-	149	3512	7548
$S.E_m(\pm)$	431.61	48.27	47.60	51.63		

** Net return includes value of straw yield of rice*

- A training programme was conducted on 18th - 19th April, 2002 on drought mitigation, community base rainwater harvesting, improved rainfed crop and water management and crop diversification for different stakeholders such as Panchyayat Raj Institutes, Gram Panchyat volunteers./village volunteer, village agriculture worker (VAW), village level workers (VLW), stage agricultural development and extension officials.
- Two farmers field day/ farmers' fair were organized on 5.9.2000 and 25.8.2001 near the experimental site for the dissemination of successful technology. In those field days/ farmer's fair, several hundreds of farmers, government official including collector and district magistrate of the district, Director of Agriculture, Govt. of Orissa, Deputy Director of Agriculture, Directors of local ICAR institutes, Dean (Research) of OUAT, Bhubaneswar were present and they interacted with the farmers.
- The complete technology package of practices of in up and lowland rainfed rice area of eastern India were prepared in different languages (English, Hindi, Oriya) and circulated widely to the farmers & NGOs, state agricultural and extension officials of different eastern Indian states.
- A farmers' meeting cum field day was organized on 19.3.2004 near the experimental site where around 250 progressive farmers along with agricultural officers of all the blocks of Dhenkanal district were attended.

- The technology generation, its scientific and socio-economic relevance was also covered by several local (The Samaj, The Dharitri, The Anupam Bharat, The Sambad) and National English Daily (The Indian Express, The Statesman, The Asian Age, The Hindustan Times) and telecasted in local cable Television Network, OTV on 22.3.2004 and ETV on 21.4.2004.

10. PROJECT IMPACT, TECHNOLOGY ADOPTION AND SUCCESS STORY

The actual impact of the recommendations in medium and low land rainfed rice ecosystem has been reflected both in terms of (a) improving productivity of rice during rainy season and (b) increasing cropping intensity through adoption of second crops in rice-fallow. The success story was covered by different national and regional news papers. The impact was also reflected from the feedback of the farmers.

10.1 Impact on productivity of rice during rainy season

During the wet/*kharif* (rainy) season, rice was growing with traditional cultivation practices and most of the rice varieties under cultivation were of comparatively longer duration and consequently average productivity of rice was low (2 t ha^{-1}). The recommendations of improved practices with high yielding varieties of rice have been adopted by farmers and after adoption the yield was enhanced from 2.0 t ha^{-1} to 3.8 t ha^{-1} in rainfed medium land and to 4.5 t ha^{-1} in rainfed lowland (Table -23)

Table-23: Adoption of improved practices for improving rainfed rice productivity during 2003

Village	Area under medium and low land (ha)	Average productivity before execution of the project	Area adopted (ha)	% of adoption	Average productivity after project execution (t ha^{-1})	Varieties adopted after project execution
Arnapurnapur	55	2.1 (Medium land)	40	72.7	3.8	Lalat, Parijat, Swarna
		3.1 (lowland)			4.8	Gayatri, Savitri
Noagao	82.3	2.2 (Medium land)	70	85.1	4.0	Lalat, Swarna, Ramachandi
		3.0(Low (lowland)			4.8	Gayatri, Savitri, T-1242, CR-1030
Kingol	403.5	2.0(Medium land)	252	62.4	3.8	Swarna, Lalat
		3.1 (lowland)			4.7	Gayatri, Savitri

10.2 Impact on increasing cropping intensity

The residual soil moisture utilization along with soil upward flux for growing double crops in shallow lowland rice fallow created a tremendous impact in Noagao, and Kingol villages of the study district (Dhenkanal). About 80 % of the farmers of these villages adopted the technology in 2002-03 and 2003-04. This second crop in shallow lowland rice fallow is total gain to the farmers because they were totally unaware about the concept of upward flux. In Arnapurnapur, with the help of harvested rain water using limited irrigation at critical growth stages, farmers are now able to grow second crops in rainfed medium land rice fallow. Maximum farmers adopted winter maize, sunflower, groundnut, cucumber owing to their high market demand and net return. With residual soil moisture in lowland valley fill area, farmers are adopting blackgram, greengram, pea with recommended seeding/tilling practices. As a result of growing second crops in rice fallow, after four years of study (1999 to 2003), cropping intensity of the villages has increased by 68.8%, 64.4 % and 24.9 % in Arnapurnapur, Noagao and Kingol, respectively (Study based on December, 2003) (Table-24).

The World Bank Team (NATP) consisting of Dr. James, G. Ryan, International Agricultural and Development Consultant, USA, Dr. J. S. Kanwar, Dr. N. G. P. Rao, Dr. I.C. Mahapatra, Ex-Vice Chancellor, OUAT, Bhubaneswar, Dr. H.P. Singh, Retd. Director CRIDA, Directors of local ICAR Institutes visited the adoption site of the project and interacted with farmers regarding viability and sustainability of the technology recommended by WTCER even in deficit rainfall years.

Table-24: Increase of cropping intensity (%) in study villages after execution of project

Village	Area under medium and low land (ha)	Double cropped area before project (ha)	Double cropping area after* project (ha)	Cropping intensity (%) before project	Cropping intensity (%) after* project	Adopted crops with limited irrigation scheduling and or with residual moisture
Arnapurnapur	55.0	4.5	42.5	108.1	177.2	Groundnut, Pea, Blackgram, Wheat, Potato, Sunflower, Winter maize
Noagao	82.3	5.4	58.3	106.5	170.8	Groundnut, Pea, Blackgram, Greengram
Kingol	403.5	43.6	159.7	110.8	135.9	Groundnut, Blackgram, greengram, Pea

* *During ending year (2003-04) of the project.*

11. CONCLUSION

The study amply demonstrated the potentiality of growing atleast two crops in rainfed medium and lowland rice ecosystem utilizing residual soil moisture, limited irrigation from harvested rain water and soil water upward flux. In medium and lowland rainfed rice area farmers were growing local rice varieties with traditional cultivation practices. The recommendations of improved practices with high yielding varieties of rice enhanced grain yield upto 4.5 t ha^{-1} in rainfed medium land and 5.31 t ha^{-1} in rainfed lowland rice area during wet/ *kharif* (rainy) season from existing 2 t ha^{-1} average yield. In the medium land with deep water table, water depletion is very fast after harvesting of rice and growing of second crop in rice fallow is risky without supplemental irrigation.

Study revealed that there was lot of potential of rain water harvesting in the region which can be used for providing supplemental irrigation to second crops in medium land rice fallow with deep water table. Among different field crops grown with limited irrigation, rice-maize(cob) was the most profitable followed by rice-sunflower (grain) and rice-groundnut (kernel). Study also revealed that light texture with high transmitting character of the soil profile produced a negative or little soil upward flux in medium land with deep water table. On the other hand, in medium land with shallow water table 37-58.1%, 36.9-55.6%, 34.4-52.7% and 38.1-51.9% of crop water requirements were satisfied through soil upward flux (capillary contribution) in groundnut, blackgram, greengram and chickpea, respectively. As a result with one or even no irrigation economic yield from second crop was obtained in rainfed rice fallow with shallow water table. It is also revealed that productivity and water use efficiency of second crops in rainfed lowland rice area can be improved following better seeding/tilling methods over traditional relay cropping with carry-over residual soil moisture.

Study also revealed that with the combination 75% in organic + 25% green manures (dhanicha) as sources of nutrients resulted in 30-35 % higher yield than that of farmers' practices.

12. ACKNOWLEDGEMENT

We take this opportunity to extend our gratitude to District Magistrate & Collector and DDA, Dhenkanal., B. D. O., Kamakhyanagar, KVK, Dhenkanal, Central Rubber Board, Dhenkanal for their support to undertake the programme in Dhenkanal district and for providing necessary information to carry out the study. Authors sincere thanks are due, to the villagers of Dhenkanal district for their active participation during study. Thanks are due to project associates, scientists, senior research fellows and staff members of WTCER, for providing necessary information and for their moral support and help rendered during study.

13. REFERENCES

Allen, R. G., Pereira, L. S., Raes, D. and Smith, M. 1998. Crop evapotranspiration Guidelines for computing crop water requirements. FAO Irrigation and Drainage Paper 56.

Budhar M.N., Palaniappan S.P. and Rang Swamy A. 1991. Effect of farm wastes and green manures. Indian J. Agronomy 36 (2): 251-52.

Das J.C. 2001. Rainwater harvesting and utilization for supplemental irrigation to crops. Compendium on state level collaboration training programme on land and water management form 6th to 10th February, 2001, 85-92.

Doorenbos, J. and Pruitt, W.O., 1975. Crop Water Requirements. Irrigation and Drainage Paper No. 24, FAO, Rome, p. 179.

Elsenbeer H. 2001. Preface of the special issue on Pedotransfer functions in hydrology. Journal of Hydrology. 251, 121-122.

Grismer, M. E., and Gates T. K., 1988. Estimating saline water table contribution to crop water use. Calif. Agric. 42: 23-24

Hunsaker D.J., Kimball BA, Pinter Jr. P.J., La Morte, R.L. and Wall G.W. 1996. Carbon dioxide enrichment and irrigation effects on wheat evapotranspiration and water use efficiency. Trans. ASAE 39 (4):1345-1355.

Jat R.L. and Das D.K. 1978. Water use by irrigated and unirrigated wheat. Proc. Int. Sym. On 'Improving crop and animal productivity by nuclear and allied techniques'. New Delhi.

Jhorar L.R., Phogat V.K. Agarwal M.C. and Dhuke R.S.2001. Water flux into the root zone of wheat vs irrigation amount under shallow water table. Journal of Agricultural Physics. 1(1): 117-120.

