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Overview of Dryland Agriculture Research and Achievements in Bastar Plateau Zone of Chhattisgarh

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Brief history

The AICRPDA centre, Jagdalpur started in the year 2004-05 at S.G. College of Agriculture and Research Station, Bastar district, Chhattisgarh under Indira Gandhi Krishi Vishwavidyalaya. The domain districts of the AICRPDA centre, Jagdhalpur are located in Bastar Plateau Zone (NARP) in Chhattisgarh and in the agro ecological sub region (ICAR) 12.1 and in the Eastern plateau and hills agro climatic region (planning commission). The domain districts of Jagdalpur centre are Bastar, Narayanpur, Dantewada, Kondagaon, Bijapur, Sukma. Since inception of the centre, both on-station and on-farm research is being carried in various thematic areas. On-farm research has been focused on farming-situation-specific *(Badi, Marhan, Tikra, Maal, Gabbar)* technology generation**.**

Agro-climatic zone characteristics

Climate

In general, the climate of the zone is sub-humid. The south-west monsoon contributes 81% while north-east monsoon 8.0%, winter season 1.2% and summer 9.8% of the total annual average rainfall of 1444.8 mm (mean of 40 years data). The normal onset of monsoon is during second week of June while normal withdrawal is during second week of September. The historical rainfall data (of 10 years) indicated 11.6% excess of the average rainfall (from 41 years) during south-west monsoon and 10.73% more annually. The dry spells are being experienced at panicle initiation and reproductive stages of the crop i.e during the month of September most frequently in 40th standard meteorological week followed by 39th week. The mean maximum and minimum temperature in the zone are 30.9 and 17.4^{o}C, respectively.

Major soil types

Major soil types are *Entisols* (*Marhan*), *Alfisols* (*Tikra*), *Inceptisols* (*Maal)*, *Vertisols* (*Gabhaar*) with area coverage of 23.3, 49.7, 14.6 and 12.4%, respectively in the region.

Major rainfed crops

The major rainfed crops cultivated in the zone during *kharif* are rice, maize, fingermillet, horsegram, blackgram, pigeonpea, niger and little millet and during *rabi* are maize, chickpea and mustard.

Mean season wise and annual rainfall and rainy days (41 years from 1980-2020) (at AICRPDA Centre, Jagdalpur)

Rainfall	Normal rainfall (mm)	Nornal rainy days (No.)	Temperature (^{o}C)		Hottest week	Coldest week
			Max.	Min.		
Southwest monsoon (June-September)	1168.5	57.5	29.6	22.5	23rd	40th
Post monsoon (October-December)	115.5	10.3	28.4	14.2	41st	52nd
Winter (January-February)	18	1.9	29.5	11.7	9th	1st
Summer (March-May)	142.8	10.9	36.1	21.0	21st	10th
Annual mean	1444.8	80.6	30.9	17.4	21st	52nd

Dryland agriculture problems

The problems related to domain districts are as enlisted below:

Soil and land management

- Lands are marginal and unfertile
- Undulated topography
- Severe soil erosion
- Water logging in low land situations
- Lack of irrigation facility

Cropping systems

- Upland rice is grown predominantly during *kharif* season as rainfed crop covering 2.89 million ha but productivity of the crop is very low (8.53 q/ha)
- Predominant monocropping
- Not following standard package of practicing crops

Socio economic

- Low land holding (1.0 to 2.0 ha) of farmers
- Migration due to limited resources and practicing traditional agriculture

Significant achievements

Rain water management

- In case of *in-situ* moisture conservation under upland situation, one feet sunken/raised bed produced higher grain yield (2440 kg ha^{-1}) and RWUE (1.97 kg $ha^{-1}mm^{-1}$) compared to crops sown on ½ feet sunken and raised bed.
- In an assessment of moisture conservation for mango, U shaped pits found superior with a maximum plant height of 159.29 cm and plant girth of 10.05 cm.
- After rice in *rabi* season, different vegetable crops were cultivated by application of supplemental irrigation from the harvested rainwater and maximum yield of 37423 kg/ha were attained in bottle gourd followed by pumpkin

Nutrient management

- In INM trial on groundnut-onion cropping system, application of 100% general recommended dose (GRD) + lime @ 3 q ha^{-1} + $MgSO_4$ @ 15 kg ha^{-1} + FYM 5 t ha^{-1} in furrow was recorded higher groundnut pod yield (3102 kg ha^{-1}). The higher agronomic and recovery efficiencies of primary nutrients were recorded under 50% GRD + $ZnSO_4$ @ 25 kg + FYM @ 5 t ha^{-1} in furrow whereas higher physiological efficiency was recorded under 50% GRD + FYM @ 5 t ha^{-1} in furrow.
- In direct seeded rice, application of half dose of NPK with FYM @ 5 t ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} and lime @ 3 q ha^{-1} resulted in higher agronomic and recovery efficiencies of primary nutrients However, the maximum net returns and B:C ratio was recorded with the application of 50% NPK.
- Under mid land farming situation, sowing of dry aerobic rice produced maximum grain yield of 4818 kg ha^{-1} and straw yield of 6604 kg ha^{-1}, RWUE of 3.16 kg $ha^{-1}mm^{-1}$ with energy productivity of 0.52 kg/MJ by adopting line sowing behind plough + 100% RDF + FYM @ 1 t ha^{-1}.
- Long term effect of inorganic and organic manures on soil fertility and productivity of direct seeded rice under rainfed midland situations, application of full dose of NPK + 5 t FYM + $ZnSO_4$ @ 25 kg ha^{-1} + Lime 3 q ha^{-1} resulted in higher grain yield, rain water use efficiency and improved soil fertility.

