

Overview of Dryland Agriculture Research and Achievements in Central Maharashtra Zone of Maharashtra

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Brief history of the centre

The All India Coordinated Research Project for Dryland Agriculture Centre at Parbhani (Maharashtra, India) was established in 1977 under Vasantrao Naik Marathwada Krishi Vidyapeeth to cater to the needs of dryland farmers of the region. The domain districts the AICRPDA Centre, Parbhani are Parbhani, Nanded, Hingoli, Beed, Latur, Osmanabad, Aurangabad, and Jalna.

Agro-climatic zone characteristics

Marathwada region is one of the four regions of Maharashtra state with cultivable area of 5.6 M ha and 85 per cent of

cultivated land is rain dependent. The region receives annual rainfall in the range of 500 to 1100 mm with assured rainfall zone (60%), moderately high rainfall zone (20%) and scarcity zone (20%). Agro-climatically, the region is divided into three zones. The Central Maharashtra plateau zone is the biggest one with assured rainfall pattern with parts of Aurangabad, Beed, Jalna, Osmanabad, Latur, Nanded, Hingoli & Parbhani. Towards the western end, the parts of Aurangabad, Beed & Osmanabad come under the scarcity; whereas the north eastern part of the region, i.e., Hingoli & Nanded has moderately high rainfall. The information is given in tabular format below.

Particulars	Scarcity Zone	Assured Rainfall Zone	High rainfall zone
Jurisdiction	Aurangabad (7 taluks) Beed (3 taluks) Osmanabad (4 taluks)	Aurangabad (3 taluks) Jalna (3 taluks) Beed (4 taluks) Osmanabad (3 taluks) Latur (4) Parbhani (6) Nanded (4) Hingoli (2)	Hingoli (3taluks) Nanded (5 taluks)
Latitude	74 ^o .40' to 76 ^o .20'	76 ^o .20' to 77 ^o .30'	77 ^o .30' to 78 ^o .16'
longitude	19 ^o .40' to 20 ^o .40'	18 ^o .20' to 20 ^o .40'	18 ^o .20' to 19 ^o .40'
Mean annual rainfall	500 to 700 mm	700-900 mm	900-1250 mm
Distribution of rainfall and soils	Bi-modal distribution of rain-June-Sept, monsoon & Oct-Dec, post monsoon Deep black (11%) Medium black (65%) Shallow/coarse textured (24%)	Bi-modal distribution of rain-June-Sept, monsoon & Oct-Dec, post monsoon Deep black (23%) Medium black (60%) Shallow/coarse textured (17%)	Bi-modal distribution of rain-June-Sept, monsoon & Oct-Dec, post monsoon Deep black (24%) Medium black (48%) Shallow/coarse textured (28%)
Major dry land crops	Field crops: Bajra, maize, cotton, sunflower, sorghum, soybean, pigeonpea greengram, blackgram, moth bean. Fruit crops: Mango, citrus, guava, tamarind, anola, custard apple and papaya, pomogranate Vegetables: Tomato, potato, brinjal, beans, leafy vegetables	Field crops: Cotton, soybean, sorghum, pigeon pea, greengram, blackgram, groundnut, chick pea, safflower Fruit crops: Mango, grapes, guava, citrus, sapota, anola, custard apple, Vegetables: Tomato, potato, chilli, bhendi, brinjal, beans, leafy vegetables	Field crops: Cotton, soybean, <i>kharif</i> sorghum, pigeonpea, greengram, blackgram, paddy, chickpea, safflower, <i>rabi</i> sorghum. Fruit crops: Mango, banana, guava, Vegetables: Tomato, potato, brinjal, beans, leafy vegetables.

The mean annual rainfall in the zone is 630 mm out of which about 80% is received during south-west monsoon (June-September). The normal onset of the monsoon is during 23rd e and the normal withdrawal is during 41st week. The mean maximum and minimum temperatures in the zone are 32.9°C and 19.5°C, respectively.

