Indian J. Dryland Agric. Res. & Dev. 2022 37(2): 43-47 10.5958/2231-6701.2022.00015.X

Overview of Dryland Agriculture Research and Achievements in North Eastern Ghat Zone of Odisha

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Brief history of the Centre

AICRPDA centre was established at Bhubaneswar in 1971-72 under Odisha University of Agriculture and Technology and was operated at Bhubaneswar upto 1992-93. Then the Centre was shifted to Bhawanipatna in 1992 and to Phulbani in 1994. Presently, the Centre is functioning at Phulbani. This Centres has been conducting research on different theme areas to generate location-specific technologies.

Agro-climatic zone characteristics

The domain districts of the AICRPDA centre, Phulbani are located in North Eastern Ghat Zone (NARP) in Odisha and in the Garjat hills, Dandakaranya and Eastern Ghats hot moist sub-humid eco-sub-region of Agro-ecological sub-region (ICAR) 12.1 and in the East coast plain and Hill region of agroclimatic region (Planning Commission).

The climate of the zone is sub-humid. Out of the total annual average rainfall of 1407 mm, south west monsoon contributes 80%, post-monsoon 10% and summer rainfall 10%. The onset of the monsoon is during second week of June and normal withdrawal is during first week of October. The historical rainfall data (of 30 years) indicated that the deviation from the normal rainfall during south west monsoon was found to be 16% excess and 13% deficit of the average rainfall. The mean annual maximum temperature is 37 °C and mean annual minimum temperature is 10.4 °C. Hottest month is May and cold month is December.

Mean season-wise and annual rainfall and rainy days at AICRPDA centre, Phulbani

Rainfall	Normal rainfall (mm)	Normal rainy days (No.)
South west monsoon (June - September)	1145	49
Post-monsoon (October - December)	125	8
Winter (January - February)	22	2
Summer (March - May)	115	6
Annual	1407	65

Major soil types

The major soil types in the zone are red (63%), lateritic alluvial (14%), brown forest (2%), mixed red and black (13%) with sandy to sandy loam texture.

Major rainfed crops

The major rainfed crops cultivated in the zone during *kharif* are rice, maize, finger millet, pigeonpea, niger, sesamum, cotton, greengram, blackgram, turmeric and off-season vegetables (tomato, brinjal, cauliflower, cabbage, cowpea, bean etc.).

Dryland agriculture problems

Crop production and soil management

- Soils have low water holding capacity, low in organic carbon and plant available nutrients (NPK)
- Prone to soil and water erosion
- Crops suffer due to erratic monsoon causing dry spells in crop cycles
- Low adoption level of farm mechanisation at farmers' field due to non-availability of improved farm implements and reluctance to adopt because of higher cost and fragmented and small land holdings
- Predominantly monocropping system, slow rate of crop diversification and non-availability of a suitable IFS model based on existing practices

Socio-economic

- Small, fragmented and scattered holdings with fragile resource base of farmers
- Frequent failure of crops leads to uncertain production
- Low borrowing and investment capacity coupled with lack of subsidiary enterprises.
- Inadequate agri-inputs during cropping season and poor marketing infrastructure.
- Lack of vegetation cover in farm without any social fencing.
- Illiteracy and gender bias

Significant achievements

Rainwater management

- Soil cement (6:1) mortar of 8 cm thickness restricted the seepage loss and the seepage flow in the farm pond. The cost of the soil cement lining of the tank of 76 m^3 is nearly 41% cheaper than the polythene lining of same tank. Hence soil-cement (6:1) lined tank is recommended.
- Excess runoff water arising due to heavy rainfall events can be saved in dug out and lined farm ponds and judiciously

utilized in continuous furrow method of irrigation. Continuous furrow irrigation exhibited 29.46%, 46.75%, 57.79% and 28.20% higher REY over 'no irrigation' in radish, cauliflower, yambean and okra, respectively.