Energy management

- Under dry aerobic rice, line sowing by *Nari* plough with 100% RDF + FYM @ 1 t ha^{-1} was recorded maximum grain yield of 5420 kg ha^{-1}, straw yield of 9853 kg ha^{-1}, RWUE of 3.69 kg $ha^{-1}mm^{-1}$ and energy productivity of 0.5 kg/MJ.
- In a study effect of reduced tillage and nutrient management on maize productivity under midland situation, summer ploughing + conventional tillage + 2 hand weeding recorded maximum to evaluate the grain yield of 3930 kg ha^{-1}. In case of nutrient management, 100% recommended dose of fertilizer recorded maximum grain yield (4880 kg ha^{-1}).

Alternate land use systems

- Under *tikra* and *marhan* situation, mango, amla, guava, sapota and cashew were evaluated. The biometric observations revealed that the fruit plants performed better under *marhan* situation.

Technologies developed

Rainwater management

- Multi-storey nursery technique to cope with heavy rainfall event and water logging conditions
- *Lehi* (sowing of sprouted seeds) technique
- Sowing rice and dhaincha together for improving root zone soil moisture
- For upland situations, sunken/ raised bed for rice and cowpea.
- Rainwater harvesting in farm pond and efficient utilization in midland (Mal) situation for *rabi* season for vegetable crops. Pond size of 20x20x3 m^3 was used for supplemental irrigation

Cropping system

Intercropping systems

- Upland rice+ pigeon pea (8:1)
- Fingermillet+ pigeon pea (6:1)
- Maize+ pigeon pea (4:1)
- Maize+ cowpea (4:1)
- Maize+ Okra (4:1)

Relay cropping systems

- Lowland rice-Lathyrus
- Lowland rice-Linseed
- Lowland rice-Fieldpea
- Lowland rice-Mustard

Double cropping systems

- Rice-Chick pea
- Rice-Field Pea
- Rice- Mustard
- Rice-linseed

Nutrient Management

- Application of Seeding dhaincha (Sesbania) with rice in same row by seed drill or broadcast and spraying of 2,4-D at 30 DAS

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- Application of full dose of NPK + 5 t FYM + $ZnSO_4$ @ 25 kg ha^{-1} + Lime 3 q ha^{-1} for medium and long duration rice varieties.
- 100% RDF (30:60:30 NPK kg/ha) + Lime @ 3 q/ha + $MgSO_4$ @ 15 kg/ha + FYM 5 t/ha in furrow for groundnut crop.
- In Zn deficient soils, spray 0.5% $ZnSO_4$ + 0.25% lime at active tillering stages twice at 10 days intervals. During dry spells, spray 1% KCl, 1% urea or 19:19:19 NPK + 0.5% $ZnSO_4$ twice at 10 days intervals.

Energy management

- Tractor drawn deep tillage equipments like disc plough and MB plough
- Line sowing by Nari plough in rice crop

Contingency crop planning

For *kharif*

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

Delay by 2 weeks (4th week of June)

- Rice- (upland bunded)-early duration varieties (Aditya, Poornima, Annada, Danteshwari)
- Rice-Midland (*mal*): (Danteshwari, Samleshwari, MTU-1010, Rajeshwari)
- Rice-Lowland (*Gabhar*): (Chandrahasani, Karma Masuri, Maheshwari, Swarna sub-1, Indira sugandhit dhan-1, Mahamaya, MTU-1001, Swarna, Badshah bhog selection-1;
- Maize (JM-216, Chandan safed makka-2&3, Navjot); Composite (NAC-6004)
- Pigeonpea (ICPL-87, No.148.BDN-2, ICPL-87, Rajeevlochan)
- Fingermillet (Indira ragi-1, Indira ragi-2, CG Ragi-3, GPU-28)

Delay by 4 weeks (2nd week of July)

- Midland rice- Poornima, Annada, Danteshwari, Samleshwari, MTU-1010, Madhuri
- Low land rice- Bamleshwari, Swarna, Jaldoobi, Indira Sugandhit Dhan-1, Pusa basmati
- Finger millet- Indira ragi-2, CG Ragi-3 to be sown in upland situation
- Little Millet- CG Kutki-1 and 2 and CG Sonkutaki in upland situation

