CAZRI

Taming the Desert

भाकृअनुप
ICAR

Central Arid Zone Research Institute

(Indian Council of Agricultural Research)
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India has 31.7 m ha hot arid area spread over Rajasthan (61.9%), Andhra Pradesh (6.8%), Karnataka (2.7%), Maharashtra (0.4%), Gujarat (18.6%), Punjab (4.6%) and Haryana (4.0%) apart from 14.0 m ha cold arid region and 5.2 m ha cold glacial area. These hot arid regions with environmental adversities of low and erratic precipitation, high temperature, high wind speed and poor soil fertility conditions support high human and animal population. Over-exploitation of natural resources, frequent droughts and desertification have moderately to severely affected 61% area. About 75% area is affected by wind erosion, 14% by water erosion and 5% by salinity and alkalinity.

In providing solution to the problem, Government of India established "Desert Afforestation Research Station" at Jodhpur in 1952, which was added with new responsibilities and renamed as "Desert Afforestation and Soil Conservation Station" in 1957. On the recommendation of the UNESCO expert Dr. C. S. Christian of CSIRO, Australia, upgraded to Central Arid Zone Research Institute (CAZRI) on October 1, 1959 on par with other institutes working on problems of desert internationally. CAZRI, a unique multidisciplinary Institute of its kind, was established to focus on sustainable land and environment management. In 1967 CAZRI was transferred from the Ministry of Agriculture to the administrative control of Indian Council of Agricultural Research (ICAR). At present the Institute has seven Divisions and four Regional Research Stations (RRS) at Bikaner, Pali, Jaisalmer, Kukma (Bhuj) and two

The Institute is primarily funded by ICAR, but work on externally funded projects, supported both by national and international agencies, is also undertaken. Some such projects included Euro, CMCCD, Dutch, ACIAR (Australian), ICRISAT, Indo-US, Agriculture Canada, CABI, JIRCAS, UNCCD, etc. Likewise inter-institutional work with other ICAR institutes and SAUs is also undertaken. The institute scientists are also in demand for consultancy, both at the national and international levels like UNCCD, IPALAC, Narmada Project, National Watershed Program, etc. and several private industries. The institute has provided number of scientists to international institutions including the World Bank, UNESCO, ICRISAT, Directors of ICAR institutes, and Vice-Chancellors of state Agriculture Universities. Two of the scientists having worked at the institute went on to become Director Generals of the ICAR.

Based on achievements in certain themes ICAR established coordinated projects including those on rodents, pearl millet, arid legume and research institutes to further work on arid horticulture, camel, spices, mustard etc. To compliment Institute work state and central Government established institutes to undertake researches on forestry and remote sensing.