Maesschalck, G. G., Lim K. H., Maene, L. M. and Mokhtaruddin, A. M., 1979. Determination of the hydraulic conductivity of a Malaysian soil using tensiometers and neutron moisture meter: Problems and Potentials. p. 41-62. In Proceedings of the symposium on water in Malaysian agriculture, Kaula Lumpur.

Merril S.D. 1992. Pressurized-wall minirhizotron for field observation of root growth dynamics. Agron. J. 84: 755-758.

Merril S D, Tanaka D.L. and Hanson J.D. 2002. Root length growth of eight crops species in Haplustoll soils. Soil Sci. SOC. Am. J. 66: 913-923.

Norwood C.A. and Dumler T.J. 2002. Transition to Dry land Agriculture. Limited irrigation vs. dryland corn. Agron. J. 94: 310-320.

Prasad U.K., Yadav V.K., Prasad T.N., Kumar A and Prasad S.M. 2000. Effects of levels of irrigation and nitrogen on oil percent, yield, moisture depletion and water use efficiency of winter sunflower (*Helianthus annus*). Indian Journal of Agronomy 45(4) : 147-152.

Prihar S.S., Cheri K.I., Sandhu K.S. and Sandhu B..S. 1976. Comparison of irrigation schedules based on pan evaporation and growth stages of winter wheat. Agron. J. 60: 650-653.

Prihar, S.S. and Sandhu B.S., 1987. Irrigation of field crops - Principles and Practices. ICAR, New Delhi. India.

Puste A.M., Bandopadhyaya S., Mishra B.P. and Gunri S.K. 1999. Effect of NPK and organic matter on the productivity and profitability in rice-oil seed cropping sequence. Orxza, 36 (4): 335-338.

Rose, C. W., Stern, W. R., and Drummond, J. E., 1965. Determination of hydraulic conductivity as a function of depth and water content for soil in situ Aus. J. Soil Res. 3:1-9.

Sarker S, Singh S.R., Singh Y. 2000. Effective use of harvested water in relation to productivity and water use pattern of barely and rajmash as intercrop. Journal of Indian Soc. of Soil Science. 824-826.

Saravaran, A., Velu V. and Ramannathan, K.M. 1987. Effect of combined application of bio-organic and chemical fertilizers on physico-chemical properties, nitrogen transformation and yield of rice in submerged soils of Cauvery delta. Oryza 24, 1-6.

Sepaskhah, A.R., Kanooni, A. and Ghasemi M. M., 2000. Estimating water table contributions to corn and sorghum water use. Agricultural Water Management. 58: 67-79

Singh V.P. and Hossain M. 2000. Rice area in different ecosystems in eastern India. Singh. V.P. and R.K. Singh, editors Rainfed rice : A source book of best practices and strategies in eastern India. International Rice Research Institute : 7-8.

Singh J.P., Prasad U.K. and Singh H. 2000. Effects of irrigation and drainage requirements on water-use-efficiency and yield of maize (*Zea mays*) based intercrops. Indian J. of Agricultural Sciences 70(2): 65-68.

Singh R.D. and Sinha H.N.1987. Water management practices for wheat. India J. Soil Conservation. 15, 101-106.

Singh, P. 1989.Water stress and plant parameters for wheat. Indian So. Agric. Engrgs, 85, 34-40.

Tyagi N.K, Sharma D.K., and Luthra S.K.2000. Evapotranspiration and crop coefficient of wheat and Sorghum J. Irrig. Drain. Eng. 126, 215-222.

Wallender, W.W. Grimes, D.W., Henderson, D.W. and Stomberg, L.K. 1979. Estimating the contribution of a perched water table to the seasonal evapotranspiration of cotton. Agron. J. 71, 1056-1060.

Zaman A., Mallick S, and Jana. P.K. 2000. Effect of mulching on water use and grain yield of wheat under different irrigation regions in latertic soil. Principles and practices of Soil and Water Conservation, edited by G. B. Ray, D. Saha and D. K. Dutta.

News-1: The Indian Express on 22.3.2004.

Training focuses on better cropping ideas

Dhenkanal, March 21 : Agriculture scientists were asked to guide farmers for a better yield and in creating employment opportunities, at the farmers training programme conducted by Western Technology Centre for Easter Region (WTCER) here.

District Collector Nitya Nanda Mohanty, in his address, urged WTCER scientists to explore employment opportunities and help reduce poverty in the district. He informed that the administration has launched watershed development projects and water harvesting structures in different parts of the district.

Watershed development projects have been launched in the district

Appreciating the efforts of WTCER in increasing production by crop diversification and inter-cropping system in Kamakhyanagar sub-division in the last three years, he sugested spread of this movement to other parts of the district. He advised farmers to adhere to scientific methods of farming and cultivate cash crops instead of traditional ones.

Former vice-chancellor of OUAT Iswar Chandra Mohapatra said there should be coordination among scientists, farmers and extension officers for better results through intercropping and crop diversification in rain-fed areas.

Senior scientist and WTCER Dhenkanal unit in-charge G. Kar highlighted the successful crop diversification and intercropping in Jiral, Kadalipal and other areas of Kamakhyanagar. Deputy Director of Agriculture K. Nayak and scientists R.C. Sribastav and R. Singh spoke• ENS

News-2: The Statesman on 22.3.2004

Scientists urged to create jobs

Statesman News Service

DHENKANAL, MARCH 21 - DC Mr. Nitya Nanda Mohanty has urged the scientists of Western Technology Centre for Eastern Region to explore and help create employment opportunities in the district. The WTCER works under Indian Council of Agriculture Research. About 47 per cent of the people live below poverty line in Dhenkanal.

Addressing a farmers' training programme conducted by WTCER here recently, Mr. Mohanty said the administration has launched watershed development projects and water harvesting structures in different places. Ample resources are available and potential sources employment opportunities can be created in the district, he said.

The district collector requested agriculture scientists to evolve measures through which farmers and youth get better economic returns and more employment avenues. Appreciating efforts of the WTCER of increasing production through crop diversification and intercropping in Kamakshyanagar subdivision over the past three years, he suggested replication of the same in other parts of the district.

Formcer vice-chancellor of Orissa University of Agriculture Technology Mr Iswar Chandra Mohapatra emphasised upon improved coordination between scientists, farmers and extension officers for better results in intercropping system and crop diversification in rain fed areas. Educated farmers should spot their problems and discuss them with scientists and agricultural experts on the spot, he said.

Senior scientist and WTCER (Dhenkanal) unit incharge Dr G. Kar highlighted the success of crop diversification and intercropping in Jiral, Kadalipal and other areas of Kamakshyanagar, which have become a success story in other parts of state.

Coverage of Technology Dissemination in Regional News Papers (Oriya)

News-3: The Samaj on 24.3.2004

ପୂର୍ବାଞ୍ଚଳ ଜଳପ୍ରାଦ୍ୟୋଗୀକୀ କେନ୍ଦ୍ରର କୃଷକ ତାଲିମ କର୍ମଶାଳା

ଢେଙ୍କାନାଳ, - ତା ୨୦।୪ (ନି.ପ୍ର.) - ଭୁବନେଶ୍ୱରସ୍ଥିତ ପୂର୍ବାଞ୍ଚଳ ଜଳପ୍ରାଦ୍ୟୋଗିକୀ କେନ୍ଦ୍ର ପକ୍ଷରୁ ଢେଙ୍କାନାଳ ଆଞ୍ଚଳିକ ବିଜ୍ଞାନ କେନ୍ଦ୍ରର ପ୍ରେକ୍ଷା ଗୃହରେ ଜିଲ୍ଲାର ବୃଷ୍ଟିପୃଷ୍ଟ ଅଞ୍ଚଳର ଚାଷୀଙ୍କ ପାଇଁ ଏକ ଦୁଇଦିନିଆ ତାଲିମ କର୍ମଶାଳା ଆୟୋଜିତ ହୋଇଯାଇଛି । ଗତ ୧୮ ଓ ୧୯ତାରିଖରେ ଅନୁଷ୍ଠିତ କର୍ମଶାଳାରେ ଜିଲ୍ଲାର ୮ଟି ଯାକ ବ୍ଲକରୁ ୨୦୦ କୃଷକ ପ୍ରତିନିଧି ଅଂଶଗ୍ରହଣ କରିଥିଲେ । ଭାରତୀୟ କୃଷି ଗବେଷଣା ପରିଷଦ ଦ୍ୱାରା ପରିଚାଳିତ ପୂର୍ବାଞ୍ଚଳ ଜଳ ପ୍ରଦ୍ୟୋଗିକୀ କେନ୍ଦ୍ର ଜିଲ୍ଲାର ଅନ୍ନପୂର୍ଣ୍ଣାପୁର, ଜହ୍ନାପଡା, କିଙ୍ଗୋଳ, ଜିରାଳ ଓ ନୂଆଗାଁ ଆଦି ୫ଟି ଗ୍ରାମରେ ସ୍ୱତନ୍ତ୍ର କୃଷି ବୈଷୟିକ ପ୍ରକଳ୍ପ କାର୍ଯ୍ୟକାରୀ କରୁଛନ୍ତି । ୧୯୯୯ରୁ ଏହି ପ୍ରକଳ୍ପର ଶୁଭାରମ୍ଭ ହୋଇଛି । ଢ଼ିପଜମିରେ ବର୍ଷାଜଳର ଫଳପ୍ରଦ ଉପଯୋଗ ଜରିଆରେ କୃଷି ଉତ୍ପାଦନ ବୃଦ୍ଧି, ଜମିରେ ଆଦ୍ରତା ସଂରକ୍ଷଣ ଓ ଗୋଟିଏ ଜମିରେ ଏକାଧିକ ଫସଲର ଧାରାବାହିକ ଚାଷ ଆଦି ସମ୍ପର୍କରେ ଚାଷୀମାନଙ୍କୁ ପ୍ରକଳ୍ପ ଜରିଆରେ ଅବହିତ କରାଯାଉଛି ।