Mean season-wise and annual rainfall and rainy days at AICRPDA Centre, Parbhani

Rainfall	Normal rainfall (mm)	Normal rainy days (Nos.)
South west monsoon (June-September)	545	30
Post-monsoon (October-December)	71	04
Winter (January-February)	03	03
Summer (March-May)	11	01
Annual	630	38

Major soil types

The major soil types in the zone are shallow to deep black soils with clayey, clay loam and loamy texture. Shallow and eroded soils 22.2%, Medium to medium deep soils 64.80% and Deep to very deep are 13.0%.

Major rainfed crops

The major rainfed crops cultivated during *kharif* are cotton, soybean, pigeonpea, greengram blackgram, sorghum and pearl millet and during *rabi* are sorghum, safflower, chickpea and linseed.

Significant achievements

- Farm pond sizes have been standardized for the Marathwada region
- A suitable open well recharge system was developed. Working principle: The improved open well recharge technology comprises a model filtration unit for the artificial recharging of open wells. The designed model consists of three blocks *viz.*, the primary filter unit, an energy dissipation structure, and the main filter unit. Runoff water is diverted towards the well recharge unit through field trenches. Then it allows it to enter in primary filter unit wherein the major sediments are arrested and water flows to the secondary filter unit where the velocity of the running water slows down and then water enters the main filtration unit. The runoff water gets filtered in the three-stage filter and passed to the open well which is connected to the filtration unit by a 4" dia. PVC pipe at 2 m below the soil layer. The artificial well recharging resulted in an increase in water level to the tune of 0.5 m to up to 3.4 m over a period of 3 years.

- Borewell recharge system was developed. Considering the specific gravity of silt in runoff water and using the principle of Stoke's law, the filtration unit was designed. The filtration unit consists of the excavation of a circular pit of diameter 1.5 m and a depth of 2 m. From the bottom, up to 50 cm above, small holes are drilled into the casing pipe of the borewell and then wrapped with nylon mesh in a double layer followed by filling of stones up to 50 cm height, the second layer above the first layer consists of a filling of metal (small stones) and then the overlaid by a horizontal nylon mesh. The third layer consists of a 30 cm height of gravel followed by a 20 cm layer of fine sand. The filtration efficiency was worked out by comparing the inlet and outlet silt compositions in the water. The pre and post-monsoon water levels in some of the recharged and un-recharged borewells were monitored using digital water level indicators. The water level fluctuations were worked out. The aquifer characteristic like specific gravity and transmissivity were determined by conducting long-duration pumping tests on some of the borewells. Thus, the groundwater recharge was estimated using specific yield and water level fluctuation data. The filtration efficiency was found to be 64 to 67 %. The groundwater level has been increased from 2.13 to 4.84 m. The ground water recharge in treated borewells was found to be 13.65 percent of annual rainfall as against 3.92% in untreated borewells. Artificial well recharging is found effective for groundwater enhancement.
- Opening of conservation furrow after every 4 rows in sole soybean and soybean + pigeonpea (4:2) intercropping (sown at 45 cm row distance) after 30 to 35 days of sowing was adopted as a strategy for moisture conservation on farmers field during last decade. The conservation furrow has opened using either bullock or tractor-drawn iron plough or ridger. The farmers are using their own plough after the first weeding operation in soybean. The cost of ridger is Rs.2200/- and the operational cost is found to be Rs. 800 to Rs. 1000 per hectare.
- Sowing of soybean was developed with standard row ratios. The tractor drawn BBF planter was effectively used for soybean sowing at 45 cm row spacing so that 4 rows on soybean are on bed and furrow was opened on both sides which helps for moisture conservation and furrows also act as drainage channels in extreme rainfall events for removing excess rainwater so that crop is not under waterlogged condition. In assured rainfall area of Marathwada region, BBF system of sowing soybean proved viable. When rainfall is less, all water conserved in furrows and crop was free from moisture stress condition and during excess rainfall event, the excess runoff water was drained through furrow and crop was free from waterlogged situation particularly in

medium to deep black soils of the regions. The crop yields under BBF are 20 to 25% higher in soybean. Similarly this BBF technology reduces runoff and soil loss by 20%. BBF system improves soil physical condition, enhances root development and water use efficiency and performed better during dry spell at pod filling and seed developing condition.