- Strip and intercropping of cereal crops with pulses/oilseeds are approved practices for breaking long slopes which prevent soil loss, reduce runoff and enhance productivity. Groundnut + pigeonpea (4:2) intercropping system also gave significantly the highest REY (49.96 q/ha), the lowest runoff (267.5 mm), the lowest soil loss (6.06 t/ha) which was 42% and 51.6% lower than the cultivated and uncultivated fallow respectively and also lead to less runoff (19.78%) as compared to other sole crops.
- Application of organic mulch in the vegetable fields was found to be the best to arrest soil erosion, conserve soil moisture, intercept surface runoff and suppress weed growth.
- Ridge furrow system of planting was found to be good for efficient irrigation from harvested rainwater and organic mulching with dried *Sal* or *Cassia* leaves in tomato – radish sequence. The ridge furrow system with organic mulching resulted in highest tomato equivalent yield (15.41 t/ha) in the tomato-radish sequence.

Crops and cropping system

- Intercropping of vegetables with rice in definite row proportion and optimum plant population resulted in higher equivalent yield and LER.
- Arhar + okra either in 2:2 or 2:1 row ratio provided optimum plant population of the crops and resulted in maximum yield of the system. The arhar + okra (2:1) and arhar + okra (2:2) in row proportions yielded the highest amongst all the arhar vegetable intercropping system and recorded LER of 1.6 and B:C ratio of 2.5.
- The INM practices viz. 50% CF + 50% N (FYM) and 50% CF + 50% N (Green leaf) in yam + maize intercropping system resulted in high productivity under rainfed upland region.
- Rice + cowpea and rice + rice bean resulted in higher equivalent yield and net income. Application of FYM @ 5 t/ha + 50% RDF recorded highest equivalent yield among nutrient management methods. Fodder helps to meet the requirement of feeding the milch animals.
- Intercropping of maize + vegetable resulted in higher maize equivalent yield (MEY) and net income as compared to sole maize. Intercropping of maize + cowpea resulted in higher MEY followed by maize + bitter gourd and maize + runner bean intercropping system. Application of FYM @ 10 t/ha + VC @ 2 t/ha as basal and spraying pot manure at 15 days interval for 4 times recorded higher yield in all the maize + vegetable intercropping system.
- Rainfed vegetables like cauliflower, cabbage, knolkhol, tomato can be taken as intercrops in pigeonpea with various proportions of combination to provide better economic returns and sustainability in production. Among all the intercropping system, pigeonpea + tomato followed by pigeonpea + cauliflower/radish were found to be the most profitable intercropping systems, hence recommended for farmers in rainfed upland.

Nutrient management

- Lime @ 8 q/ha with P and K each @ 40 kg/ha should be applied in maize - horsegram cropping system for higher yield of the system.
- Application of 100% RDF ($N:P_2O_5:K_2O$:20:40:20 kg/ha) + Ca (in the form of PMS @ 5 q/ha) + S (in the form of gypsum @ 30 kg S/ha) + B (in the form of Borax @ 12.5 kg/ha) exhibited highest pod yield in groundnut under rainfed conditions.
- Application of chemical fertilizer and organic manure separately and in combination along with lime and bio-fertilizer resulted in increase of turmeric yield. Blackgram was grown after the turmeric cultivation on residual fertility of different nutrients applied previously.
- Greengram-*toria* cropping sequence can be taken in place of upland rice to overcome drought. However, the productivity of the system is low due to inadequate nutrient supply and the soil is acidic in nature in this area. The productivity of the system can be improved through liming and use of other organic sources of nutrients as FYM and green leaf along with P and K.

Energy management

- Use of Phulbani dryland weeder saved almost 53 MD (Man days) in weeding 1.0 ha of upland crop as against 111 man-days in case of local weeder (Gadi) and also registered around 21 and 9% higher grain yield than that with manual weeding and weeding with local weeder (Gadi). It creates soil mulch and conserves moisture besides working as a crust-breaker and potato digger. The weeder eliminates weeds early in closely sown (15 cm) upland rice.
- Conventional tillage + two interculture and integrated nutrient management with both organic and inorganic sources such as 50% organic + 50% inorganic gives the maximum rice yield.

