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Overview of Dryland Agriculture Research and Achievements in Western Plateau Zone of Jharkhand

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Brief history of the Centre

All India Coordinated Research Project for Dryland Agriculture Centre was started in 1971 at Kanke, Ranchi, Jharkhand. The location of the Centre has been shifted from Kanke to Zonal research station, Chainki during 2009. The Centre is running under the umbrella of Birsa Agricultural University, Kanke, Ranchi.

Agro-climatic zone characteristics

The domain districts of the AICRPDA Centre, Chainki are located in Western Plateau zone (NARP) in Jharkhand, in the Agroecological subregion 11.0 and in the Eastern Plateau and Hills agroclimatic region (planning commission). The climate of the zone is sub-humid to semi-arid. The annual rainfall varies from 800 mm to 1200 mm of which 90% is received during south west monsoon while 6, 3, and 1% during north-east monsoon, winter and summer season respectively. The normal onset of monsoon is during June and the normal withdrawal is during the first week of November. The rise in maximum mean annual temperature (2.9^{o} C) and decline in minimum mean annual temperature (3.60^{o} C) has been observed.

Mean season-wise and annual rainfall and rainy days (AICRPDA Centre, Chianki)

Rainfall	Normal rainfall (mm)	Normal rainy days (No.)
South west monsoon (June-September)	1032	43
North east monsoon (October-December)	69	74
Winter (January-February)	36	3
Summer (March-May)	33	4
Annual	1170	54

Major soil types

The major soil types in the zone are loamy and sandy loam soils.

Major rainfed crops

The major rainfed crops cultivated in the zone during *kharif* are rice, maize, pigeonpea and blackgram and during *rabi* are chickpea and wheat.

Dryland Agriculture Problems

Soil and land management related

- Excess surface runoff due to undulating topography.
- The upland soils are acidic, light and low in organic matter and plant nutrients
- Poor fertility status of soils
- Soils are generally acidic in nature having pH 5-6.5

Crop production related

- Primitive nature of cultivation, i.e, broad casting methods of sowing of uplands crops, such as rice, maize, pigeonpea, blackgram, sesame and niger
- Lack of sate seed corporations and other recognized seed multiplying agencies
- In sufficient or imbalance use of chemical fertilizer
- Poor irrigation facilities
- Lack of mechanization
- Traditional crops/varieties/cropping system
- Predominant monocropping
- Weed infestation and higher incidence of disease and pests

Socio-economic

- Fragmented land holdings
- Lack of input supply
- Low adoption of improved crop production technology
- Lack of credit facilities provided by the public sector banks
- Poor post-harvest facilities
- Less use of high yielding varieties of crops grown in the region
- Problem of stray cattle

Significant achievements

Rainwater management

- *In-situ* moisture conservation measures such as land shaping, broad bed & furrow system, timely tillage and mulching improved soil moisture retention which helped germination, crop growth and reduced soil loss by providing more opportunity time for rainfall to enter into the soil. *Ex-situ* moisture conservation measures such as collection of excess rainfall from micro catchments into small ponds facilitated the supplemental irrigation in *rabi* and *kharif* crops during dry spells. Also, it has helped to grow vegetable crops of short duration. Studies in the Centre helped to estimate probability and recurrence period of droughts and heavy rainfall. Optimization of natural resources through improved land preparation, optimal use of organic and inorganic fertilizer and conjunctive use of water helped to increase the sustainability in crop production and the natural resources like rainfall, land and vegetation has been used at optimal level. Timely tillage operation has increased moisture retention of the soil and use of organic and inorganic fertilizers has helped to maintain the soil fertility. Conjunctive use of surface and groundwater has helped to maintain the water table.