- Application of two sprays of 19:19:19 @ 0.5 % at 35 days and at 75 days after sowing, respectively or potassium nitrate (KNO_3) at 35 days (@ 1.0%) and at 75 days after sowing (@ 2.0%) respectively along with a recommended dose of fertilizers (120:60:60 NPK kg/ha) in medium to deep black soils was found significantly superior for dry spell management in Bt cotton.
- In soybean within 40 days after sowings to mitigate dry spells, an additional two to three hoeing are to be taken up in addition to normal hoeings with the help of bullock-drawn hoe. This is to create dust mulch. Further, mulching can be done with locally available crop residues (within two weeks after sowing) and also foliar spray is done with kaolin (6%). The above similar practice can be adopted in cotton within 75-80 days after sowing to mitigate dry spells however with an additional four to five hoeing with the help of bullock drawn harrow. The cost of operations is Rs. 3000/- ha. These practices help in a yield increase up to 15% in soybean and 23% in cotton compared to no mitigation practices.
- Integrated application of vegetative mulch @ 2t/ha, kaolin spray (6%), and soil mulch by additional hoeing during critical dry spells for water stress control and sustainable crop yield under important intercropping systems of Marathwada region

Technologies developed

Rainwater Management

- Opening of furrow after every 4 rows in soybean + pigeonpea intercropping system (4:2)
- Bore well recharging for ground water enhancement in assured rainfall zone of Marathwada region
- Broad Bed Furrow (BBF) sowing technique for soybean
- Application of cetyl alcohol for reducing water loss due to evaporation in Farm pond

Standardization of farm pond technology for assured rainfall zone of Marathwada region

Catchment area (ha)	Dimensions, m (L x W x D)	Side slope	Storage volume, (Cubic m)	Area under protective irrigation (ha)	Area covered by farm pond (%)
1	20x20x3	1.5:1	741	0.75	4.0
2	25x25x3	1.5:1	1281	1.05	3.13
3	30x30x3	1.5:1	1971	2.25	3.0

Cropping System

Intercropping system

- Soybean + pigeonpea (4:2)
- Cotton + pigeonpea (6:1)
- Cotton + greengram (1:1)
- Sorghum + pigeonpea (4:2)
- Maize + soybean (2:2)
- Maize + green gram (1:1)
- Pigeonpea + sesamum (2:4)

Double cropping systems

- Greengram - *rabi* sorghum
- Soybean-chickpea
- Sorghum- safflower
- Soybean-linseed

Integrated nutrient management

Crop	INM
Soybean	5.0 t FYM or compost /ha + 30:60:30 NPK kg/ha
Cotton	10.0 t FYM or compost /ha + 120:60:60 NPK kg/ha
Sorghum	5.0 t FYM or compost /ha + 80:40:40 NPK kg/ha
Maize	-
Pigeon pea	5.0 t FYM or compost /ha + 25:50 NP kg/ha
Greengram & blackgram	5.0 t FYM or compost /ha + 20:40 NP kg/ha
Pearl millet	5.0 t FYM or compost /ha + 40:20:20 NPK kg/ha
Chickpea	5.0 t FYM or compost /ha + 20:40 NP kg/ha

Foliar nutrition

Crop	Nutrients (kg/ha)				
	K	Zn	B	Mg	Fe
Soybean	0.5 to 1.0%	-	-	-	-
Cotton	0.5 to 1.0%	-	-	-	-
Sorghum	0.5 to 1.0%	0.5 to 1.0%	0.02 %	0.02 %	0.5 to 1.0%
Maize	0.5 to 1.0 %	0.5 to 1.0 %	-	-	0.5 to 1.0 %
Pigeon pea	0.5 to 1.0 %	-	-	-	-
Chickpea	0.5 to 1.0 %	0.5 to 1.0 %	-	-	0.5 to 1.0 %

Contingency crop planning

For *kharif* planning

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

Cropping systems based contingency crop planning for aberrant weather condition during *kharif* season for Marathwada region under normal, delayed, late and very late sowing conditions is as under.