Technologies developed

Rainwater management

- Lining in farm pond for seepage control
- Water harvesting through farm pond and judicious utilization of conserved water in rainfed olericulture
- Mulching of vegetable crops under rainfed condition

- *In-situ* soil moisture conservation methods and efficient rainwater utilization on tomato - radish sequence in N-E Ghat Zone of Odisha

Cropping systems

Intercropping system

- Maize + cowpea (2:2)
- Maize + pigeonpea (2:2)
- Pigeonpea + radish (2:2)
- Maize + runner bean (2:2)
- Maize + bitter gourd (2:1)
- Maize + cucumber (2:1)
- Maize + ridge gourd (2:1)

Double cropping system

- Upland rice - greengram
- Upland rice - horsegram
- Maize - potato
- Maize - horsegram
- Maize - mustard

Nutrient management

- Liming of maize - horse gram cropping system for P and K availability and yield
- Integrated nutrient management of turmeric
- Organic farming in turmeric - blackgram crop rotation in NE ghat hills
- Long term fertilizer and organic manure application on rice- horse gram crop sequence
- Nutrient management for turmeric - blackgram crop rotation

Energy management

- Phulbani Dryland Weeder
- Low till farming in rice - pulses relay cropping system

Integrated nutrient management practices

Crops	INM practices
Upland rice, maize, cotton and turmeric	Recommended dose of NPK + FYM 5 t/ha + lime 200 kg/ha, application of *Azospirillium* 2-3 kg/ha in seedling treatment for paddy, application of *Azospirillium*/*Azatobacter* 0.5 kg/ha in seed treatment for maize, application of *Azatobacter* 0.6-1.0 kg/ha in seed treatment for cotton.
Niger, sesame, greengram, blackgram and pigeonpea	Recommended dose of NPK + FYM 5 t/ha + lime 400 kg/ha, application of *Rhizobium* 1-2 kg/ha for pigeonpea and 0.4-0.6 kg/ha for greengram and blackgram for seed treatment purpose, application of *Azatobacter* 0.2 kg/ha in seed treatment for niger and sesame crops.

Contingency crop planning

***Kharif* crop planning**

a. Suggested contingency crops and cropping systems and cultivars under delayed onset of monsoon

Delay by 2 weeks (June 2nd to 4th week)

- Rice (Vandana, Khandagiri, Lalat, Naveen), Maize (Navjot, Hybrids), Blackgram (Pant U-19 & 30, Ujala, Sarala), Ragi (Dibya Singha), Niger (Deomali, Utkal Niger), Kharif vegetables Tomato (Utkal Kumari, Utkal Raja), Brinjal (Blue star, Utkal Anushree, Tarini), Cow pea (Utkal Manika), Cabbage (Pride of India, Disa Pusa early synthetic), Cauliflower (Summer king)
- Closer row and plant spacing in rice, maize, blackgram, tomato, brinjal
- Apply full dose of P, K and 20% recommended dose of N along with well decomposed organic matter for early seedling vigor.
- Conservation furrow at 3-5 m apart in maize and blackgram
- Sow crops across the slope to develop a ridge and furrow type of land configuration for effective soil moisture conservation

Delayed by 4 weeks (2nd week of July)

- Rice (Sahabhagi, Vandana), Maize (Navjot, Hybrids), Blackgram (Pant U-19 & 30, Ujala, Sarala), Ragi (Dibya Singha), Niger (Deomali, IGP-76), Kharif vegetables Tomato (Utkal Kumari, Utkal Raja), Brinjal (Blue star, Utkal Anushree, Tarini), Cow pea (Utkal Manika), Cabbage (Pride of India, Disa Pusa early synthetic), Cauliflower (Summer king), Toria (Parvati, Anuradha, PT-303).
- Intercropping system such as maize + cowpea (2:2), maize + pigeonpea (2:2), pigeonpea + radish (2:2), maize + runner bean (2:2), maize + bitter gourd (2:1).
- If mortality is less than 50% gap filling should be done, if more than 50% mortality, resow the crop with short duration high yielding low water requiring crops like green gram, black gram, cow pea after receiving the rainfall.
- In-situ moisture conservation practices may be adopted complete hoeing, weeding followed by ridging to the base of the crop rows at 20 days after sowing for moisture conservation.
- Hoeing and weeding followed by ridging to the base of the root crop for in-situ moisture conservation.

