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Overview of Dryland Agriculture Research and Achievements in Malwa Plateau Zone of Madhya Pradesh

Bharat Singh[1], D.V. Bhagat[1], S.K. Choudhary[1], K.S. Bangar[1], M.L. Jadav[1], N. Kumawat [1], S. Holkar[1], A. Upadhyay [1], S.K. Sharma [1], K.A. Gopinath [1], G. Ravindra Chary[1], A.K. Shukla[2] and V.K. Singh[2]

[1]All India Coordinated Research Project for Dryland Agriculture Centre,

Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Indore – 452 001, Madhya Pradesh

[2]All India Coordinated Research Project for Dryland Agriculture, ICAR-CRIDA, Hyderabad – 500 059

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Brief history of the centre

The All India Coordinated Research Project for Dryland Agriculture (AICRPDA) centre at Indore was started in 1971 while the Operational Research Project (ORP) at the centre started in 1986. Indore centre since its inception has been carrying out location-specific research on various themes of dryland agriculture, *viz.* rainwater and soil management, cropping systems, integrated nutrient management, participatory approach for crops/varietal selection, energy management, alternate land use system.

Agro-climatic zone characteristics

The centre is located in central highlands (Malwa) Gujarat plain Kathiawar peninsula semi – arid eco-region (AESR 5.1). It represents Malwa region situated at 76° 54' E longitude and 22° 43' N latitude at an altitude of 618 m above MSL. The agro-climatic zone IX *i.e.,* Malwa plateau comprises of districts Ujjain, Shajapur, Indore, Rajgarh, Dewas, Dhar, Neemuch, Mandsaur, Ratlam, Jhabua (only Petlawad tehsil) covering an area of 5.18 million hectares. The climate in this zone is semi-arid. Out of the total annual average rainfall of 941 mm, about 90 to 94% is received during south-west monsoon while 3 to 6% and 3 to 4% is received during northeast monsoon and summer, respectively. The normal onset of monsoon is during third week of June and normal withdrawal is during third week of September. The dry spells during crop season are experienced during September coinciding with seed formation stage of the soybean and maize.

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

Rainfall	Normal rainfall (mm)	Normal rainy days (No.)
South west monsoon (June-September)	855.91	-
North east monsoon (October-December)	48.50	-
Winter (January-February)	13.40	-
Summer (March-May)	21.36	-
Annual	939.17	-

Major soil types

The major soil types in the zone are clayey and clay loam and shallow to medium deep, deep black soils.

Major rainfed crops

The major rainfed crops cultivated in the zone during *kharif* are soybean, maize and sorghum and during *rabi,* chickpea, mustard and wheat.

Dryland agriculture problems

Soils and land problems

- High intensity of rains
- Poor infiltration rate of water
- Lack of adoption of suitable conservation measures
- The soils are low in nitrogen, medium in phosphorus and high in potassium

Crop production

- Low seed replacement rate
- Residue management
- Lack of locally growing green manure
- Poor mechanization

Socio economic conditions

- Small land holdings
- Low risk bearing capacity of farmers
- Poor adoption of technologies
- Market risks
- Short supply of inputs

Significant achievements

Rainwater management

- Maize (grain)-sweet corn cropping system with supplemental irrigation from harvested rainwater in farm pond was found more remunerative with total net returns of Rs.159844 ha^{-1} followed by maize (grain) – chickpea (Rs. 120433 ha^{-1}) and soybean- onion (Rs. 108394 ha^{-1}). Seven irrigations (317 m^3) were given in sweet corn and onion (344.25 m^3) at critical growth stages and one irrigation (39.25 m^3) was given to chickpea crop before flowering stage.

Crops and cropping systems

- Soybean-chickpea, maize-chickpea and green gram-chickpea were grown with three land configuration treatments *viz.,* farmers practice (flat sowing), broad bed furrow system (BBF) and raised bed furrow system (FIRBS) under rainfed condition. The maximum soybean equivalent yield (SEY) of 3285 kg ha^{-1} was recorded under FIRBS-maize-chickpea system followed by BBF-maize-chickpea system (3011 kg ha^{-1}).
- Higher soybean equivalent yield SEY (6359 kg ha^{-1})), net returns (Rs. 236150/ha) and B: C ratio (5.72) were recorded under soybean + maize (4:2)-berseem cropping system followed by soybean + pigeonpea (4:2) – wheat (4414 kg ha^{-1} & Rs. 127178 ha^{-1}, respectively).