Sowing date	Crops/cropping systems to be adopted
Up to 30 June (Normal sowing)	Cotton + soybean, soybean + pigeonpea, sorghum + pigeonpea, Castor + soybean, bajra + pigeonpea, greengram, blackgram, sorghum, pearl millet, cotton and soybean
30 June to 15 July	Cotton + soybean, soybean + pigeonpea, castor + soybean and bajra + pigeonpea
16 July to 30 July	Soybean + pigeonpea, bajra + pigeonpea and castor + soybean
1 August to 15 August	Soybean + pigeonpea, bajra + pigeonpea and castor + soybean (exceptional situation)

Crop	Variety
Soybean	MAUS-158, MAUS-162, MAUS-612, MAUS-71
Cotton	NHH-44 Bt BG II, NH-615, PA-740
Greengram	BDN 2003-02
Udid	TAU-1, AKU-10-1
Pigeonpea	BDN 711, BDN 716, BSMR 736, BDN-781 (Godavari, BDN-2013-41)
Sorghum	PVK 1009 (Parbhani shakti), CSH -25
Pearl Millet	AHB-1200 Fe

Delay by 4 weeks

Crop	Variety
Soybean	MAUS-158, MAUS-162, MAUS-612, MAUS-71
Cotton	NHH-44 Bt BG II, NH-615, PA-740
Greengram	BDN 2003-02
Udid	TAU-1, AKU-10-1
Pigeonpea	BDN 711, BDN 716, BSMR 736, BDN-781 (Godavari, BDN-2013-41)
Sorghum	PVK 1009 (Parbhani shakti), CSH -25
Pearl Millet	AHB-1200 Fe, ABPC-4-3

Delay by 6 weeks

Crop	Variety
Soybean	MAUS-158, MAUS-162, MAUS-612, MAUS-71
Cotton	NHH-44 Bt BG II, NH-615, PA-740
Greengram	BDN 2003-02
Udid	TAU-1, AKU-10-1
Pigeonpea	BDN 711, BDN 716, BSMR 736, BDN-781 (Godavari, BDN-2013-41)
Sorghum	PVK 1009 (Parbhani shakti), CSH -25
Pearl millet	AHB-1200 Fe, ABPC-4-3
Sesamum	AKT-64, Punjab-1, Phule-1
Castor	DCH-9

Delay by 8 weeks

Crop	Variety
Soybean	MAUS-158, MAUS-162, MAUS-612, MAUS-71
Cotton	NHH-44 Bt BG II, NH-615, PA-740
Greengram	BDN 2003-02
Udid	TAU-1, AKU-10-1
Pigeonpea	BDN 711, BDN 716, BSMR 736, BDN-781 (Godavari, BDN-2013-41)
Sorghum	PVK 1009 (Parbhani shakti), CSH -25
Pearl millet	AHB-1200 Fe
Sesamum	AKT-64, Punjab-1, Phule-1
Castor	DCH-9

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

a. Early season drought

- Gap filling at 7 to 10 days after sowing by pot watering within the rows with same cultivar or pigeonpea to maintain at least 75% plant population.
- Raise cotton seedlings in polythene bags and transplant when sufficient soil moisture is available. Take up interculture with harrow when crop is at two weeks old.
- In case of resowing, adopt 15-20% more seed rate than recommended and reduce fertilizer dose by 25%.
- Gap filling within the rows with same or short duration cultivar to maintain at least 75% plant population or if the plant population is less than 50%, take up resowing.
- If the plant population is less than 75% of optimum, take up sowing of the alternate crops like sunflower/pigeonpea.

b. Midseason drought

- Give protective irrigation, if possible.
- Avoid applying fertilizers till sufficient soil moisture is available.
- Open conservation furrows for moisture conservation, interculture with harrows (every four or six rows)
- Adopt intra row thinning
- Interculture for weeding and to create soil mulch to conserve moisture.
- Spraying 13:00:45 (Potassium nitrate 1% solution 100 g/ 10 lit of water) or 2% urea solution 200g /10 lit. of water during stress period after 15 days.

c. Terminal drought

- Provide life-saving irrigation, if available
- Harvest at physiological maturity
- Plan for *rabi* crops like chickpea, safflower and linseed
- Sowing of *rabi* crops like sorghum, chickpea, safflower immediately after harvest of soybean with minimum tillage with tractor drawn harrow / cultivator
- Harvest, greengram at physiological maturity or in case of severe drought use as fodder/green manuring.
- In pigeonpea, provide life-saving irrigation and or foliar spray of 2% KNO₃

