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Overview of Dryland Agriculture Research and Achievements in North Saurashtra Zone of Gujarat

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Brief history of the Centre

The All India Coordinated Research Project for Dryland Agriculture Centre was started in 1972 under Junagadh Agriculture University. This Centre has been catering to the needs of the North Saurashtra Agro-climatic Zone for the seven domain districts viz. Rajkot, Morbi, Jamnagar, Devbhumi Dwarka, Surendranagar, Bhavnagar and Amreli.

Agro-climatic zone characteristics

The climate in this zone is semi-arid. Out of the total annual average rainfall of 680 mm, the south- west monsoon contributes 70-80%. The normal onset of monsoon is during 1st or 2nd week of June and withdrawal is during 1st or 2nd week of October. The crops experience dry spells during second to fourth week of August to second week of September. The mean maximum/ and minimum temperature during crop season is 33.8ºC and 24.6ºC, respectively.

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

Rainfall	Normal rainfall (mm)	Normal rainy days (No.)
South west monsoon (June-September)	652	27.5
Post-monsoon (October-December)	22.3	1.5
Winter (January-February)	-	-
Summer (March-May)	-	-
Annual	674.3	29

Major soil types

The major soil types in the zone are clayey (66.4%), clay loams (15%), sandy clay loams (7.8%), sandy loams (6.2%) and loamy sands (4.6%).

Major rainfed crops

The major rainfed crops cultivated in the zone during *kharif* are groundnut, Bt-cotton, *Deshi* cotton, sesame, pearl millet, castor, soybean, green gram and black gram.

Dryland agriculture problems

The problems related to the domain districts are:

Soil and land management

- The zone consists of shallow to very shallow black soils which limits available water holding capacity.
- Uneven topography leading to increased runoff.
- High cracking in Vertisols and soil moisture loss through evaporation.
- Soils are low in available N, P, organic matter and deficient in micronutrients resulting in poor crop yields.

Crop production

- Aberrant weather/rainfall situation
- Lack of varieties suitable for rainfed groundnut based cropping systems**.**
- Lack of suitable implements for harvesting and threshing of various crops.
- Monocropping and poor crop diversification further reduces yield of crops.

Socio-economic

- Fragmented and very small landholding causes problems in adopting farm machinery on hire basis for various agricultural operations.
- Poor resources (economic conditions), low level of literacy, high cost of inputs, lack of awareness and know-how with regards to available technology.
- Unavailability of timely and affordable credit facilities.
- Market risks
- Unavailability of labours during peak times and high labour wages.

Significant achievements

Rainwater management

- For effective conservation and management of rainwater, cultivation of bunch groundnut in medium black soils at 30 cm distance between rows having three rows on broad bed of 90 cm and furrow of 45 cm (BBF) for getting higher yield and net returns as well as to check runoff and soil loss.
- Preparation of ridge and furrow or broad bed with 2 rows (180 cm width) and furrow (60 cm) at 20 days after sowing in Bt cotton and application of plastic mulch (25 micron)/straw mulch @ 5 t/ha at withdrawal of monsoon

in the month of September helped in obtaining higher productivity, maximum net returns as well as higher *in-situ* moisture conservation and rain water use efficiency under dry farming conditions. Apart from this, if the slope of field is around 1.5%, then growing of vegetative barrier of *Dicanthium annulatum* or Vetiver or *Cenchrus cilliaris* at interval of 7 meters checks runoff and minimizes soil loss and nutrient losses.

- For *in-situ* soil moisture conservation, application of *murrum* @ 40 t/ha or FYM @ 10 t/ha helped in increasing yield of groundnut and moisture conservation.
- Adoption of two to four interculture operations along with deep ploughing for higher yield of groundnut and maximum moisture conservation.
- Mulching with black plastic (50 micron) or groundnut shell or wheat straw mulch @ 7.5 kg/plant in guava resulted in higher soil moisture content and fruit yield.
- Application of FYM @ 10 t/ha and kaolin @ 4% spray (400 gm/10 litres water) during dry spell in groundnut and Bt cotton helped in getting higher productivity and maximum rain- and crop water use efficiency.
- Farm pond of size 450 m^3 for 1 ha cultivable area provided one-irrigation of 5 cm and 7.5 cm to crop covering an area of 0.764 ha and 0.51 ha, respectively.