Nutrient management

- In the permanent manurial trial (PMT), based on the average of last 30 years, FYM 6 t ha^{-1} + N20 P13 gave higher seed yield of 1862 kg ha^{-1}. The study clearly indicated that a part of the inorganics can be substituted, thus substantially cutting the cost of cultivation. Application of 50% of RDF through inorganic fertilizer + 50% through organic manure gave higher seed yield (1383 kg ha^{-1}) followed by RDF through inorganic fertilizer (1330 kg ha^{-1}) and 10 t organic manure ha^{-1} (1306 kg ha^{-1}).
- Application of micronutrients significantly improved the yield of soybean and chickpea. The highest seed yield of soybean (1654 kg/ha) and chickpea (2113 kg/ha) was recorded with RDF + Mo (soil application) 0.5 kg ha^{-1} (ammonium molybdate as basal dose).

Energy management

- Among sowing techniques, higher seed yield (971 kg ha^{-1}) was recorded under raised bed and furrow system, which was at par with broad bed furrow and significantly superior to sweep blade type seed drill. Raised bed furrow system recorded 12.90% and broad bed furrow (BBF) 8.37% higher seed yield of soybean as compared to sweep blade type seed drill. The maximum output energy (14279 MJ ha^{-1}) was in FIRBS followed by BBF (13694 MJ ha^{-1}) and lowest was in sweep blade type seed drill (12639 MJ ha^{-1}).

Technologies developed

Rainwater management

- Broad bed furrow system of planting to enhance productivity of rainfed soybean
- Ridge furrow system of planting to enhance productivity of rainfed soybean
- Rainwater management through economically feasible water harvesting tanks in black soils
- Sweet corn with harvested water for higher income in deep black soils
- Percolation tanks for ground water recharge
- Farm ponds
- Enhancing water productivity in micro-watershed through efficient utilization
- Contingent crop plans to tackle drought situations

Cropping systems

- Use of mulches to enhance productivity of rainfed crops in Malwa region of Madhya Pradesh
- Sustainable, productive and profitable intercropping systems for Malwa Plateau of M.P.
- Improved varieties of major crops of the zone Malwa plateau
- Improved varieties of rainfed crops for higher productivity in Malwa region of Madhya Pradesh.
- Sunflower as contingent crop in very delayed sown conditions in Malwa plateau of Madhya Pradesh
- Alternate crop for the region

Double cropping systems

Soybean based

Soybean - chickpea

Soybean - safflower

Maize based

Maize - chickpea

Blackgram - chickpea

Blackgram - safflower

Nutrient management

- Potassium spray to combat mid-season drought stress in soybean

Integrated nutrient management

Crop	INM practices
Soybean, maize, sorghum	6 t FYM /ha + 75% of the recommended nutrients through fertilizers; seed inoculation with *Rhizobium/Azotobactor* and PSB
Chickpea, wheat, mustard	75% of the recommended nutrients through fertilizers and seed inoculation with *Rhizobium/ Azotobactor* and PSB

Foliar nutrition

- Foliar spray of urea, NPK and $ZnSO_4$ is done during the flowering and pod filling stage in soybean.

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Foliar nutrition in soybean

Treatments	Seed yield kg/ha	Gross returns (Rs./ha)	Cost of cultivation (Rs./ha)	Net returns (Rs./ha)	B:C Ratio
Urea 2% at 25 and 40 days after sowing	1111	38941	20000	18941	1.95
Spray of 19:19:19 NPK @ 2% + insecticide	1037	34678	20000	14678	1.73
Spray of 19:19:19 NPK @ 2%	1040	34904	20000	14904	1.74
Spray of $ZnSO_4$ 0.5%	968	38727	20000	18727	1.94

Alternate land use systems

Drum-stick *(Moringa oleifera)* /aonla *(Phyllanthus emblica)* + soybean + pigeonpea - chickpea

Contingency crop planning

For *kharif* planning

a. Crop/cropping system for normal onset of monsoon (3rd week, June)

- Soybean - JS 20-34, JS 20-29, JS 95-60, RVS 2001-4, Pigeonpea - TJT 501, Pusa 992, Maize - JM 216, JM 219 JM 215, Sorghum - Sweet corn- Sugar-75, Golden cob).
- Intercropping systems: Soybean + pigeonpea, maize + soybean maize + pigeonpea, soybean + blackgram

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

Delay by 2 weeks (4th week of June)

- Soybean (early) (JS 20-34, JS 20-29, JS 95-60), Blackgram (PU 31, T-9, PU 36);
- Sorghum (RVJ-2357, CSV- 27, CSH- 27, CSH- 41**)**
- Intercropping system: Pigeonpea (medium) (TJT 501) + soybean (early) (JS 20-34, Raj Soya 18); sorghum (RVJ 1862) + early soybean (JS 20-34, JS- 20-29); soybean + blackgram (JU-86)

Delay by 4 weeks (2nd week of July)