Cropping systems

- Rice is considered as a dominant crop of the state and therefore maximum emphasis was given on rice. In the evaluation of drought tolerant lines of rice conducted during 2011, the entry BVD-109 and BVD-110 (24.36 q ha^{-1}) out yielded significantly in comparison of all the 15 entries tested. In rice varietal trial conducted in the year 2011, the entry Vandana was found to be higher yielder (28.34 q ha^{-1}) in comparison to others whereas in the evaluation of drought tolerant lines of rice during the year 2011-2012, the entry RR-616-B-2-75-2 (26.75 q ha^{-1}) yielded significantly higher followed by RR-F-25 (24.71 q ha^{-1}), Vandana (23.54 q ha^{-1}.).
- Birsa Dhan 108 (matures in 70 days), Birsa Vikas Dhan 109 (matures in 85 days) and Birsa Vikas Dhan 110 (matures in 95 days) of upland rice has been developed and given to the farmers. Farmers are preferring these varieties because of early maturity, high yielding and also having capabilities of tolerating drought. Birsa Dhan 108, an extra early maturing variety and very much suitable for dryland and mono-cropped system because second crop during *rabi* may be taken on residual moisture available in the field and thus help in cropping intensity. Birsa Vikas Dhan 109 and Birsa Vika Dhan-110 are promising varieties for rainfed upland ecology of rice because both are having superfine grain quality where all the varieties of rice which has been developed for this ecology are having course grain. Therefore, farmer may get good price in the market by cultivating these varieties under rainfed upland condition.
- In the experiment entitled 'Evaluation of drought tolerant lines of finger millet' conducted continuously for four years from 2010-11, the entry GPU – 28 (30.4 q ha^{-1}) followed by BBM-10 yielded (27.35 q ha^{-1}) out yielded significantly in comparison of all the test entries. In multilocational trial of sorghum conducted during 2013-14 , ten entries of sorghum were evaluated for suitability of rainfed ecology of Palamau region. Out of which, CSV-20 surpassed the yield 32.58 q ha^{-1} and was also superior in comparison of all entries tested. Whereas SPV-1820 (31.95 q ha^{-1}), SPV-2064 (28.26 q ha^{-1}), CSV-15 (27.65 q ha^{-1}) and CSH-16 (27.62 q ha^{-1}) were also at par in comparison to other test entries including local. In linseed varietal trial conducted from 2011-12 and 2012-2013, the entry NL-259 (7.46 q ha^{-1}) has recorded higher yield in comparison to check T-397 (6.40 q ha^{-1}).
- J-1 variety of groundnut was found significantly higher yielder over existing variety AK 112-24 during 1981-83. A-300 and A-1 variety of safflower were identified as drought tolerant, short duration and high yielder for this region during 1990-91.BAU 149-2, BAU 148-30 and BAU 4045 variety of rice was found significantly higher yielder over existing variety brown Gora during 1999-2000. CSV-20, SPV-1820 variety of sorghum were found early maturing, high yielder and suitable for drought like situation during 2008-2009. In Horse gram var., Birsa Kulthi -1, Madhu and GHG-19 were found early maturing, high yielder and suitable for drought like situation. Birsa vikas Makka-2 a composite and short duration hybrid of maize has been evolved and it matures in 80 days having plant height of 180-185 cm. Because of early maturity, it can escape drought which has become regular feature in the state. This variety has also qualified for high quality protein maize (QPM) which may provide the nutritional security to the tribal farmers of the region. The yield potential is 40-45 q ha^{-1} and has been found very much suitable under rainfed condition. Quality seed of high yielding varieties is being provided to the farmers and has been found promising under the farmers managed condition. The quality seed has also been found to increase the yield by 15-20% alone and if package of practices and IPM recommended by the University are followed by the farmers, the yield increase may go up to 60-70%.
- The Intercropping of pigeonpea + Okra (1:1) has given maximum pigeonpea equivalent yield (2834 kg ha^{-1}) which is about 100% more in comparison to pigeonpea and okra alone. This intercropping has helped farmers in increasing their livelihood. The effect of inter-row spacing and level of nitrogen on grain yield of lentil was studies and maximum grain yield 4.47 q ha^{-1} of lentil was observed when 30 kg N ha^{-1} was applied while maintaining the spacing of 30 cm from row to row. The farmers for harvesting the highest grain yield of lentil are following this recommendation. Sowing of horsegram, sorghum and gundli in case of failure of monsoon has yielded satisfactorily in the prevailing drought situation.
- Sowing of early maturing varieties of *kharif* crop like rice which may be harvested by the end of September and *rabi* crop like Toria, mustard, linseed and lentil has been sown on the residual moisture available in the field. This has not only increased the crop production but also the profitability

and sustainability. Pigeonpea based intercropping with upland rice has been easily adopted with high sustainability and profitability. The rate of adoption is 40-50%. This has been very remunerative that is why farmers has attracted and adopted this intercropping.

Energy management

- Improved animal drawn implements like Birsa ridger plough, seed drill, dutch hoe and handy implements like grubber, improved sickle has been tested in farmers field and found suitable for increasing the operational efficiency.