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

Weather aberration	Crop	Stage of crop	Real time contingency measure implemented
a. Early season drought	Rice	Tillering stage	Each 7th row opening by country plough
	Rice	Tillering stage	Life saving irrigation at tillering
	Maize	Vegetative stage	Scooping in alternate row
b. Mid-season drought	Rice	Tillering stage	Each 7th row opening by country plough
	Rice	Late jointing	Foliar spray of 2% urea, 1% KCl, 3% Kaolin, 19:19:19 NPK 1% with 0.05% $ZnSO_4$
	Maize	Vegetative stage	Foliar spray of 2% urea, 1% KCl, 3% Kaolin, 19:19:19 NPK 1% with 0.05% $ZnSO_4$
	Horse gram	Vegetative stage	Foliar spray of 2% urea, 1% KCl, 3% Kaolin, 19:19:19 NPK 1% with 0.05% $ZnSO_4$
	Niger	Vegetative stage	Spraying water twice
c. Terminal drought	Rice	Flowering stage	Life saving irrigation at flower initiation stage,
	Horse gram	Flowering & poding	Water spraying @ 750 litre water per ha
	Niger	Flowering & poding	Water spraying @ 750 litre water but failed

Agro-horti system/ Dryland horticulture technology

Mango plantation (*cv*. Dashhari and Langra) with spacing of 10 m x 10 m with ragi and/or horsegram as intercrop for uplands (Marhan and Tikra) of Bastar plateau.

Technologies upscaled in convergence with various programmes

The technologies upscaled through various programmes are drought tolerant varieties, furrow opening technique at 2 m interval in direct seeded rice crop, mechanization of sowing and threshing by tractor operated machine, placing of FYM in rice row at the time of sowing for conservation soil moisture during short term drought at mid-way of growth stages, residual moisture utilization by growing field pea and chickpea after rice under midland and lowland situation of the region are some of technologies which have been gone. District wise contingency plans were also upscaled in the zone with the help of KVK and line departments, (agriculture, horticulture, fisheries, veterinary etc.)

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Impact of dryland technologies

Soil moisture conservation practices like U shaped pit found superior which could control 10% runoff. One feet sunken/ raised bed produced 13% higher yield and recharged ground water due to sunken bed. In bunded midland and lowland situations, integration with fish farming produced 6% extra income to the farmers of Bastar. Utilization of harvested rain water increased 10% more yield than rainfed situation. The irrigation was supplied with sprinkler systems. For integrated nutrient management in groundnut-onion cropping system and direct seeded rice- field pea cropping system, recommended dose of fertilizers with micronutrient produced higher yield and increased soil fertility, agronomic efficiency and recovery efficiency etc. Under dryland conditions, line sowing with Nari plough reduced 10% operation cost and manage the crop easily than the broadcasting. Reduced tillage save the energy and produced optimum yield which was at par with conventional methods. Application of bispyrabac sodium herbicides as post emergence reduced 20% labour and 25 % cost of cultivation.

Under *marhan* conditions, rice + pigeonpea (5:1) with transplanting of pigeonpea 40 days after sowing + sodium molybdate seed treatment @ 4 g/kg seed of pigeonpea gave maximum rice yield of 2186 kg/ha followed by rice + pigeonpea (5:1) line sowing + sodium molybdate seed treatment @ 4 g/ kg seed to pigeonpea (2063 kg ha^{-1}). However, the intercropped pigeonpea yield was highest (862 kg ha^{-1}) with rice + pigeonpea (5:1) with transplanting of pigeonpea 40 DAS + pigeonpea seed treatment with sodium molybdate @ 4 g/kg and application of lime@ 200 kg ha^{-1} for pigeonpea were successful. In rice based double cropping system under *gabhar* situation conventional tillage (2 pass of country plough and sowing of seed) for field pea recorded higher seed yield (1823 kg ha^{-1}), net Pigeonpea + okra (1:1) Pigeonpea + cowpea (1:1) Pigeonpea + blackgram (1:1) Pigeonpea + maize (1:1) produced returns of Rs. 63812 ha^{-1}, B:C ratio of 3.48 and RWUE of 3.41 followed by relay cropping of field pea (*Utera*) (1234 kg ha^{-1}). In the relay cropping of rice (MTU 1001)-chickpea (JG-11) under lowland farming situation, higher rice crop equivalent yield of 5569 kg ha^{-1}, net returns of Rs.68262 ha^{-1}, B:C ratio of 3.93 and RWUE of 4.14 kg $ha^{-1}mm^{-1}$ was recorded with rice-chickpea.

Way forward

In view of the emerging problems in dryland agriculture, the following research areas to be addressed are

- *In-situ* and *ex-situ* moisture conservation in view of the rainfall variability in the zone.
- Focus to be on crop intensification after upland rice to work in *rabi* season.
- IFS model for upland, midland and lowland considering the natural resources
- In direct seeded rice, package of rainfed rice system with sowing window to enhance yield through dry aerobic rice, wet seeding and moist seeding to avoid transplanting.
- Mechanization in dry aerobic rice in collaboration with AICRP-Rice centre
- Focus on agroforestry systems

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