- Early varieties of soybean (JS 20-34, JS 20-29, JS 95-60), sweet corn (Sugar-75, Golden cob); early to medium pigeonpea (Rajeshwari, TJT 501)
- Maize fodder; brinjal/tomato/sponge gourd/*kharif* onion
- Intercropping systems: Pigeonpea (JKM-89, TJT-501) + soybean (2:4 rows)
- Blackgram (Pusa-16, PU-31); greengram (Sikha) + sunflower (Modern); sesame (TKG-55, TKG- 8, JT 21)

Delay by 6 weeks (4th week of July)

- Sunflower (Modern); sweet corn (Sugar - 75, Golden cob for cobs); *kharif* onion; Maize (JM 216, JM 219 JM 215), Maize for fodder (African Tall); Bajra chari/ MP chari.

Delay by 8 weeks (2nd week of August)

- Cultivate field for moisture conservation and sowing of *rabi* crops, *i.e.* Toria (JT -1)
- Maize fodder (African tall); Ashwagandha.

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

Early season drought

- In soybean, gap filling with improved seed if the plant population is less than 60%
- Foliar spray with 2% Urea, 2% NPK 19:19:19 during dry spell
- Frequent intercultural operations using *doura*
- Green leaf mulching (subabul/gliricidia)
- Thinning for maintain optimum plant population
- Foliar spray of water
- Earthing up in maize and groundnut

Mid-season drought

- Removal of lower leaves in maize, sorghum and soybean
- Weed management through intercultural operation between rows using *doura*
- Gap filling with improved variety, if the plant population is less than 60%
- Green leaf mulch like gliricidia, etc
- Supplemental irrigation, if available
- Open conservation furrows and ridge and furrow
- Foliar spray of 2% solution of MoP/DAP/NPK 19:19:19

Terminal drought

- Supplemental irrigation, if available

For *rabi* planning

a. Crops and varieties for normal season

- Chickpea (Desi- RVG-201, RVS- 202, RVS-203, RVS-204), Kabuli-RVKG-101, RVKG-102
- Mustard- Varuna, Pusa bold, Safflower- JSI 97, JSI -99, JSI-112, Wheat- Amrita, Harshita, Purna

b. Suggested crops and varieties for delayed season

- Chick pea – (Desi- RVG-201, RVS- 202, RVS-203, RVS-204)
- Safflower- (JSI -99, JSI-112), Wheat- (GW –173, Pusa -111)

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Technologies upscaled in convergence with various programmes

AICRPDA centre Indore developed many location-specific dryland technologies for the benefit of farmers. Many technologies were tested and demonstrated on farmers' fields and popularised. Such successful technologies were up scaled in convergence with Govt. programmes, NGOs and KVKs.

Impact of technologies

The dryland technologies developed from AICRPDA - Indore have significantly improved the productivity of rainfed crops grown in scarce rainfall zone of Malwa. Farm pond technology and percolation tanks are the technologies which are more popular, climate resilient and successful in rainwater harvesting and mitigating the frequent dry spells in the zone. The impact of technologies was clearly visible with increase in productivity, yield stability and enhancing the livelihoods of farmers in the region. The impact of the technologies in terms yield enhancement and overall productivity improvement in the zone is presented below.

Rainwater management

Broad bed furrow system of planting to enhance productivity of rainfed soybean - The soybean was planted with 25 per cent reduced seed rate on BBF will enhance yield along with the improved physical property of soil, root development and water use efficiency. The excess rainwater collected in furrows takes care of crops during long dry spell and save crops from drought stress at pod filling and seed development stage of crop.

Ridge furrow system of planting to enhance productivity of rainfed soybean - The soybean planted with 25 per cent reduced seed rate on R&F enhanced yield along with the improved physical properties of soil, root development and water use efficiency.

Rainwater management through economically feasible water harvesting tanks in black soils - Storing excess rainwater in dugout farm ponds for utilization during the dry spells of monsoon season or for raising a subsequent crop was a promising way to improve the cropping intensity and crop productivities and to stabilize the farming in the Malwa region. As the programme got wide publicity through media and its demonstrational value/ site, various farmers of the region contacted the project team to get acquainted with the project objectives and showed their willingness to construct water harvesting tanks in their fields if the team members provide technical guidance. In view of this, the team members provided technical guidance and helped the farmers to create water bodies in their own fields for better runoff management. Thus, the project could generate awareness among the farmers of the region to adopt and propagate this technology.

Sweet corn with harvested water for higher income in deep black soils - Medium to small farmers from the villages nearer to the highways or which are well connected with local mandi of nearby city were practicing this technology. Micro irrigation methods like drip, sprinklers are getting popularized amongst farmers. Govt. of M.P. is providing for these systems at subsidized rate.