କର୍ମଶାଳାରେ ପୂର୍ବାଞ୍ଚଳ ଜଳପ୍ରାଦ୍ୟୋଗିକୀ କେନ୍ଦ୍ରର ନିର୍ଦ୍ଦେଶକ ଡା. ଏଚ.ଏନ. ବର୍ମା ସ୍ୱାଗତ ସୂଚନା ଦେଇଥିଲେ । କେନ୍ଦ୍ରର ବରିଷ୍ଠ ବୈଜ୍ଞାନିକ ଡାଃ ଗୌରାଙ୍ଗ କର କର୍ମଶାଳାର ଉଦ୍ଦେଶ୍ୟ ସମ୍ପର୍କରେ ସୂଚନା ଦେଇଥିଲେ । ଶକ୍ତି ସୁଗାରର ସାଧାରଣ ପରିଚାଳକ ଡ. ଆର. ଭେନୁଗୋପାଳ, କୃଷି ଉପନିର୍ଦ୍ଦେଶକ ଘନଶ୍ୟାମ ପାଲ ଏବଂ କଟକ ଧାନ ଗବେଷଣା କେନ୍ଦ୍ରର ପୂର୍ବତନ ନିର୍ଦ୍ଦେଶକ ଡା. ଏଚ.କେ. ପାଣ୍ଡେ ଆଲୋଚନାରେ ଭାଗ ନେଇଥିଲେ ।

News-4: The Dharitri on 21.3.2004

ଢେଙ୍କାନାଳରେ କୃଷକ ପ୍ରଶିକ୍ଷଣ କାର୍ଯ୍ୟକ୍ରମ

ଢେଙ୍କାନାଳ ଅଫିସ, ୧୯।୩- ପୂର୍ବାଞ୍ଚଳ ଜଳ ପ୍ରାଦୌଗିକୀ କେନ୍ଦ୍ର, ଭୁବନେଶ୍ୱର ଆନୁକୂଲ୍ୟରେ ଢେଙ୍କାନାଳଠାରେ ଆଜି ଜାତୀୟ କୃଷି ପ୍ରଯୁକ୍ତି ଯୋଜନା ମାଧ୍ୟମରେ ଏକ କୃଷକ ପ୍ରଶିକ୍ଷଣ କାର୍ଯ୍ୟକ୍ରମ ଅନୁଷ୍ଠିତ ହୋଇଯାଇଛି ।

ପୂର୍ବାଞ୍ଚଳ ଜଳ ପ୍ରାଦୌଗିକୀ କେନ୍ଦ୍ର ଭୁବନେଶ୍ୱର ଆନୁକୂଲ୍ୟରେ ସ୍ଥାନୀୟ ଟାଉନହଲଠାରେ ଆଜି ଦିନ ୧୦ଟା ୩୦ମି.ରେ ଆୟୋଜିତ ଏହି କୃଷକ ପ୍ରଶିକ୍ଷଣ କାର୍ଯ୍ୟକ୍ରମରେ ଓ.ୟୁ.ଏ.ଟି.ର ଅବସରପ୍ରାପ୍ତ ଭାଇସ ଚାନ୍ସେଲର ଡଃ ଇଶ୍ବର ଚନ୍ଦ୍ର ମହାପାତ୍ର ମୁଖ୍ୟଅତିଥି ଭାବେ ଯୋଗ ଦେଇଥିଲେ । ଏହି ଅବସରରେ ଡଃ ମହାପାତ୍ର ଉଦ୍‌ବୋଧନ ଦେଇ କହିଲେ ଯେ, ଗତ ୫୭ବର୍ଷ ମଧ୍ୟରେ ଆମଦେଶରେ କୃଷିର ଯଥେଷ୍ଟ ଉନ୍ନତି ଘଟିଛି । ଏଥିସହିତ ଅଳ୍ପ ଜମି ଓ ବୃଷ୍ଟି ବହୁଳ ଜମିରେ ଚାଷୀମାନେ କିପରି ଭଲ ଫସଲ କରିପାରିବେ ସେଥିପାଇଁ ସେମାନଙ୍କୁ ଭଲଭାବରେ ପ୍ରଶିକ୍ଷଣ ଦେବା ଉଚିତ୍ । ଏହି ପ୍ରଶିକ୍ଷଣ କାର୍ଯ୍ୟକ୍ରମରେ ଢେଙ୍କାନାଳ ଜିଲ୍ଲାପାଳ ନିତ୍ୟାନନ୍ଦ ମହାନ୍ତି ସମ୍ମାନିତ ଅତିଥି ଭାବେ ଯୋଗଦେଇ ବିଭିନ୍ନ ଗ୍ରାମାଞ୍ଚଳରେ ବେକାର ଥିବା ଯୁବକମାନେ ପ୍ରଶିକ୍ଷଣ ମାଧ୍ୟମରେ ଉନ୍ନତ ପ୍ରଣାଳୀର କୃଷିଭିତ୍ତିକ କାର୍ଯ୍ୟରେ ମନୋନିବେଶ କରିପାରିଲେ ସେମାନଙ୍କ ଆର୍ଥିକ ପରିସ୍ଥିତ ଭଲ ହୋଇପାରିବ ବୋଲି ମତବ୍ୟକ୍ତ କରିଥିଲେ । ଅନ୍ୟମାନଙ୍କ ମଧ୍ୟରେ କୃଷି ବୈଜ୍ଞାନିକ ଦିନେଶ ଚନ୍ଦ୍ର, ବୈଜ୍ଞାନିକ ଡଃ ରବୀନ୍ଦ୍ର ସିଂ, ବୈଜ୍ଞାନିକ ଡଃ ଆର.ସି. ଶ୍ରୀବାସ୍ତବ ଓ ଜିଲ୍ଲା କୃଷି ଉପନିର୍ଦ୍ଦେଶକ କ୍ଷେତ୍ରବାସୀ ନାୟକ ପ୍ରମୁଖ ଯୋଗଦେଇ ଉନ୍ନତ ପ୍ରଣାଳୀର ଚାଷ ସଂପର୍କରେ ଚାଷୀମାନଙ୍କୁ ଗୁରୁତ୍ୱପୂର୍ଣ୍ଣ ପରାମର୍ଶ ଦେଇଥିଲେ । ପୂର୍ବାଞ୍ଚଳ ଜଳ ପ୍ରାଦୌଗିକୀ କେନ୍ଦ୍ର, ଭୁବନେଶ୍ୱରର ବୈଜ୍ଞାନିକ ଡଃ ଗୌରାଙ୍ଗ କର ଜାତୀୟ କୃଷି ପ୍ରଯୁକ୍ତି ଯୋଜନା ପ୍ରକଳ୍ପ ସଂପର୍କରେ ଚାଷୀମାନଙ୍କୁ ପ୍ରାରମ୍ଭିକ ସୂଚନା ପ୍ରଦାନ କରିଥିଲେ । ଏହି କାର୍ଯ୍ୟକ୍ରମରେ ଭାଗ ନେଇଥିବା ଚାଷୀମାନଙ୍କୁ ସଂସ୍ଥା ପକ୍ଷରୁ ଢେଙ୍କାନାଳ ଜିଲ୍ଲାରେ ଉନ୍ନତ ପ୍ରଣାଳୀରେ ଚାଷ କରାଯାଇଥିବା କେତେକ ଅଞ୍ଚଳକୁ ପରିଦର୍ଶନରେ ନିଆଯାଇଥିଲା ।

News-5: The Anupam Bharat on 21.3.2004

ଢେଙ୍କାନାଳରେ କୃଷକ ପ୍ରଶିକ୍ଷଣ କାର୍ଯ୍ୟକ୍ରମ

ଢେଙ୍କାନାଳ ଅଫିସ, ୧୯।୩- ପୂର୍ବାଞ୍ଚଳ ଜଳ ପ୍ରାଦୌଗିକୀ କେନ୍ଦ୍ର, ଭୁବନେଶ୍ୱର ଆନୁକୂଲ୍ୟରେ ଢେଙ୍କାନାଳଠାରେ ଆଜି ଜାତୀୟ କୃଷି ପ୍ରଯୁକ୍ତି ଯୋଜନା ମାଧ୍ୟମରେ ଏକ କୃଷକ ପ୍ରଶିକ୍ଷଣ କାର୍ଯ୍ୟକ୍ରମ ଅନୁଷ୍ଠିତ ହୋଇଯାଇଛି ।