Cropping systems

- Groundnut + castor (3:1 or 6:1), groundnut and sesame (6:3), cotton + groundnut/green gram/black gram/sesame/ cowpea (1:1), groundnut + pigeonpea (3:1), pearl millet + pigeon pea (2:1 or 4:1), sorghum + pigeonpea (1:1), castor + cowpea/green gram (1:1) were found to be promising intercropping systems with increased yield and net return over their sole cropping.
- Adoption of paired row planting of castor + green gram (2:1) and cotton + groundnut (2:1) was found to be economically viable for getting higher yield and net return.
- Intercropping of cotton (Bt Hybrid-8) with cowpea (Guj. cowpea-4) (1:1) gave higher yield and net return than sole cotton.
- In alley cropping system, sowing 16 rows of either groundnut (GG-2) or sorghum (CSH-5) in alley of perennial pigeonpea (ICPL-185)/ subabul (Hawaiian Giant) with 8.1 m between two rows helped in obtaining higher equivalent yield of green fodder and monetary returns.

Nutrient management

- Application of 12.5-25-0 kg N-P-K/ha in groundnut, 80-40-0 kg N-P-K/ha in pearl millet, 90-30-0 kg N-P-K/ha in sorghum, 20-40-0 kg N-P-K/ha in pulses crop, 40-0-0 kg N-P-K/ha in *desi* cotton, 30-30-0 kg N-P-K/ha in castor and 50-25-0 kg N-P-K kg/ha in sesame crop resulted in sustained crop productivity and soil health.
- Application of 50% recommended NPK to groundnut and 100% recommended NPK to castor in groundnut + castor (3:1) intercropping resulted in higher groundnut pod equivalent yield and net returns.
- Application of 80 kg N/ha to hybrid cotton and 25-12.5-0 kg N-P-K to sesame in cotton + sesame (1:1) intercropping system gave higher seed cotton equivalent yield and net returns.
- In crop rotation, application of 100% NPK (80-40-0 kg N-P-K kg/ha) only to pearl millet in groundnut-pearl millet crop rotation resulted in higher productivity under dry farming condition.
- Integrated nutrient management *viz.,* application of 80 kg N + 10 t compost + 500 kg castor cake/ha along with bio-fertilizer (*Azotobacter* + PSB, each @ 1.25 kg/ha) in Bt cotton gave higher yield and net return besides improving soil fertility.
- Mulching of wheat straw or groundnut shell or farm waste @ 5 t/ha with 50% RDN to groundnut and 75% RDN to pearlmillet in groundnut – pearlmillet crop sequence resulted in improved soil fertility and crop productivity.
- Application of 25% recommended NPK + compost @ 5 t/ha + castor cake @ 500 kg/ha + *Azotobacter* and PSM in groundnut, sesame, pearlmillet, cotton and castor mono-cropping or crop rotation, preparation of enriched compost by recycling of crop residues with addition of bio-inoculants and recycling of cotton stalk to prepare enriched compost within 120 days for sustaining soil fertility and crop productivity.

Energy management

- Use of tractor drawn deep tillage implements like disc plough, mould board plough and chisel plough conserved more moisture in the lower strata of soil and helped in better growth and yield of groundnut and cotton.
- Ploughing with tractor up to 20 cm depth in alternate furrow once in two years and application of FYM @ 5 t/ha + RDF helped in reducing the cost of ploughing and increased yield of groundnut.
- Improved tractor drawn seed-cum-fertilizer drill helped in maintaining optimum plant population and reduced the seed rate up to 20% compared to farmers' practice (broadcasting and drilling).

Technologies developed

Rainwater management

- Recharging open wells

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- Broad Bed Furrow system for higher productivity of groundnut
- Rainwater harvesting in farm ponds

Cropping systems

Intercropping system

Groundnut + castor (3:1), Groundnut + cotton (2:1), Cotton + sesame (1:1), Cotton + cowpea (1:1), Cotton + greengram (1:1), Cotton + groundnut (1:1), Castor + cowpea (1:1), Castor + greengram (1:1), Castor + greengram (2:1).

Nutrient management

Crop/crop rotation	INM practice
Groundnut	Vermicompost @ 1 t/ha or castor cake @ 500 kg /ha and 6.25:12.5 NP kg/ ha through inorganic sources.
Bt Cotton BG-II	10 t/ha compost + 500 kg castor cake + bio-fertilizer (*Azotobacter* + PSM) each 1 kg/ha + 80 kg N/ha.
Pearl millet	2.5 t/ha compost and 500 kg castor cake /ha or 1 t/ha vermicompost + NP @ 40:20 kg/ha through inorganic sources.
Sorghum	2 t/ha vermicompost + NP @ 45:15 kg/ha through inorganic sources.
Sesame	1 t/ha vermicompost + 5:12.5 kg/ha NP through inorganic sources.
Castor	5 t/ha FYM or 1 t/ha castor cake & seed treatment with *Azospirillum* and PSB (25 g/kg seed) + NP @ 23.5:20 kg/ha through inorganic sources.
Greengram/ Blackgram /Cowpea	Vermicompost @ 1 t/ha + NP @ 10:20 kg/ha through inorganic sources.