Rabi crop planning

Suggested crops and varieties

Crop	Varieties/ hybrids	Yield potential (kg/ha)	Duration (days)
Chickpea	BDN-797	1800-2400	105-110
	Vijay, Digvijay	1600-2300	105-110
Safflower	PBNS-12	1200-1500	135-140
	PBNS-40		
	PBNS-86		
Rabi sorghum	Parbhani Shakti (PVK-1009)	1600-1800	110-115
	PVK-1411	1200-1400	105-110
	PVK-1595	1350-1700	110-115
	SPV -2407 (Parbhani Super Moti)	1400-1800	110-115
Linseed	LSL-93	800-1000	80-90

Agro-horti systems

- Custard apple (Balanagar / Dharur -6) + soybean (MAUS-612) (1:4)
- Custard apple spacing 5 m x 5 m, soybean 45 cm x 5 cm
- Drumstick (PKM-1) + soybean (MAUS-612, MAUS-158) (1:4)
- Drumstick spacing: 4 m x 4 m, soybean 45 cm x 5 cm
- Ber (Umbran) + soybean (MAUS-612)
- Ber spacing: 6 m x 6 m, soybean 45 cm x 5 cm

Impact of dryland technologies

Broad bed and furrow technology for soybean: Mode of transfer of technology to the farmers' fields: Field demonstrations and farmers training; Convergence with PoCRA project of Govt. of Maharashtra for upscaling; Impact of technology: 25000 BBF planters have been distributed to farmers in the State; Increased crop production by 25 to 30 per cent; 16 lakh ha and area already covered: 2.5 lakh ha (15%); No. of beneficiaries: 1.5 to 2 lakh farmers; Improvement in yield by 25%; Increased farmer's income by 10%.

Borewell recharge technology: Mode of transfer of technology to the farmers' fields: Field demonstrations and farmers training; Convergence for up scaling: PoCRA project of Govt. of Maharashtra; Increased crop production by 25 to 30% due to protective irrigation; Targeted area of coverage and area already covered: 1000 no.; No. of beneficiaries: 200; Improvement in yield by 25%; Increased farmers' income by 30 per cent.

Farm pond technology: Mode of transfer of technology to the farmers' fields: Field demonstrations and Farmers' training; Convergence with any state/national programme for up scaling: PoCRA project of Govt. of Maharashtra; Increased crop production by 25 to 30% due to protective irrigation; No. of beneficiaries: 50000; Improvement in yield by 25% due to protective irrigation; Increased farmers' income by 25 per cent.

Dissemination of all developed dryland technologies has been and is being constantly carried out through various extension activities like on-farm demonstrations, agro-advisories, and participation in various farmer rallies.

Impact in terms of the unit increases in yield of crops as a result of research efforts of technologies developed by centre

Name of crop	Name of AICRPDA technology adopted by the farmers	Area (ha)	Increase in yield (kg/ha)	Increase in yield (%) over control
Soybean	Conservation furrow after every 4 rows at 30 days after sowing	1.7 Lakh	270	25
Cotton	Conservation furrow after every 2 rows at 30 days after sowing	1.8 lakh	210	22
Soybean + pigeonpea	Intercropping system of soybean + pigeonpea (4:2)	70000	240	21
Soybean	Broad Bed and Furrow (BBF) sowing	2.5 lakh	280	26
Open well and borewell recharge technology		1000 no.	30% increase in crop yield due to protective irrigation during dryspell	28% increase in ground water recharge
Farm pond- Rainwater harvesting and recycling		50000	250	45
Soybean	Foliar application of KNO ₃ for dryspell mitigation	12000	145	14
Cotton	Foliar application of KNO ₃ for dryspell mitigation	14000	190	16

Way forward

The future thrust area of research are real time contingency plans for aberrant weather condition, crop specific *in-situ* and *ex-situ* rain water conservation techniques, crop diversification, energy management, Integrated farming system models for rainfed area,

alternate land use system like cultivation of bamboo species and its economics and complete or partial mechanisation for small and marginal farmers.