ପୂର୍ବାଞ୍ଚଳ ଜଳ ପ୍ରାଦୌଗିକୀ କେନ୍ଦ୍ର ଭୁବନେଶ୍ୱର ଆନୁକୂଲ୍ୟରେ ସ୍ଥାନୀୟ ଟାଉନହଲଠାରେ ଆଜି ଦିନ ୧୦ଟା ୩୦ମି.ରେ ଆୟୋଜିତ ଏହି କୃଷକ ପ୍ରଶିକ୍ଷଣ କାର୍ଯ୍ୟକ୍ରମରେ ଓ.ୟୁ.ଏ.ଟି.ର ଅବସରପ୍ରାପ୍ତ ଭାଇସ ଚାନ୍ସେଲର ଡଃ ଇଶ୍ବର ଚନ୍ଦ୍ର ମହାପାତ୍ର ମୁଖ୍ୟଅତିଥି ଭାବେ ଯୋଗ ଦେଇଥିଲେ । ଏହି ଅବସରରେ ଡଃ ମହାପାତ୍ର ଉଦ୍‌ବୋଧନ ଦେଇ କହିଲେ ଯେ, ଗତ ୫୭ବର୍ଷ ମଧ୍ୟରେ ଆମଦେଶରେ କୃଷିର ଯଥେଷ୍ଟ ଉନ୍ନତି ଘଟିଛି । ଏଥିସହିତ ଅଳ୍ପ ଜମି ଓ ବୃଷ୍ଟି ବହୁଳ ଜମିରେ ଚାଷୀମାନେ କିପରି ଭଲ ଫସଲ କରିପାରିବେ ସେଥିପାଇଁ ସେମାନଙ୍କୁ ଭଲଭାବରେ ପ୍ରଶିକ୍ଷଣ ଦେବା ଉଚିତ୍ । ଏହି ପ୍ରଶିକ୍ଷଣ କାର୍ଯ୍ୟକ୍ରମରେ ଢେଙ୍କାନାଳ ଜିଲ୍ଲାପାଳ ନିତ୍ୟାନନ୍ଦ ମହାନ୍ତି ସମ୍ମାନିତ ଅତିଥି ଭାବେ ଯୋଗଦେଇ ବିଭିନ୍ନ ଗ୍ରାମାଞ୍ଚଳରେ ବେକାର ଥିବା ଯୁବକମାନେ ପ୍ରଶିକ୍ଷଣ ମାଧ୍ୟମରେ ଉନ୍ନତ ପ୍ରଣାଳୀର କୃଷିଭିତ୍ତିକ କାର୍ଯ୍ୟରେ ମନୋନିବେଶ କରିପାରିଲେ ସେମାନଙ୍କ ଆର୍ଥିକ ପରିସ୍ଥିତ ଭଲ ହୋଇପାରିବ ବୋଲି ମତବ୍ୟକ୍ତ କରିଥିଲେ । ଅନ୍ୟମାନଙ୍କ ମଧ୍ୟରେ କୃଷି ବୈଜ୍ଞାନିକ ଦିନେଶ ଚନ୍ଦ୍ର, ବୈଜ୍ଞାନିକ ଡଃ ରବୀନ୍ଦ୍ର ସିଂ, ବୈଜ୍ଞାନିକ ଡଃ ଆର.ସି. ଶ୍ରୀବାସ୍ତବ ଓ ଜିଲ୍ଲା କୃଷି ଉପନିର୍ଦ୍ଦେଶକ କ୍ଷେତ୍ରବାସୀ ନାୟକ ପ୍ରମୁଖ ଯୋଗଦେଇ ଉନ୍ନତ ପ୍ରଣାଳୀର ଚାଷ ସଂପର୍କରେ ଚାଷୀମାନଙ୍କୁ ଗୁରୁତ୍ୱପୂର୍ଣ୍ଣ ପରାମର୍ଶ ଦେଇଥିଲେ । ପୂର୍ବାଞ୍ଚଳ ଜଳ ପ୍ରାଦୌଗିକୀ କେନ୍ଦ୍ର, ଭୁବନେଶ୍ୱରର ବୈଜ୍ଞାନିକ ଡଃ ଗୌରାଙ୍ଗ କର ଜାତୀୟ କୃଷି ପ୍ରଯୁକ୍ତି ଯୋଜନା ପ୍ରକଳ୍ପ ସଂପର୍କରେ ଚାଷୀମାନଙ୍କୁ ପ୍ରାରମ୍ଭିକ ସୂଚନା ପ୍ରଦାନ କରିଥିଲେ । ଏହି କାର୍ଯ୍ୟକ୍ରମରେ ଭାଗ ନେଇଥିବା ଚାଷୀମାନଙ୍କୁ ସଂସ୍ଥା ପକ୍ଷରୁ ଢେଙ୍କାନାଳ ଜିଲ୍ଲାରେ ଉନ୍ନତ ପ୍ରଣାଳୀରେ ଚାଷ କରାଯାଇଥିବା କେତେକ ଅଞ୍ଚଳକୁ ପରିଦର୍ଶନରେ ନିଆଯାଇଥିଲା ।

Translation of News-3

Farmers training organized by WTCER

Dhenkanal - Dt. 20-04. (.N.): For the farmer's of rainfed areas of the district, two days' training cum workshop was held in the auditorium of dhenkanal Science Center by the Water Technology Center for Eastern Region (WTCER), Bhubaneswar on 18th and 19th April, 2002 where 200 farmers of 8 blocks of the district were trained. Since the initiation a NATP project in the district in 1999, the farmers were trained through this project by agricultural scientists for effective and proper use of water for multicropping in rainfed rice ecosystem.

Presently the NATP is under-going in five villages *viz.* Annapurnapur, Janapada, Kingol, Jirl and Nuagon of Dhenkal District. In the workshop Dr. H.N. Verma, Director of the WTCER addressed the inaugural session. Dr. Gouranga Kar, Scientist of WTCER appraised the purpose of the workshop. Dr. R. Venugopal, the General Manager, Shakti Sugar, Deputy Director Agriculture of Dhenkanal, Dr. Ghanashyam Pal and Dr. H.K. Pande, Ex-Director CRRI were also present in the workshop.

Translation of News-4

Farmers training programme at Dhenkanal

Dhenkanal : A. farmers' training cum awareness programme was organized on 19.03.2004 at Dhenkanal Town Hall by WTCER, Bhubaneswar. Dr. I.C. Mahapatra, retd. Vice Chancellor, OUAT. Bhubaneswar was the chief guest on that occasion. On that occasion Dr. Mohapatra addressed the farmers and told that there are remarkable achievements in the field of agriculture during the last fifty-seven years. The farmers with small and marginal holdings sould be trained to grow remunerative crops in the rainfed areas. The guest of honor on that occasion, Mr. Nityananda Mohanty, Collector, Dhenkanal, Urged the scientists to create employment opportunity for farmers and advised the unemployed rural youths to be trained through improved farming technology.

On the occasion Dr. Dinesh Chandra, Dr. R. Singh, Dr. R.C. Srivastava, the Scientists of WTCER and Dr. K. Nayak, DDA, Dhenkanal, hightlighted some important rainfed farming technology. Dr. Gouranga Kar, Scientist WTCER informed the objectives of National Agricultural Technology Project (NATP), undergoing in Dhenkanal. After completion of inaugural programme all the participated farmers visited the experimental field sites.

Translation of News-5

Farmers Training programme held at Dhenkanal

Dhenkanal : On 21.3.04 A farmers' training cum awareness programme was organized at town-hall, Dhenkanal by Water Technology Centre for Eastern Region, Bhubaneswar.

Dr. I.C. Mohapatra, retired Vice Chancellor, OUAT, Bhubaneswar was present in that training programme as chief guest and highlighted how to grown remunerative crops in rainfed areas and urged the farmers to take proper training from scientists. Mr. Nityananda Mohanty, Collector, Dhenkanal was present there as guest of honor and advised farmers to take training on modern agricultural technology for self employment. In that programme, agricultural scientists of WTCER, Bhubaneswar Dr. Dinesh Chandra, Dr. Ravinder Singh, Dr. R.C. Srivastava and Deputy Director Agriculture, Dhenkanal, Dr. K. Nayak, were present and shared their experiences regarding rainfed farming. In the beginning of the programme Dr. G. Kar, Scientist, WTCER informed the objective of the National Agricultural Technology Project, under going at Dhenkanal.

COVERAGE OF TECHNOLOGY DISSEMINATION IN REGIONAL NEWS PAPERS (ORIYA)