Delayed by 6 weeks (1st week of August)

- Rice (Sahabhagi, Vandana), Maize (Navjot, Hybrids), Blackgram (Pant U-19 & 30, Ujala, Sarala), Ragi (Dibya Singha), Niger (Deomali, IGP-76), *kharif* vegetables Tomato (Utkal Kumari, Utkal Raja), Brinjal (Blue star, Utkal Anushree, Tarini), Cow pea (Utkal Manika), Cabbage (Pride of India, Disa Pusa early synthetic), Cauliflower (Summer king), Toria (Parvati, Anuradha, PT-303).

- Intercropping system such as maize + cowpea (2:2), maize + pigeonpea (2:2), pigeonpea + radish (2:2), maize + runner bean (2:2), maize + bitter gourd (2:1).
- Hoeing and weeding in crops except upland rice to provide dust mulch.
- Post emergence spray of Quizalophos 5% EC @ 0.05 kg ai / ha in 500 litres of water to control weeds in groundnut.
- Foliar spray of 2% KCl + 0.1 ppm Boron to black gram.
- Foliar application of 2% urea at pre-flowering and flowering stage of green gram.
- Spray 1% urea in vegetables crops.
- Top dressing of 25 % urea and potash after receipt of the rain for upland rice.
- Remove the pest and disease infected plants from the main field.
- In-situ rain water conservation, harvesting excess run off for recycling.

Delayed by 8 weeks (2nd week of August)

- Prefer early *rabi* pulses such as blackgram with favorable residual moisture under upland conditions.
- Provide life saving irrigation.
- Remove the pest and disease infected plants from the field.

b. Crop, soil, water and nutrient management strategies during seasonal drought

Early season drought

- Inter-cultivation and thinning to maintain plant population per unit area of the crop
- If mortality is less than 50% gap filling should be done, if more than 50% mortality, resow the crop with short duration high yielding low water requiring crops like green gram, black gram, cow pea after receiving the rainfall.
- Hoeing and weeding followed by ridging to the base of the root crop for in-situ moisture conservation.
- Post emergence spray of Quizalophos 5% EC @ 0.05 kg ai / ha in 500 litres of water to control weeds in groundnut.
- Provide lifesaving irrigation.

Mid-season drought

- Hoeing weeding and earthing up for moisture conservation in maize, groundnut and vegetable crops.
- Provide life saving irrigation from rainwater stored in farm ponds/check dams
- Weeding and mulching with organic materials such as *Sal* leaves and paddy straw based on the availability.
- Foliar spray of water soluble fertilizer N:P:K 19:19:19 @ 5 g/litre to rice crop.
- Foliar spray of 2% KCl + 0.1 ppm boron to blackgram to overcome drought situations.
- Strengthen the field bunds and close the holes to check seepage loss.

Terminal drought

- Provide lifesaving irrigation from check dam/farm pond
- Harvest rice at physiological maturity stage
- *Paira* cropping of greengram (TARM 1, TARM 2, OBGG-52, Pusa 9072)/ Blackgram (PU-31, IPU 2-43).
- Sowing of greengram/ blackgram by Zero seed drill for moisture conservation.
- Foliar spray of water-soluble fertilizer N:P:K:19:19:19 @ 5 g/litre to pulse crops.

Rabi crop planning

Suggested crops and varieties for delayed seasons

- Pulse crops like blackgram (PU-31, IPU 2-43) and greengram (TARM 1, TARM 2, OBGG-52, Pusa 9072) can be grown if irrigation facilities are available.