Technologies upscaled in convergence with various programmes

The Centre is working as a nodal agency for addressing the problems related to Dryland Agriculture and contingency planning of the region. The electronic and printing media are very much helpful while covering the experimental details and publishing it in daily newspaper and also telecasted by Radio and Doordarshan. The films of the success stories are also prepared and shown to the farmers at the time of visit to the Centre. The soil testing facilities helped to know the status of nutrients and their deficiency. This helps in providing the balanced use of fertilizer for harvesting the potential yield of the crops/varieties. These outcomes have been beneficial in improving the socio-economic condition of the farmers in general and resource poor farmers in particular because the farming community of the region has been benefited a lot by adopting the recommended variety/technology developed by the Centre. Improved varieties and its popularization improved the yield of *kharif* and *rabi* crops. Birsa seed cum fertilizer drill is very much popular in ORP village.

Technologies developed

Rainwater management

- Use of harvested rainwater for production of short duration leafy vegetables in Ranchi region of Jharkhand.
- Restricted irrigation in mustard during *rabi* crop for higher productivity and water use efficiency
- Cultivation of crops with field bunds
- *In-situ* moisture conservation by ridge and furrow
- Rainwater harvesting in farm ponds

Cropping system

Intercropping systems

- Pigeonpea + okra (1:1)
- Pigeonpea + maize (1:1)
- Pigeonpea + sorghum (1:1)
- Pigeonpea + groundnut (1:2)
- Chickpea + linseed (4:2)
- Chickpea + safflower (2:1)

b. Double/triple cropping systems

- Rice-wheat
- Rice-chickpea
- Rice-lentil
- Rice-linseed
- Rice-safflower
- Varieties recommended: Upland – Vandana, BVD 109 and 110; Medium land - Naveen and Sahabhagi Dhan and hybrid Arize Tej, PAC-801 and PAC-807.

Nutrient management

- Spray of 2% Urea solution in rainfed chickpea to compensate yield loss due to delay sowing of chickpea.
- 50% N through organic source + 50% N through inorganic source for rice

Energy management

- Adoption of zero tillage technology under rainfed medium land situation after harvest of rice for saving of energy, labour cost and time
- Dutch hoe as sowing, weeding and interculture tool for reducing drudgery and improving efficiency in operation.
- Birsa ridger plough for timely planting of rainfed crops

Contingency crop planning

For *Kharif* planning

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

- Rice (BVD-109, 110,Vandana, IR-36, IR-64, Lalat, Birsa Dhan-202, Birsamati, Rajendra munsuri-1, MTU-7029), maize, sorghum (CSV-20, CSV-17 hybrid), pigeonpea (Birsa arhar-1, Bahar, BR-65, local)
- Inter croping systems: pigeonpea + maize, pigeonpea + groundnut; blackgram (Birsa urd-1, T-9, Pant U-19); soybean (Birsa soybean-1); pigeonpea + sorghum

b. Suggested crops/varieties/cropping systems under delayed onset of monsoon

Delay by 2 weeks (4th week of June)

- Rice (Naveen, shabhagi); hybrid rice (PAC-807, Uday - 111, 27 P31, Arize-6444); pigeonpea + maize
- Intercropping systems: pigeonpea + groundnut, pigeonpea + sorghum; sorghum (CSV- 20, CSV-17 hybrid); pigeonpea (ICPH-2671, ICPH-8)

Delay by 4 weeks (2nd week of July)

- Rice (Naveen, shabhagi); maize (Kanchan, Suwan, Composite-1, BVM-2) or fingermillet (A-404, Birsa Marua-1)
- Intercropping systems: Pigeonpea + sorghum (sorghum: CSV-20, CSV-17); pigeonpea + okra (Pravani kranti, Arka Anamika, A-4); pigeonpea + groundnut (Birsa Bold); hybrid pigeonpea (ICPH–2671); maize (HQPM-1); hybrid rice

(PAC-807, Uday-111, 27P-31, Arize- 6444); blackgram (Birsa Urd-1, T-9, Pant U-19)

Delay by 6 weeks (4th week of July)

- Fingermillet (A 404, Birsa Marua-1); maize (Kanchan, Suwan, composite -1, BVM-2)
- Intercropping systems: Pigeonpea + sorghum (CSV-20 and CSV-17); Pigeonpea + okra (Pravani kranti, Arka Anamika, A-4); hybrid pigeonpea (ICPH-2671); hybrid rice (PAC-807, Uday-111, 27P31, Arize-6444); blackgram (Birsa Urd-1, T-9, Pant U-19); fingermillet (A-404, Birsa Marua-1)

Delay by 8 weeks (2nd week of August)