News-6: The Dharitri on 6.9.2001

ଜାତୀୟ ଜଳ ପ୍ରାଦ୍ୟୋଗିକୀ କେନ୍ଦ୍ରର କୃଷିମେଳା

ଢେଙ୍କାନାଳ,-(ନି.ପ୍ର.) - ଜାତୀୟ ଜଳ ପ୍ରାଦ୍ୟୋଗିକୀ କେନ୍ଦ୍ର (National water technology centre) ପକ୍ଷରୁ କାମାକ୍ଷାନଗର ଉପଖଣ୍ଡର ଅନପୂର୍ଣ୍ଣାପୁରଠାରେ ଗତ ୨୫ତାରିଖ ଦିନ ଏକ କୃଷିମେଳାର ଆୟୋଜନ କରାଯାଇଥିଲା । ହାଇଦ୍ରାବାଦସ୍ଥିତ କେନ୍ଦ୍ରୀୟ ଶୁଷ୍କଜମି କୃଷି ଗବେଷଣା ସଂସ୍ଥାର ନିର୍ଦ୍ଦେଶକ ଡ଼ଃ ଏଚ.ପି. ସିଂହ ଏଥିରେ ମୁଖ୍ୟଅତିଥି ଭାବେ ଯୋଗଦେଇ କହିଲେ ଭାରତର କ୍ରମବର୍ଦ୍ଧିଷ୍ଣୁ ଜନସାଧାରଣଙ୍କର ଖାଦ୍ୟର ଚାହିଦା ପୂରଣ ଉଦ୍ଦେଶ୍ୟରେ ବିଶ୍ୱବ୍ୟାଙ୍କ ସହାୟତାରେ କେନ୍ଦ୍ର ସରକାରଙ୍କ ପକ୍ଷରୁ ସାରାଦେଶରେ ୨୬୦କୋଟି ଟଙ୍କାର ପ୍ରକଳ୍ପ ଆରମ୍ଭ କରାଯାଇଛି । ସେଥିମଧ୍ୟରୁ କେବଳ ବର୍ଷାଜଳ ଉପରେ ସଂପୂର୍ଣ୍ଣ ନିର୍ଭର କରୁଥିବା ଅଞ୍ଚଳରେ କୃଷିର ଉନ୍ନତି ପାଇଁ ୧୨୦କୋଟି ଟଙ୍କା ଖର୍ଚ୍ଚ କରାଯିବ ।
ଢେଙ୍କାନାଳ ଜିଲ୍ଲାରେ କାର୍ଯ୍ୟକାରୀ କରାଯାଉଥିବା ଜଳପ୍ରଯୁକ୍ତି ଯୋଜନାର ପରିଚାଳକ ଡ଼ଃ ଜି. କର ଯୋଜନା ସମ୍ପର୍କରେ ସୂଚନା ଦେଇ କହିଲେ ଢେଙ୍କାନାଳ ଜିଲ୍ଲାର ଅନପୂର୍ଣ୍ଣାପୁରଠାରେ ୧୯୯୯ ମସିହା ମଇ ମାସରୁ ଏହି ଯୋଜନା ଆରମ୍ଭ କରାଯାଇଛି । ସମ୍ପୂର୍ଣ୍ଣ ବର୍ଷାଜଳ ଉପରେ ନିର୍ଭରଶୀଳ ଏହି ଅଞ୍ଚଳରେ ବୈଜ୍ଞାନିକ ପଦ୍ଧତିରେ ବିକଳ୍ପ ଓ ସ୍ୱଳ୍ପ ସମୟରେ ଅମଳକ୍ଷମ ଶସ୍ୟ ଚାଷକରି ଚଳିତବର୍ଷର ବନ୍ୟା ସତ୍ତ୍ୱେ କୃଷକମାନଙ୍କୁ ଲାଭବାନ କରାଇବା ସହ ସେମାନଙ୍କ ମନରେ କୃଷି ପାଇଁ ଉତ୍ସାହ ସୃଷ୍ଟି କରାଯାଇ ପାରିଛି ।
ଏହି କୃଷିମେଳାରେ କଟକସ୍ଥ କେନ୍ଦ୍ରୀୟ ଧାନଗବେଷଣା କେନ୍ଦ୍ରର ନିର୍ଦ୍ଦେଶକ ଡ଼ଃ ବି.ଏନ୍. ସିଂହ, ଓଡ଼ିଶା କୃଷି ବୈଷୟିକ ବିଶ୍ୱବିଦ୍ୟାଳୟର ଡିନ୍ ଉମାକାନ୍ତ ମିଶ୍ର, ଶକ୍ତି ସୁଗାର୍ସର ଉପମୁଖ୍ୟ ପରିଚାଳକ ଆର. ଭେନୁଗୋପାଳ, ଢେଙ୍କାନାଳ ଜିଲ୍ଲାପାଳ ନିତ୍ୟାନନ୍ଦ ମହାନ୍ତି, ଢେଙ୍କାନାଳସ୍ଥ ଉପକୃଷି ନିର୍ଦ୍ଦେଶକ ପ୍ରମୁଖ ଉଦ୍‌ବୋଧନ ଦେଇ ବୈଜ୍ଞାନିକ ପଦ୍ଧତିରେ ଚାଷ ଉପରେ ଗୁରୁତ୍ୱାରୋପ କରିଥିଲେ ।

News-7: The Krantidhara on 29.4.2002

ଢେଙ୍କାନାଳରେ ଦୁଇଦିନିଆ କୃଷକ ପ୍ରଶିକ୍ଷଣ ଶିବିର ଅନୁଷ୍ଠିତ

ଢେଙ୍କାନାଳ୨୮।୪(ନିପ୍ର) : ଢେଙ୍କାନାଳ ବିଜ୍ଞାନ କେନ୍ଦ୍ରଠାରେ ଉନ୍ନତ ଚାଷପାଇଁ ସଚେତନତା କରାଇବା ତଥା ଉନ୍ନତ ପ୍ରଣାଳୀ ଚାଷପାଇଁ ଏକ ଦୁଇଦିନିଆ କୃଷକ ତାଲିମ ଶିବିର ଅନୁଷ୍ଠିତ ହୋଇଯାଇଛି ।
ପୂର୍ବାଞ୍ଚଳ ୱାଟର ଟେକ୍‌ନୋଲୋଜି ସେଣ୍ଟର ଆନୁକୂଲ୍ୟରେ ଅନୁଷ୍ଠିତ ଦୁଇ ଦିନିଆ ଏହି ଶିବିରରେ ସୁବର୍ଣ୍ଣ ବିପ୍ଳବ ଦ୍ୱାରା ପାଣିଥିବା ଅଂଚଳରେ କିପରି ଖାଦ୍ୟ ଉପଯୋଗୀ ଚାଷ ଅଧିକ ପରିମାଣରେ କରାଯାଇପାରିବ ଏବଂ ଉନ୍ନତ ପ୍ରଣାଳୀ ଚାଷ ମାଧ୍ୟମରେ କିପରି ଅଧିକ ଶସ୍ୟ ଉତ୍ପାଦନ ହୋଇପାରିବ ଏହି ବିଷୟରେ ବୈଜ୍ଞାନିକ ତଥା ବିଶେଷଜ୍ଞମାନେ ଚାଷ ତଥା କୃଷକମାନଙ୍କୁ ପରାମର୍ଶ ଦେଇଥିଲେ । ଏହି ଶିବିରରେ ମୁଖ୍ୟ ଅତିଥି ଭାବେ ଯୋଗଦେଇ ସି.ଆର.ଆଇ. କଟକର ପ୍ରାକ୍ତନ ନିର୍ଦ୍ଦେଶକ ଶ୍ରୀ ଏଚ୍.କେ. ପଣ୍ଡା ଉନ୍ନତମାନର ଧାନଚାଷ ସମ୍ବନ୍ଧରେ କୃଷକମାନଙ୍କୁ ପରାମର୍ଶ ଦେଇଥିଲେ । ସମ୍ମାନୀତ ଅତିଥି ଭାବେ ଯୋଗଦେଇ ସି.ଆର.ଆର.ଆଇ. ନିଦେଶକ ଡକ୍ଟର ବି.ଏନ୍.ସିଂହ ସ୍ୱତନ୍ତ୍ର ନିମନ୍ତ୍ରଣ ଅତିଥି ଭାବେ ଯୋଗ ଦେଇଥିବା ଉପନିର୍ଦ୍ଦେଶକ ଜି.ଏସ.ପଟାଲ, ଶକ୍ତି ସୁଗାର୍ସର ଡି.ଜି.ଏମ୍. ଆର୍. ଭେନୁଗୋପାଳ ପ୍ରମୁଖ ଚାଷ ସମ୍ବନ୍ଧୀୟ ସୂଚନାମାନ ଦେଇଥିଲେ ।
ଶିବିର ଉଦ୍‌ଘାଟନ ପ୍ରାରମ୍ଭରେ ବିଭାଗୀୟ ନିର୍ଦ୍ଦେଶକ ଡକ୍ଟର ଏଚ.ଏନ୍.ବର୍ମା ସ୍ୱାଗତ ଭାଷଣ ପ୍ରଦାନ କରିଥିବାବେଳେ ବିଭାଗୀୟ ବୈଜ୍ଞାନିକ ଜି. କର ପ୍ରଶିକ୍ଷଣ ଶିବିର ସମ୍ବନ୍ଧୀୟ ସୂଚନା ପ୍ରଦାନ କରିଥିଲେ । ଏହି ଶିବିରରେ ଢେଙ୍କାନାଳ ଜିଲ୍ଲାର ସମସ୍ତ ବ୍ଲକରୁ ୨୦୦ ଜଣ ଉନ୍ନତ ଚାଷୀ ଓ ୧୦୦ଜଣ କର୍ମକର୍ତ୍ତା ଯୋଗଦାନ କରିଥିଲେ । ଶେଷରେ ବୈଜ୍ଞାନିକ ଶ୍ରୀ ଆର୍. ସିଂହ ଧନ୍ୟବାଦ ଅର୍ପଣ କରିଥିଲେ ।