FACILITIES

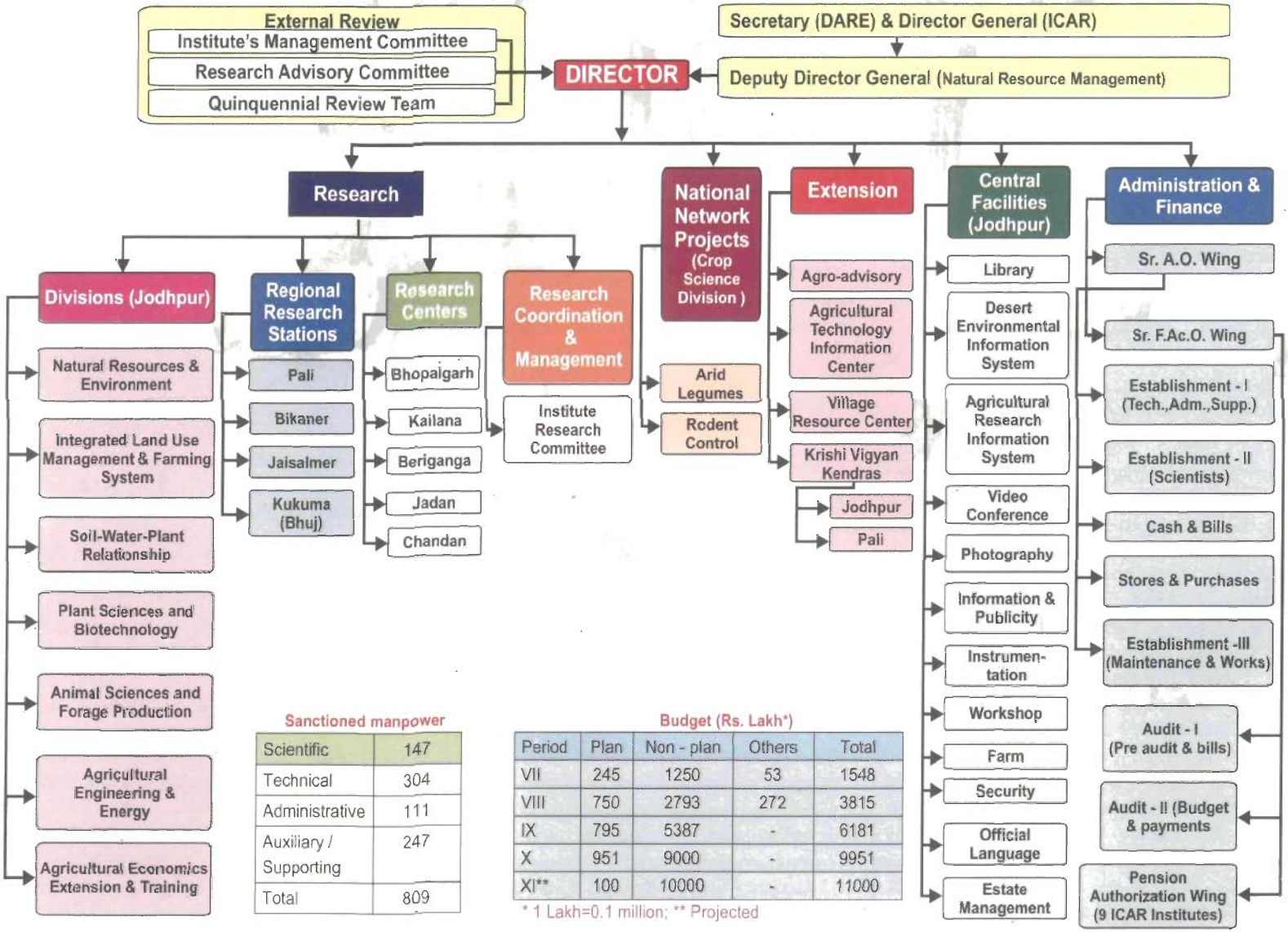
The Institute has play ground and is venue to hold annual sports meet for the ICAR Institutes in the Western Zone. The Institute has laboratories equipped with modern state of the art equipments, excellent library with Agris data base from 1975 to date catering for the information on desert, Agricultural Research Information System (ARIS), hostels, auditorium and lecture halls to impart different levels of trainings, from administrators to farmers, farm women, rural youth and workers at grass root level extension. An Agriculture Technology Information Center (ATIC) caters to the day-to-day needs of farmers. CAZRI can be viewed through its web site: http://www.cazri.res.ni.

ACHIEVEMENTS

Integrated Natural Resources Assessment

Integrated natural resources survey and mapping of the arid lands, using conventional and remote sensing tools, has been completed in more than 27 million ha area in the states of Rajasthan, Gujarat, Haryana, Punjab and Karnataka, to assess their problems and potentials. Major Land Resources Units form the basis for suggesting land use and development strategies. Survey reports and thematic maps and atlases have been published.