Technologies upscaled in convergence with various programmes

- Lining of farm pond on all the four sides with soil cement (6:1) mortar of 8 cm thickness restricted the seepage loss and conserves excess runoff water from the field and the stored water could be utilized for raising high value vegetable crops, which ultimately can double the farm profit. This technology has been upscaled by the watershed and fishery departments of the state.
- Rainwater management technologies such as raising bund height of field bund, graded bunding, staggered trench has been taken up as land development programme under MGNREGS programme in Kandhmal District.
- Maize + cowpea (2:2) intercropping system is advised to farmers of this district as sole maize cultivation is comparatively less remunerative, vulnerable to hazards of nature and depletes soil nutrients. The technology has been picked up by the Agriculture Department and demonstrated in all the blocks of Kandhamal district.
- Rice + fodder intercropping system has been adopted by the farming community as they realized the importance of the green fodder for the cattle. More nos. of training and demonstration on these aspects need to be conducted for their awareness.
- Intercropping of maize + arhar (2:1) and arhar + radish (2:2) adopted by state and district action plans
- Intercrop like cowpea / greengram / blackgram are intercropped in mango / cashew orchard for first 3 years and turmeric/ginger in subsequent years to develop an ALUS

which has been included in NHM programme of Dept. of Horticulture.

- Popularization of drought tolerant rice (Vandana, Sahabhagi, ZHU 11-26) varieties among farmers in the domain districts.
- Contingent crop plans in adopted village (Budhadani and Gunjidraga of Phulbani block) during dryspell motivated farmers of the adjoining villages to include these interventions in their crop plan.
- Maize + ridge gourd (2:1) intercropping systems have been adopted by the local maize growers. Local maize is grown in 0.15 lakh ha and hybrid maize is grown in another 0.35 lakh ha in the domain area. Such technology is being up-scaled through the RKVY programme of the state department of agriculture.
- Organic manures rather than chemical fertilizers in turmeric is being prioritized by NGOs, state department of horticulture through large scale demonstrations in village levels.
- Mulching practice in maize-based intercropping systems is being popularized by RKVY and ATMA programme of the state department of agriculture. This technology has also been extended to the maize growing interior district of Odisha.

Impact of technologies

The AICRPDA, Phulbani centre conducted demonstrations and training programme for farmers to update their knowledge and skills in modern dryland technologies. The impact of different dryland technologies in the North Eastern Ghats Agro-climatic Zone of Odisha are given below. The Centre also conducted demonstrations on location specific technologies to establish its production potentials on the farmers' fields. The Centre is working as resource and knowledge centre of dryland agricultural technology for supporting the farmers and line departments. The Centre also supported Agriculture and Horticulture Department of the district as technical expert for capacity building of functionaries and farmers. The Centre also acts as an integral part of different agricultural committees of district administration. Ridge furrow system and broad bed furrow system with organic mulching improved the water holding capacity of soil by 34% and equivalent yield by 58%. Water harvesting in farm pond and its utilization for vegetable crops increased the equivalent yield by 62%, economic benefit (net return, B:C ratio) by 35% and 37% respectively. Maize + Cowpea, Maize + Pigeonpea, Pigeonpea + Radish resulted in 60-70% increase in equivalent yield by intercropping system than sole cropping. Green manuring with Dhanicha: Rice resulted in 15% increased yield

Way forward

The following research and development programme of the centre need to be focused in future.

- More focus should be given to rain water conservation and effective utilization of technologies in accordance with 'more crop per drop'.
- Farming system research to aim at doubling the farm income by identification and addition of supplementary and complimentary components to the existing set up.
- Preparation of situation specific crop wise contingent plan for dissemination, adoption and validation.
- Focus should be given on system research involving traditional crops. Emphasize on supporting technology to "Paramparagat Krishi" and Krishi Sinchai Yojana".
- Block level contingent plan should be prepared in context of climate change.
- More research should be given on organic agriculture, drought coping, carbon sequestration as Kandhamal district has been declared to be the organic district of Odisha.
- Emphasis should be given to strengthen and popularize the RIFS model in the zone incorporating more components like seasonal flowers, perennial exotic fruit trees, piggery, duckery and improved fingerlings of fish on a cluster model.