News-8: The Sambad on 29.4.2002

ଢେଙ୍କାନାଳରେ କୃଷି ପ୍ରଶିକ୍ଷଣ ଶିବିର

ଢେଙ୍କାନାଳ,୨୮।୪(ଇ.ମି.ସ): ପୂର୍ବାଞ୍ଚଳ ଜଳ ପ୍ରାଦ୍ୟୋଗିକୀ କେନ୍ଦ୍ର ଭୁବନେଶ୍ୱର ପକ୍ଷରୁ ସ୍ଥାନୀୟ ବିଜ୍ଞାନ କେନ୍ଦ୍ର ସଭା ଗୃହରେ ଏକ ଦୁଇଦିନିଆ କୃଷି ପ୍ରଶିକ୍ଷଣ ଶିବିର ଅନୁଷ୍ଠିତ ହୋଇଯାଇଛି । ବର୍ଷାଜଳ ସଂରକ୍ଷଣ କରି ଜଳଛାୟା ସୃଷ୍ଟି କରିବା ଏବଂ ଏହି ଜଳକୁ ଉପଯୋଗ କରି ତିପଜମିରେ ଆଦ୍ରତା ସଂରକ୍ଷଣ, ଗୋଟିଏ ଜମିରେ ଖରିଫ ଫସଲ ସମତେ ବର୍ଷସାରା ବିଭିନ୍ନ ରବି ଫସଲ ଉତ୍ପାଦନ କରିବା ନେଇ ଏହି କର୍ମଶାଳାରେ ଆଲୋଚନା ହୋଇଥିଲା ।
ଶିବିର ପ୍ରାରମ୍ଭରେ ପୂର୍ବାଞ୍ଚଳ ଜଳ ପ୍ରଦ୍ୟୋଗିକ କେନ୍ଦ୍ର ନିର୍ଦ୍ଦେଶକ ଡା. ଏଚ.ଏନ. ବର୍ମା ସ୍ୱାଗତ ସୂଚନା ଦେଇଥିଲେ । କେନ୍ଦ୍ରର ବରିଷ୍ଠ ବୈଜ୍ଞାନିକ ତଥା ଯୋଜନା ପରିଚାଳକ ପ୍ରଯୁକ୍ତି ଶିବିରର ଲକ୍ଷ ଓ ବର୍ଷାଜଳ ଆଧାରିତ ଚାଷ ପ୍ରଣାଳୀ ଉପରେ ସୂଚନା ଦେଇଥିଲେ ।
ସ୍ଥାନୀୟ 'ଶକ୍ତି ସୁଗାର'ର ସାଧାରଣ ପରିଚାଳକ ଡ. ଆର୍. ଭେନୁଗୋପାଳ ଚାଷ କ୍ଷେତ୍ରରେ ବିଭିନ୍ନ ସମସ୍ୟା ଓ ତା'ର ନିରାକରଣ ଉପରେ ଆଲୋକପାତ କରିଥିଲେ । ଢେଙ୍କାନାଳ କୃଷି ଉପନିର୍ଦ୍ଦେଶକ ଘନଶ୍ୟାମ ପାଲ ଚାଷ କ୍ଷେତ୍ରରେ ଉନ୍ନତ ଜ୍ଞାନକୌଶଳ ଓ ଜିଲ୍ଲାରେ ଉପଲବ୍ଧ ହେଉଥିବା ବିଭିନ୍ନ ରିହାତି, ସାର, ବିହନ ଆଦି ସଂପର୍କରେ ବିବରଣୀ ଦେଇଥିଲେ । ଉନ୍ନତ ଜ୍ଞାନକୌଶଳ ପ୍ରୟୋଗ କରି ଏବେ ଗୋଟିଏ ସିଜିନରେ ବହୁପ୍ରକାର ଚାଷ କରାଯାଇପାରୁଛି ବୋଲି ସୂଚନା ଦେଇ ଶ୍ରୀ ପାଲ କହିଲେଯେ, ପଡ଼ୋଶୀ ଆନ୍ଧ୍ରପ୍ରଦେଶ, ପଞ୍ଜାବ, ହରିଆନା, ମରୁଭୂମିପ୍ରବଣ ରାଜସ୍ଥାନ, ଗୁଜୁରାଟ ଆଦି ଅଞ୍ଚଳରେ କୃଷିର ଅଶେଷ ଉନ୍ନତି ହୋଇଛି । ଆମ ରାଜ୍ୟର କୃଷକ ଭାଇମାନେ ଏହାର ସୁଯୋଗ ନେବାକୁ ସେ ଆହ୍ୱାନ ଜଣାଇ ଥିଲେ । ଲୁଧିଆନା କୃଷି ବିଶ୍ୱବିଦ୍ୟାଳୟର ନିର୍ଦ୍ଦେଶକ ଏମ.ଏସ.ଗିଲ ପଞ୍ଜାବର ଚାଷୀ ଓ ଚାଷ ପ୍ରଣାଳୀ ଉପରେ ଆଲୋକପାତ କରିଥିଲେ । ପଶ୍ଚିମବଙ୍ଗ କୃଷି ଉଦ୍ୟୋଗର ଡ. ବି.କେ. ମଣ୍ଡଳ, ବୈଜ୍ଞାନିକ ଡ. ନାରାୟଣ ସାହୁ ବର୍ଷାଜଳ ସଂରକ୍ଷଣର ଆବଶ୍ୟକତା ଓ ରବି ଫସଲ ଉପରେ ଆଲୋଚନା କରିଥିଲେ । କଟକ ଧାନ ଗବେଷଣା କେନ୍ଦ୍ରର ପୂର୍ବତନ ନିର୍ଦ୍ଦେଶକ ଡ. ଏଚ.କେ. ପାଣ୍ଡେ ବିହନ ସଂଗ୍ରହ ଓ ଉନ୍ନତ ଧରଣର ବୈଜ୍ଞାନିକ ଚାଷ ପ୍ରଣାଳୀ ଉପରେ ଆଲୋକପାତ କରିଥିଲେ । ଶେଷରେ ବରିଷ୍ଠ ବୈଜ୍ଞାନିକ ଡ. ରବିନ୍ଦ୍ର ସିଂ ଧନ୍ୟବାଦ ଅର୍ପଣ କରିଥିଲେ । ଜିଲ୍ଲାର ସମସ୍ତ ବ୍ଲକରୁ କୃଷକ ପ୍ରତିନିଧିମାନେ ଏହି କର୍ମଶାଳାରେ ଯୋଗ ଦେଇଥିଲେ । ସୂଚନାଯୋଗ୍ୟ, ଭାରତୀୟ କୃଷି ଗବେଷଣା ଦ୍ୱାରା ପରିଚାଳିତ ପୂର୍ବାଞ୍ଚଳ ଜଳ ପ୍ରଦ୍ୟୋଗିକ କେନ୍ଦ୍ର ମାଧ୍ୟମରେ ଏହି ଜିଲ୍ଲାରେ ୧୯୯୯ ମସିହାରୁ ସଂପୃକ୍ତ ପ୍ରକଳ୍ପର ଶୁଭାରମ୍ଭ କରାଯାଇ ବର୍ତ୍ତମାନ ଅନପୂର୍ଣ୍ଣାପୁର, ଜହ୍ନପଡା, କିଙ୍ଗୋଳ, ଜିରାଳ ଓ ନୂଆଗାଁ ଆଦି ୫ଟି ଗ୍ରାମରେ ଉକ୍ତ ସ୍ୱତନ୍ତ୍ର କୃଷି ବୈଷୟିକ ପ୍ରକଳ୍ପ କାର୍ଯ୍ୟକାରୀ ହେଉଛି ।

Translation of News-6

The farmers fair or WTCER

Dhenkanal, 05.09.2001(O.R) - A farmers' fair was organized on 25th August at Arnapuranapur village of Kamakhyanagar sub division. Being the chief guest of this occasion Dr. H.P. Singh, Director CRIDA. Hyderabad said that to fulfill the food requirement of ever increasing population of India, projects worth Rs.260 crore has been started all over India through the assistance of World Bank, Out of which for the rainfed agricultural development Rs. 120 crore will be spent.

Dr. G. Kar, the project leader told that the project was started at the Arnapuranapur village of Dhenkanal in the month of May, 1999. Farmers of this rainfed tract have been encouraged for agriculture through the modern agriculture alternative technology.

In that farmers' fair, Dr. B.N. Singh, Director CRRI, Cuttack, Mr. U.K. Mishra, Dean OUAT, Mr. R. Venugopal, General Manager, Shakti Sugar, Dhenkanal, and Mr. Nityananda Mohanty, Collector, Dhenkanal, stressed upon the modern agricultural technology.

Translation of News-7

Two day farmers' training camp at Dhenkanal

Dhenkanal: A two day farmers' training programme was organized by Water Technology Centre for Eastern Region, Bhubaneswar at Science Centre, Dhenkanal in order to make aware of modern agricultural practice to the farmers.

The Scientists from WTCER and local ICAR institutes delivered their experiences and shared the technical know-how to farmers for growing more crops with improved water and crop management practices. The Chief guest of the occasion Dr. H.K. Pandey, the former Director of CRRI highlighted some improved rice cultivation technology. Among others Dr. B.N. Singh, Director, CRRI, Mr. G.S. Pal, DDA, Dhenkanal and R. Venugopal, DGM, Shakti sugar were present and shared their valuable experiences.

In the beginning of the programme Dr. H.N. Verma, Director, WTCER gave welcome remarks and Dr. G. Kar, Scientist appraised the farmers about the objectives of the training programme. In that training programme 200 progressive farmers and 100 state agriculture staff were trained. At the end Dr. R. Singh, Pr. Scientist, WTCER made vote of thanks.

Translation of News-8

Farmers' Training / workshop at Dhenkanal

Dhenkanla, 28.4 (EMS) A two days' farmers training/ workshop was organized at Dhenkanal by WTCER, Bhubaneswar. In that workshop technologies regarding water storage through rainwater harvesting and moisture conservation were discussed for raising crops in *kharif* as well as in *rabi* season

In the beginning of workshop Dr. H.N. Verma Director, WTCER, gave inaugural address. The senior scientist cum the project investigator, Dr.Gouranga Kar briefed about the objective of the workshop based on rainfed farming.

Dr. R. Vengupal, the Regional Manager, Shakti Sugar highlighted about the problems and management of different farming practices. Mr. Ghanashyam Pal, D.D.A, Dhenkal briefed about modern technology adopted in the district and availability of subsidized fertilizer, seed etc. in the district. In a single seson several crops can be grown through the use of modern technology, said Mr. Pal. He also stressed to improve the productivity of Orissa state like Andhra Pradesh, Punjab, Haryana and drought prone Rajasthan, Gujurat. Dr. M.S. Gill, Professor from Punjab Agricultural University, Ludhiana highlighted some positive aspects of Punjab agriculture. On that occasion Dr. B.K. Mondal, Professor from B.C.K.V., Kalyani, West Bengal and Dr. N. Sahoo, Pr. Scientist, WTCER, Bhubaneswar highlighted some rainwater conservation measures. The Ex-Director of CRRI, Cuttack, Dr. H.K. Pandey presided the workshop and addressed the farmers to adopt improved rainfed rice farming. Lastly Dr. Ravender Singh, Pr. Scientist, WTCER gave vote of thanks.

It is to be mentioned that the project was initiated in 1999 at Arnapuranapur village, Dhenkanal, now the implementation has been covered in other villages like janapara, Kingol, Jiral and Naogao of that district.

News-9: The Statesman on 7.4.2004.