- Plan to sow toria/ cowpea/ niger/vegetable pea (Toria: Bhawani, Panchali, Pant toria- 303, Lotni (Local)); hybrid pigeonpea (ICPH-2671, ICPH-8); niger (N-5, Birsa niger-2 and 3); vegetable pea (Azad, Arkel); mustard (Pusa Bold, Shivani, Pusa Kranti); kulthi (Birsa kulthi-1, Madhu); *kharif* potato (Kanchan)
- Sowing of early toria (Var-9, PT-303), niger, horsegram and *kharif* potato
- Transplanting if is available mid early variety (Anjali, BVD 109,110,111)

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

Early season drought

- Thinning and gap filling of existing crop
- Resowing of crop if previous crop completely fails
- Soil mulching, gap filling and conservation furrow
- Extend area under Shabhagi Dhan variety of rice

Mid season drought

- Repeated intercultivation
- Opening of conservation furrows
- Mulching with available farm waste
- Presowing application of compost to enhance the water holding capacity of soil
- Removal of weeds and use for mulching
- Life saving irrigation, if available

Terminal drought

- Harvest the crop at physiological maturity stage
- Provide protective irrigation, if available
- Transplanting rice with 5-6 seedling/hill, if age of seedling is more than 30 days reduce fertilizer dose to 20%
- Harvesting at physiological maturity, early harvest for use as fodder in case of impending crop failure, in case of total crop failure early rabi planning
- Plan for *rabi* with niger/mustard/ chickpea/ linseed

Impact of technologies

Cultivation of HYV Vandana in bunded fields yielded higher (1989 kg ha^{-1}) in comparison to unbunded fields. The BC ratio was found maximum (1.69) in bunded condition compared to unbunded condition (1.34). Chickpea variety KPG 59 was tested with farmers variety under minimum tillage condition on available moisture after paddy harvest. Variety KPG 59 produced significantly higher mean grain yield (1657 kg ha^{-1}) as compared to local variety (1227 kg ha^{-1}). Improved varieties of upland rice, black gram, pigeonpea and mustard produced 40-50 percent higher yields over local checks. The improved varieties of these crops were highly adopted by the farmers. About 80-90 percent adoption is recorded in case of Birsa Vikas Dhan-109 variety of rice, 60-70% adoption in case of Birsa urad-1 of black gram and 50-60% adoption in case of Birsa Arhar-1 of pigeonpea in Ranchi district.

Pigeonpea + rice (1:3), pigeonpea + maize (1:1) and pigeonpea + ground nut (1:2) gave pigeonpea equivalent yield of 749, 1233 and 1587 kg ha^{-1} as against sole pigeonpea yields of 556, 491 and 500 kg ha^{-1} with a B:C ratio of 0.81, 0.83 and 1.77 respectively. These systems are adopted by over 25 percent of farmers in the region. Intercropping of pigeonpea + okra (1:1) gives maximum pigeonpea equivalent yield of 2965 kg ha^{-1} with B:C ratio of 4.10 as compared to sole pigeonpea yield of 2123 kg ha^{-1} with B:C ratio of 2.5 and sole okra yield of 900 kg ha^{-1} with BC ratio of 3.10. The system gives RWUE of 2.51 kg/ha-mm as against 1.8 kg/ha-mm in sole pigeonpea and 1.97 kg ha^{-1}mm^{-1} in sole okra. There is an additional income of Rs.40000 ha^{-1} with this system as compared to sole crops.

Labour savings through sowing behind plough was 42 man-hour per ha over sowing using Dutch hoe. However, higher mean yield was recorded in treatment of sowing by Dutch hoe (3084 kg ha^{-1}) as compared to behind plough (2560 kg ha^{-1}). The use of Birsa ridger plough gives 20-30% higher yield advantage over traditional plough for major rainfed crops.

Way forward

About 80 percent area of the state of Jharkhand is rainfed and hence there is a need to give more emphasis on rainwater management. The declining annual rainfall and its erratic behavior, necessitates the needs for adoption of newer dryland farming technology. The watershed management is crucial for the development of the entire region.

Focused research areas are:

- Optimized use of natural resources, i.e. rainfall, land and water to minimize the soil and water loss and degradation of environment through soil and water conservation practices is essential.
- The drought has become regular phenomenon in the region and therefore there is need to introduce drought resistant varieties for higher grain yield and fodder.
- The alternate land use systems such as agroforestry needs to be encouraged along with animal husbandry for generating additional income.
- Crop diversification with pulses and oilseeds
- Rainfed integrated farming systems models
- Farm mechanization