ORGANOGRAM OF CAZRI



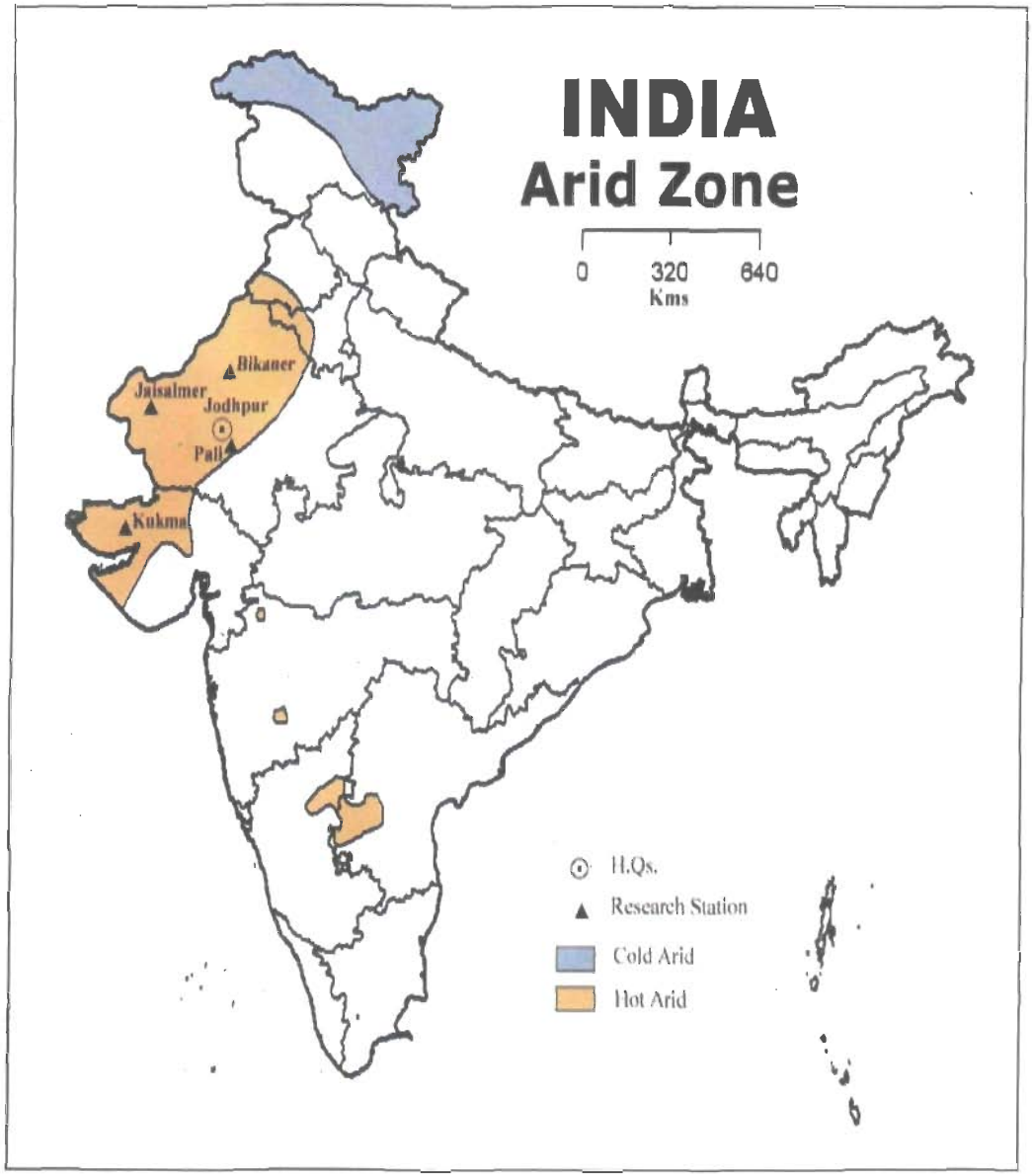
Sanctioned manpower

Scientific	147
Technical	304
Administrative	111
Auxiliary / Supporting	247
Total	809

Budget (Rs. Lakh*)