Percolation tanks for ground water recharge - Percolation tank near the ridgeline was successful in retaining runoff and recharging the open wells, besides saving the adjoining fields from sheet erosion. This practice was gradually adopting by farmers.

Enhancing water productivity in micro watershed - Construction of water harvesting tank on farmers' field leads to availability of water for crop production. Once there is availability of water farmers raise crops and other components of farming system like poultry farming, fish rearing, crop diversification etc.

Cropping systems

Use of mulches to enhance productivity of rainfed crops - About 11 to 24 per cent higher production of soybean was obtained by using mulches which conserved soil moisture efficiently. 52 to 110 per cent higher production of *rabi* crop *i.e*., safflower was recorded as compared to without mulching. It is obvious that in soybean – safflower cropping system, by the using mulches the germination and production of crops were enhanced by conserving soil moisture effectively).

Sunflower as contingent crop in very delayed sown conditions - This technology is important as contingent crop planning in very delayed onset of monsoon or failure of timely sown crop due to drought or any other adverse conditions. In such situation, the department of agriculture should have sufficient seed of sunflower and green gram to be provided to farmers. The plan further can be strengthened by seed bank concept in villages in which seed of such crops and their varieties be kept for use in abnormal weather conditions.

Alternate crop for the region - Sweet corn and baby corn can be cultivated in limited area only and that too in areas, which are well connected to *mandi* and near high ways as shelf-life of these products is less and the produce should reach to sale outlet immediately after harvest. Medium to small farmers from the villages nearer to the highways or which are well connected with local *mandi* of nearby city, are practicing cultivation of sweet corn /baby corn. However, for larger area and general farmer the cultivation maize is good alternative to soybean.

Nutrient management

Potassium spray to combat mid-season drought stress in soybean - This practice is been recommended to reduce water

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loss *via* evapo-transpiration by application of potassium while crop is experiencing drought stress.

Alternate land use systems and integrated farming systems

Vegetable cultivation on the bunds of farm tank/water harvesting tank - Bottle gourd, sponge gourd, bitter gourd and *Sem* (*Dolichos lablab*) were planted on the bund of farm tank whose perimeter is of 160 m and the income thus generated was of Rs. 5661. The maximum WUE of 58.15 kg ha^{-1} cm^{-1} was recorded by *Sem* (*Balhar*) *(Dolichos lablab),* This practice is currently adopted by 5-10% farmers in the region. It can be further upscaled in the zone with more extension efforts and demonstrations)

Drum-stick *(Moringa oleifera)* /aonla *(Phyllanthus embelica)* + soybean + pigeonpea - chickpea - Fruit crops *viz*., drumstick (cv. PKM-4) and aonla (cv. N-7) along with soybean (JS 93-05), pigeonpea (C-11) and soybean + pigeonpea (4:2 row ratio) found highly productive, profitable and economically viable. This practice is currently adopted by 5-10% farmers in the region. It can be further upscaled in the zone with more extension efforts and demonstrations).

Way forward

Though many technologies have been developed to improve the productivity of dry lands, a holistic approach on watershed basis needs to be promoted. Sustainable agriculture calls for development of land and water resources without deterioration of ecosystem and the solution for rainfed areas lies in watershed approach. The key attributes are conservation of rain water and optimization of soil and water resources in a sustainable and cost effective mode. The strategies required to harness the potential of dryland agriculture in Malwa region are

- Modeling weather variability for forecasts in crop planning
- Up-scaling of conservation techniques that have scope for integration in a watershed through participatory approach
- Developing strategies for recharging groundwater in the watersheds
- Promotion of conjunctive use of harvested rainwater with groundwater through micro irrigation technologies
- Identifying water-productive cropping systems and potential crops
- Studies on potential for biomass and fodder production from marginal lands through a combination of annual and perennial species
- Enhancing abiotic stress tolerance of important dryland crops through conventional physiological approach
- Strategies for improving and sustaining soil quality in rainfed agro-ecoregions
- Strategies for promoting balanced fertilization through site specific and integrated nutrient management and enhancing nutrient and water use efficiency through precision farming
- Strategies for improving and sustaining soil quality through conservation agricultural practices in rainfed agro-eco-regions
- Capitalization of potential of terrestrial rainfed ecosystem for enhanced carbon sequestration through perennials, efficient cropping systems and enhancement of C-sequestering capacity of soil
- Quantifying the economic advantage of selective farm mechanization
- Assessing economic viability of crop husbandry and alternate income generating occupations
- Evaluating on-farm technologies, providing feedback and identifying socio-economic constraints in technology adoption
- Crop and income diversification in rainfed regions

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