Farmers carry sunflower heads to their houses after a bumper harvest in Annapurnapur in Dhenkanal - BN Seth

Annapurnapur expects a bumper crop this season

Statesman News Service

DHENKANAL, April6.- The villagers of Annapurnapur in Kamakshyanagar subdivision are expecting a bumper crop even in a drought season and have, as a result, stopped migrating to urban areas in search of work, thanks to the efforts of the scientists of the Water Technology Centre for Eastern Region, a branch of the Indian Council of Agriculture Research.

Crop diversification initiated by the scientists in the rain-fed upland has made the village self sufficient and it has witnessed an unexpected produce within two years of WTCER's experiment, Farmers were overjoyed when the WTCER selected Annapurnapur village for their experiment. The scientists planted crops over four acres of land in 2000. They also involved some farmers in the experiment.

The aim was to replace the cultivation of the rain-fed upland paddy with maize, pigeon pea, groundnut, black gram and cow pea, during the *kharif* seasons of 2000-02. The experiments proved that the farmers would be more benefited if they followed intercropping like rice and pigeonpea, groundnut and pigeonpea and groundnut and green gram. The second series of crops horse gram and sesame would be cultivated with maize.

Initially seeds, fertilizer and even technical knowhow were provided to some farmers. But after the success of the experiment, hundreds of farmers in the village have cultivated cash crops over 150 to 200 acres and the success stories have spread to nearby villages too. Cash crops like sun flower, maize, pigeon pea, horse gram, cucumber and other vegetables cultivated as per the intercropping system have earned them lakhs of rupees.

Thus instead of migrating to other areas for work, the village, in turn, has provided engagement to labourers from nearby villages. Farmer Mr Sivaram Sahoo said many farmers used to go to districts like Cuttack, Jagatsinghpur and Angul after the harvesting of paddy in search of work but with the intercropping and crop diversification over the last two years, they are never in dearth of employment. One farmer, Mr. Kailash Roul, proudly said he spent more than five hours in his land and added his investment was only around Rs. 1,000 to 1,5000 for maize and groundnut in 2.8 gum of land. In return he got Rs. 35,000 after 80 days, he said Mr. Roul said his five sons now help him some thing which they were reluctant to do earlier. He said he has advised them not to bribe officials or brokers for a job in the cities. Another farmer, Mr. Hrushikesh Nayak, has planted maize this year Nayak invested Rs. 900-1,000 for maize in 15 guntha of land which showed high yield and earned him Rs. 15,000 with limited use of water. The farmers can also market their produce more easy now. They have thanked MP Mr. KP Singh Deo for providing assistance for a check bund as water from the bundh area has helped them to irrigate their crops.

WTCER senior scientist Dr. Gouranga Kar said crop diversification is the need of hour in the rainfed upland rice area. WTCER has made efforts to help farmers in Jiral and Dahanbili villages in Kamakshyanagar subdivision. Dr. Kar said the success can spread to other villages if the district administration extends cooperation with active support of the deputy director of agriculture and horticulture department at the district level. The WTCER always aims not to alter the existing ground system and the available infrastructure and resources of the farmers.

News-10: The Indian Express on 3.4.2004.

They no longer migrate for livelihood

BY BIRANCHI N. SETH

Dhenkanal, April 2 : There is no rain, no water, yet there is a bumper harvest.

And people of Arnapurnapur village in Kamakshyanagar sub-division have stopped migrating to urban areas in search of livelihood. For they are self-sufficient now.

COMING BACK

Thanks to Water Technology Centre for Eastern Region (WTCER) under Indian Council of Agriculture Research (ICAR), that has brought prosperity to the village.

Besides, helping them grow, WTCER scientists have boosted the self-confidence of farmers.

With the scientists' advise in 2000, the farmers took to crop diversification in rainfed uplands and output was beyond their expectation. Trials on crop diversification were conducted during *kharif* seasons from 2000 to 2002. The crops were maize (Navjot), pigeon pea, groundnut, black gram and cow pea. The farmers received more returns when they combined growing two crops - rice and pigeon pea, groundnut and pigeon pea, groundnut and green gram.

The second crop, horse gram and sesame were grown after maize.

Initially, sedds, fertiliser and technical knowhow were provided to some farmers at the beginning of experiment.

After success of the experiment, many farmers of the villages, started growing cash crops. Now the success stories have spread to neighbouring villages.

The cultivation of cash crops have made the farmers self-reliant. And instead of going to other places in search for work, they provide work to labourers of neighbouring villages.

Sivaram Sahoo, a farmer, said many farmers used to go to districts like Cuttack, Jagatsinghpur and Angul in search of work after the harvest of paddy, but now due to success in inter-cropping methods and crop diversification, they get work throughout the year.

Another farmer Kailash Roul said he invested only Rs. 1500 for maize and groundnut cultivation and received yield worth Rs. 35,000.

Farmer Hrushikesh Nayak who invest Rs. 1000 for maize cultivation, has received returns worth Rs. 15,000.

Farmers do not face marketing problems. As soon as the harvest is over, they are picked up by local businessmen and poultry firm owners.

When asked about the success, WTCER senior scientists Dr. Gouranga Kar said crop diversification is the need of hour in rainfed upland areas to increase productivity because of drought.

14. FEEDBACK FROM FARMERS WHO ADOPTED THE TECHNOLOGY GENERATED FROM THE PROJECT

After *rabi* (winter) season of 2003-04, the adopted farmers were asked to share their experiences and gain from the project implemented by WTCER. Different farmers have given their feedback in the following ways.

[illegible]

(I, Sri Satyananda Mahabhoi, a resident of Arnapurnapur village. Earlier by growing local varieties in medium and low land rice area I was getting net profit of only Rs. 2500/- per acre. But after learning form the project since last three years I am cultivating high yielding rice varieties like Lalat, Gayatri and Savitri with improved methods of cultivation and getting net profit of Rs. 7500/- per acre. After rice now I am able to grow sunflower, maize, blackgram and groundnut with limited irrigation from harvested rainwater of pond.)

Satyananda Mahabhoi, Arnapurnapur

[illegible]

(This year 25 acre of Lalat, 15 acre of Swarna, 12 acre of Gayatri and 4 acre of Savitri varieties of rice were adopted in our village with improved practices. With limited irrigation from harvested rainwater and by adjusting the sowing time of rice, we are able to grow sunflower, cucumber and maize after rice. I am getting net return per acre of Rs. 10,000/- from sunflower, Rs. 20,000/- from maize cob, Rs. 6,000/- from blackgram and Rs. 12,000/- from groundnut.)

Meghanad Khatua, Arnapurnapur

[illegible]

(Earlier I was growing local rice varieties but after learning from the project, since two years I have adopted Lalat, Gayatri rice and getting net profit of Rs. 8000/- per acre. After rice on the same land I am growing sunflower, maize, groundnut, potato and cucumber, pea and blackgram with harvested rainwater /limited irrigation. Now I am getting more profit. The per acre profits were Rs. 10,000/- from sunflower, Rs. 21,000/- from maize cob and Rs. 6,000/- from blackgram. I am thankful to WTCER scientists.)

Pradeep Samal, Kadalipal(Arnapurnapur)

[illegible]

(I was growing local rice in medium and low land and getting only Rs. 1500/- per acre. Since last three years after learning from the project I am growing high yielding rice like Lalat, Gayatri and Swarna and getting profit not less than Rs. 8000/- from an acre.)

Gokulananda Mahabhoi, Arnapurnapur

[illegible]

(Previously I was growing local rice varieties in all areas but since two years I am getting net profit of Rs. 8000/- per acre. On the same land after rice I am growing sunflower, blackgram and mustard with limited irrigation and getting net profit of Rs. 10,000/- per acre from sunflower, Rs. 23,000/- per acre from maize cob. In coming year I will grow more area of maize.)

Tankadhar Khatua, Kadalipal(Arnapurnapur)

[illegible]

(Since last three years I am growing high yielding rice varieties with improved practice and getting net profit of Rs. 7000/- per acre. But before this we were getting profit only of Rs. 2000/- from acre. After rice I am taking sunflower, field pea, maize and groundnut as second crop with limited irrigation. Many many thanks to scientists of WTCER.)

Iswar Chandra Samal, Arnapurnapur

[illegible]

(I am raising now high yielding rice such as Lalat, Swarna, Gayatri etc. with improved practice and getting profit of Rs. 7,000/- per acre. After rice on the same land, I am now able to grow second crops like sunflower, groundnut, fieldpea, blackgram and maize and getting net profit of Rs. 10,000/- per acre form sunflower, Rs. 12,000/- from groundnut, Rs. 20,000/- from maize cob and Rs. 5000/- per acre form blackgram.)

Kailash Chandra Sahu, Arnapurnapur

[illegible]

(I am Sri Sibaram Sahu, resident of Arna-purnapur village. Since four years through the project we have learned many rainfed crop and water management technologies. Now I am in a position to grow two to three crops (rice-maize/groundnut/blackgram/greengram in a year, as per the guidance of Dr. Gouranga Kar.)

Sibaranm Sahoo, Arnapurnapur

[illegible]

(In medium land after harvesting rice now I am growing sunflower, maize and getting profit of Rs, 10000 per acre from sunflower, Rs. 20000 per acre from maize cob. In coming years I will grow sunflower and maize in more areas.)

Kasinath Samal, Arnapurnapur

[illegible]

(Many many thanks to Kar Sir who have changed the outlook of farmers of our village. Our income has been raised and now getting year round employment.)

Antaryami Sahoo, Arnapurnapur

[illegible]

(We are grateful to WTCER authority that has helped us to grow more than one crop with residual moisture and limited irrigation by adjusting sowing time.)

Alekh Parida, Arnapurnapur

[illegible]

(I was growing only one crop, rice in a year. After learning from the project now I am able to grow three crops in a year with low water use and getting higher profit than earlier.)