Foliar nutrition

- Groundnut:1. Foliar application of seaweed liquid fertilizer-SLF (Fe-1.3%, Mn-0.7%, Zn-0.5%, Cu-10.2% and B-0.5% at 15, 30 and 45 DAS.
- Foliar application of urea @ 2% at 30-35 DAS.
- Pearlmillet: Foliar application of multi-micronutrient Grade-IV (Fe-4%, Mn-1%, Zn-6%, Cu-0.5% and B-0.5%) @ 1% at 20, 30 and 40 DAS.

Contingency crop planning

For *kharif*

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

Delay by 2 weeks (1st week of July)

- Groundnut: (spreading) (GG-12, 13, 17, 18); semi spreading (GG-20, GJG-22), bunch (GG-2, 5 and GJG-9, 32); cotton (G.Cot.-10, G.Cot.-13, G.Cot.-21, Guj. Cotton Hybrid-4, 6, 8, 10, & Govt. approved Bt hybrids), sesame (GT- 2, 3 , 4, 5 & 6); castor (GAUCH-1, GCH-3, GCH-4, GCH-7, 9); pearl millet (GHB- 538, GHB-558, GHB-732, GHB-744, GHB-744, GHB-905, GHB-1129, GHB-1225, GHB-1231); greengram (GM-4, GAM-4); blackgram (GU-1, 2 & T-9).

Delay by 4 weeks (3rd week of July)

- Groundnut bunch (GG-2, GG-5, GJG-9, TG 37A); semi spreading (GG-20, GJG-22); castor (GAUCH-1); sorghum (GFS-4 & 5, Gundhari, S-1049); greengram (GM-4, GAM-5); blackgram (GU-1, T-9); soybean (GJS-3, G.S.1); sesame (GT-2, 3 & 4).

Delay by 6 weeks (1st week of August)

- Greengram (GM-4, GAM-5); castor (GC-3, GCH-4, 7); sorghum (Gundhari, GFS-3, GAFS-11, CSV-21F, S-1049); sesame (GT-2, 3, 4); pigeonpea (BDN-2, Vaishali); soybean (GS-1, 3); cotton (G.Cot. 13, 15, 21, 23, 25 & V-797).

Delay by 8 weeks (3rd week of August)

- Sesame (Purva-1); castor (GC-3, GCH-4, 7); sorghum (Gundhari, GFS-3, GAFS-11, CSV-21F, S-1049); pigeonpea (BDN-2, Vaishali, GJP-1); soybean (GS-1, 3); greengram (Variety GM-4, GAM-5); blackgram (GU 1, T-9); pearlmillet (GHB-538, 905, 1129, 1225 and Govt. approved hybrids).

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

Early season drought

- Intercultivation to fill soil cracks, mulching with wheat straw or shredded cotton stalk mulching.
- Provide life saving irrigation, if available.
- After receipt of rainfall, spray 2% urea solution for revival of crop.
- Foliar spray of Kaolin @ 4% spray (400 gm/10-liter water) during dry spell.

Mid-season drought

- Weeding, interculturing and mulching/ foliar spray with 1% KNO_3.
- Mulching with wheat straw or crushed cotton stalk mulching or plastic mulching (Plastic film 25 micron - 200 kg/ha).
- Thinning to maintain plant to plant distance (5 cm) in sesame.
- Avoid top dressing of urea.
- Supplemental irrigation, if possible followed by weeding.

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- Protection against sucking pests (control of jassid and aphid, spray imidacloprid 17.8 SL (4 ml/10 lit. water).

Terminal drought

- Provide supplemental irrigation, if possible followed by weeding.
- In cotton, harvest mature bolls and in sesame, harvest mature plants, thin out plant population, remove old leaves and completely remove weeds.

Agro-horti system/ dryland horticulture

Ber + groundnut/ blackgram/ greengram/ cowpea/ sesame, Custard apple + groundnut/ greengram/ blackgram agri-horti system

Crop	Spacing	Management practices
Ber (variety-Gola)	6 m X 6 m	Timely training, pruning, application of RDF (year wise) and fruit fly trap for ber fruit fly management.
Custard apple (Gujarat Junagadh custard apple-1)	5 m x 5 m	Timely application of RDF (year wise), keep orchard clean and use sticky trap for management of mealy bug. Spray profenofos 50 % EC 20 ml/10 liters of water for the control of mealy bug.
Intercrops - groundnut/black gram/greengram/ cowpea/sesame	45 cm x 10 cm	For intercrops, give recommended dose of NPK, spacing, seed rate and control measures against pest and diseases.