Prafulla Khatua, Arnapurnapur

[illegible]

(Earlier most of the people of village were going out during off-season when much agricultural woks were not available in the village. Now all are busy with farming activities round the year and as a result labor migration has been checked from our village.)

Ramesh Mahabhoi, Arnapurnapur

[illegible]

(Earlier I was growing blackgram, greengram after lowland rice as relay cropping. But after learning from the project we are growing pea, groundnut with improved seeding and tilling methods and getting Rs. 4000 per acre from blackgram and Rs. 5,000 per acre from pea after low land rice.)

Kailas Behera, Arnapurnapur

[illegible]

(In our village we used to grow local varieties of rice with traditional practices and we were getting lower yield (<1 ton/acre) but since three years we are growing high yielding, varieties like Lalat, Swarna, Savitri, Gayatri etc. with improved technologies, learned through the project.)

Kumud Sahoo, Arnapurnapur

[illegible]

(The WTCER has taught us to grow different crops with residual moisture and limited irrigation. Among all the crops I have got the highest benefit from cob of winter maize (Rs. 23,000 per acre), which was 4-5 times more than that of rice.)

Dharmananda Khuntia, Arnapurnapur

[illegible]

(Earlier the existing water body in our village was not properly utilized, as a result our village was mainly mono-cropped. But through proper crop and water management planning of WTCER, almost entire rainefd rice area is under double crops.)

Yoginath Parida, Arnapurnapur

[illegible]

(I am a resident of Arnapurnapur village, Dhenkanal and since last 15 years I am in farming practice. After WTCER technology, I am getting benefit of Rs. 10,000 per acre from sunflower, during *rabi* and Rs. 12,000 from groundnut + pigeonpea, during *kharif*)

Hrusikesh Nayak, Arnapurnapur

[illegible]

(I have no words to express thanks to Dr. Kar who has guided us through the project and shown us the various ways to become progressive.)

Akhil Mhabhoi, Arnapurnapur

[illegible]

(Earlier in upland we used to grow rice but due to drought frequently rice was damaged. Now after learning from the project I am growing pigenonpea, groundnut etc. with rice and getting high return even in drought years.)

Gati Krishna Samal, Arnapurnapur

[illegible]

(With the WTCER technology after rice on the same land now we are able to grow second crops like groundnut, greengram, blackgram and pea after rice even without irrigation. Without irrigation we are getting Rs. 5000 per acre from blackgram, Rs. 10,000 per acre from groundnut, Rs. 6000 per acre from pea.)

Purusottam Aich, Noagao(Dahanabil)

[illegible]

(From the NATP project by WTCER, Bhubaneswar we have learned how to grow double crops in our rice land with proper crop and water management practices.)

Athani Kr. Aich, Noagao(Dahanabil)

[illegible]

(I have much benefited from WTCER project, running in our village, now even in drought year we are getting higher return from our rice land due to improved practices.)

Manoranjan Aich, Noagao(Dahanabil)

[illegible]

(Thanks to NATP project run by WTCER, Bhubaneswar and Kar sir whose timely guidance in raising crops helped a lot. Now we are growing second crops like groundnut, blackgram, pea and geengram etc. from our own inputs and we hope we will continue for ever.)

Hrudananda Aich, Noagao(Dahanabil)

[illegible]

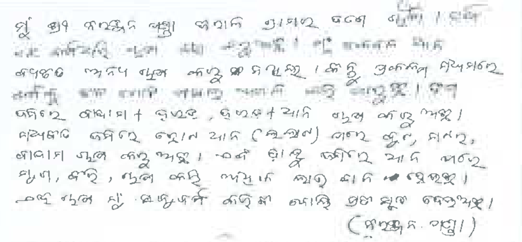
(After learning from the project in the medium land after rice I am taking groundnut, pea, gram and greengram with better return of Rs.15,000/- from pea, Rs.7,000/- per acre from gram and Rs.10,000/- net profit from greengram. Many many thanks to WTCER scientists.)

Khageswar Jena, Jiral

[illegible]

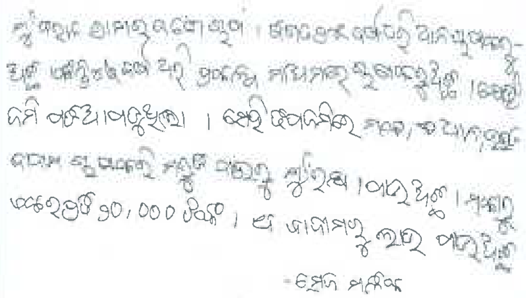
(In the medium land, previously I was growing only rice. But after guidance of project on the same land I am taking groundnut, wheat after Lalat with good net return.)

Pitabas Sethy, Kingol



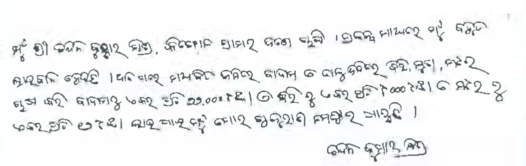
(I Sri Niranjan Panda, a farmer of Jiral village. I am in farming profession since last fifteen years. Besides rice, I was not growing any crop. But after learning from the project on upland I am growing groundnut + pigeonpea, piegonpea+rice in intercropping system. In medium land after medium duration rice (Lalat) I am taking gram, pea and groundnut, In lowland after rice blackgram, greengram etc.)

Niranjan Panda, Jiral



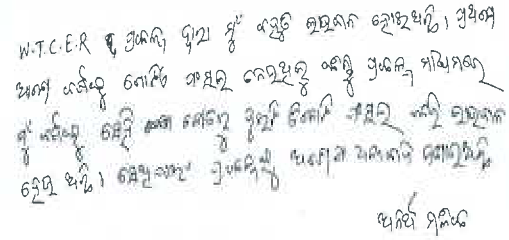
(I am a farmer of Jiral village, for the last 25 years I am in rice cultivation. But in the last four years I am cultivating maize, rice, pigeonpea and groundnut after substituting rice in upland and getting net profit of Rs.20,000/- per acre from maize.)

Seja Mallick, Jiral



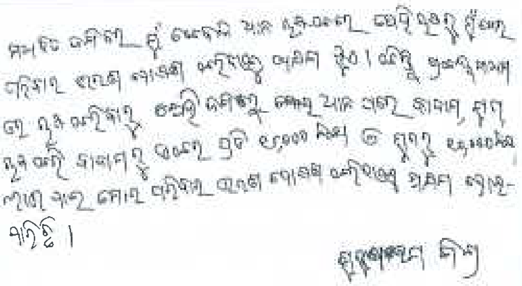
(I Sri Chandan Kumar Mishra a farmer of Kingol village. I have learned lot of things from the WTCER running project in our village. By growing groundnut after rice in medium land and growing greengram, blackgram and fieldpea in lowland I am getting net profit Rs.12,000/- per acre from groundnut, Rs.9,000/- per acre from greengram and Rs.12,000/- from field pea. Now that earning is sufficient for livelihood of my family)

Chandan Kumar Mishra, Kingol



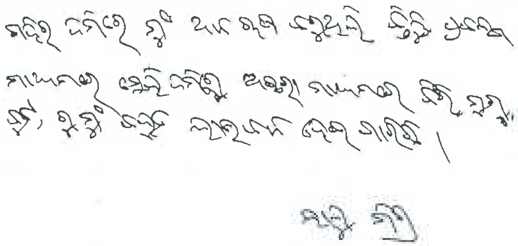
(I have much benefited form the WTCER run project. Previously I was taking only on crop but presently I am taking 2-3 crops and getting more profit. Many many thanks to WTCER.)

Anarth Mallick, Kingol



(Earlier I was not able to run my family smoothly. But with the guidance of the project I am taking groundnut, blackgram, greengram after rice on the same land after rice. I am getting net profit of Rs.18,000/- per acre from groundnut and Rs.10,000/- from greengram and now running family smoothly.)

Prusottam Mishra, Kingol



(Previously I was taking only rice in lowland. But knowing from the project I am taking greengram, blackgram, bengalgram after rice and getting better return.)

Lalu Mishra, Kingol

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Former Vice Chancellor,
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International Consultant
UNDP, FAO, WORLD BANK, IFDC, CGIAR, IRRI, IITA, ICRISAT, WARDA, ADB, IADS, AFC, CWD, ASRB, ICAR, UPSC, EWS, MOA, NATP
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Letter No. ____________________

Dated the. ____________________

A WORD OF APPRECIATION

It is an excellent effort from the part of Dr. Gouranga Kar, Principal Investigator of the project (NATP-RRPS-3) and Dr. H.N. Verma, Director, WTCER to bring out such an important publication which has direct relevance to increase cropping intensity and productivity of lowland rainfed rice area of eastern India. Since the inception of this project, I was closely associated to review it and I had an opportunity to visit several times at the on-farm research and implementation site along with different ICAR Directors, Collector & district Magistrate and DDA Dhenkanal, members of Review team, World Bank Team to attend the field days/farmers fair, training programme organized under the project. When I interviewed the farmers at the adoption site and collected feedback from them, they were very much satisfied with the outcome of the project. They feel that the recommendations emerging from the studies on crop diversification on farmer's fields over the years shall be sustainable. It is happy to note that farmers of the study district (Dhenkanal) have already adopted the recommendations of the project in large area and crop diversification with improved rainwater management has created a great impact in the state of Orissa, which is need of the hour to combat drought in the state. Scientific dissemination through training and extension bulletins in local language highlighting this cost effective and farmer's friendly technology for wide scale adoption to other rainfed areas are the real needs. Authors deserve much appreciation for this valuable documentation based on their on-farm research findings for increased productivity of rainfed lowland rice areas.

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