Technologies upscaled in convergence with various programmes

Technologies have been upscaled on farmers' fields in collaboration with KVKs, department of agriculture and department of watershed, Government of Gujarat. District wise contingency plans and various drought proofing action plans in the domain agro-climatic zones of the centre were upscaled with the help of GSDA. The centre, in collaboration with other AICRP schemes such as AICRP on groundnut, pearl millet, pulses, sesame, soybean and castor developed various improved varieties of crops *viz.*, GG-2, GG-5, GG-9, GJG-32 bunch groundnut, GG-20, GG-22 semi spreading groundnut, GM-4 greengram, GU-1, GU-2 blackgram, GC-5 cowpea, GT-3, GT-4 sesame, GS-3 soybean and GCH-7 which helped to increase the productivity of these dryland crops. All these varieties were evaluated and upscaled through front line demonstrations in farmers' fields, organising field day, etc. in the domain area through KVKs, ATMA, FTC and other line departments operating in the zone.

The technologies for soil fertility management were upscaled through Soil Health Card program of GSDA. The NGOs, Co-operative societies and FPOs working in village level helped in upscaling of dryland technologies. The agromet advisories based on forecast given by State Meteorological Centre were regularly provided to the farmers in adopted villages. The farm pond technology, nala plugging, soil and water conservation measures such as deep ploughing, bunding and deep trenches in orchards were upscaled through watershed program.

Impact of technologies

Sowing of bunch groundnut in medium black soils at 30 cm distance between rows having three rows on broad bed of 90 cm and furrow of 45 cm (BBF) gave higher pod yield (11%) as well as reduced runoff and soil loss (17%) as compared to flatbed system. If the slope of field is around 1.5%, then growing of *Dicanthium annulatum*/Vetivera/*Cenchrus cilliaris* as vegetative barrier at interval of 7 meters checks runoff and minimizes soil and nutrient losses. Application of *murrum* @ 40/ FYM @ 10 t/ha increased pod yield of groundnut (16.0-16.5%) and moisture conservation (2.7-3.5%) than farmers' practice. Mulching with black plastic (50 micron)/groundnut shell/ wheat straw mulch @ 7.5 kg/plant in guava increased growth and fruit yield (9.22- 9.88 kg/plant) than crop without mulching (6.45 kg/plant). Application of FYM @ 10 t/ha and kaolin @ 4% spray (400 g/10 litres water) during dry spells increased the productivity of groundnut (1257 kg/ha) and Bt cotton (1924 kg/ ha) with maximum rainwater use efficiency of 2.31 kg/ha-mm in groundnut and 3.82 kg/ha-mm in Bt cotton. Preparation of ridge & furrow and broad bed with 2 rows (180 cm width) and furrow (60 cm) at 20 days after sowing in Bt cotton increased seed cotton yield by 18 and 14%, respectively with higher rain water use efficiency as compared to flat sowing under dry farming conditions. Groundnut based replacement series of intercropping system *viz.,* groundnut + castor (3:1), groundnut + pigeon pea (3:1), groundnut + sesame (1:1) increased productivity and net returns during normal rainfall and reduced risk during erratic and late rainfall. Bt cotton + groundnut/greengram/blackgram/ sesame/cowpea (1:1) also increased productivity and net return during normal rainfall and reduced risk during erratic & uneven distribution of rainfall. In groundnut, pulses, cereals and other oilseed crops, application of recommended N-P-K kg/ha to groundnut (12.5-25-0), pearl millet (80-40-0), sorghum (90-30-0), pulses (20-40-0), *desi* cotton (40-0-0), castor (30-30-0) and sesame (50-25-0) increased crop productivity and sustained soil fertility under normal rainfall distribution. Application of 75% recommended NPK to groundnut (1809 kg/ha) and 100%

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recommended NPK to castor (1841 kg/ha) in groundnut + castor (3:1) intercropping system increased groundnut pod equivalent yield and saved 25% recommended NPK of groundnut. The integrated nutrient management *viz.,* application of 80 kg N + 10 t compost + 500 kg castor cake/ha along with bio-fertilizer (*Azotobacter* + PSB, each @ 1.250 kg/ha) in Bt cotton gave around 19% higher yield (2298 kg/ha) and net return beside improving soil fertility as compared to farmers' practice (1924 kg/ha). Adoption of INM practice (25% recommended NPK + compost @ 5 t/ha + castor cake @ 500 kg/ha + *Azotobacter* and PSM in groundnut, sesame, pearl millet, cotton and castor mono-cropping or crop rotation also increased crop productivity with sustained soil fertility.

Way forward

Research focus would be more on systems based approach with emphasis on rainwater management and efficient use of harvested water using micro-irrigation system, integrated nutrient management, crop diversification/intensification, contingency planning, use of bio-fertilizers and organic manure for balanced nutrition, organic recycling of farm residues and farm mechanization.

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