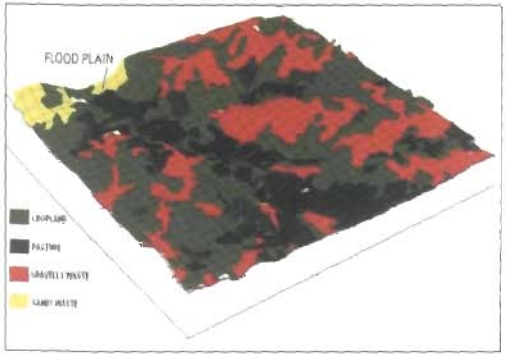
Period	Plan	Non - plan	Others	Total
VII	245	1250	53	1548
VIII	750	2793	272	3815
IX	795	5387	-	6181
X	951	9000	-	9951
XI**	100	10000	-	11000

* 1 Lakh=0.1 million; ** Projected



Regional Research Station	Soil Type & Topography	Rainfall (mm)	Activities
Pali Estd: 1953* Area: 380 ha	Shallow sandy loam, Transitional plain of Luni Basin	400	Management of saline / sodic water R & D for location specific farming systems Seed production of grasses and trees
Bikaner Estd: 1958* Area: 263 ha	Loamy sand, duny sand and interdunal arid western plains	250	Integrated farming system research with focus on silvopastoral and livestock management Water management (canal) - drip and sprinkler irrigation Environment Impact Analysis (EIA)
Jaisalmer Estd: 1959* Area: 133 ha	Loamy sand, duny sand and interdunes and rocky-semi-rocky areas	150	*Lasiurus sindicus* (Sewan grass) based silvopastoral system Research on khadin water harvesting system Water management (Ground and canal water) EIA and biodiversity conservation Seed production of trees and grasses
Bhuj Estd: 1987 Area: 58 ha	Saline/sodic, sandy loam and silty clay loam (Banni area)	275	Assessment, fine tuning and demonstrations of technology Evaluation of suitable farming systems for saline/sodic soil Seed production of trees and grasses

* Established as experimental areas subsequently upgraded as RRSs in 1986



Assessment of natural resources using GIS

DIVISIONS	MAJOR PROGRAMMES
Natural Resources and Environment	Integrated basic and human resource appraisal, monitoring, and desertification
Integrated Land use Management and Farming Systems	Integrated arid land farming system research, plant product processing and value addition
Soil - Water - Plant Relationship	Management of land and water resources
Plant Science and Biotechnology	Biodiversity conservation and Improvement of annual and perennials, integrated pest management
Animal Sciences and Forage Production	Improvement in livestock, forage production and conservation
Agricultural Engineering and Energy	Non-conventional energy systems and farm machinery power
Agricultural Economics, Extension and Training	Socio-economic investigation and evaluation, technology assessment, refinement and training

Saraswati river system in the Thar Desert

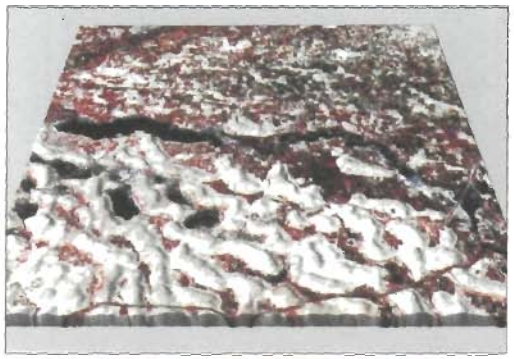
Several courses of the buried Saraswati and Drishadvati rivers from the Himalayas, sustained by the water of the Sutlej River, as well as other buried streams in the Thar Desert have been explored. Potentials of groundwater are being tapped by various government agencies.

MANDATE

- To undertake basic and applied researches for the development of sustainable farming systems in the arid ecosystem.
- To act as repository of information on the state of natural resources and desertification processes and their control.
- To provide scientific leadership and collaboration with State Agricultural Universities for generating location specific technologies.
- To provide training in relevant scientific areas and consultancy.

Weather and climate change

Available weather data from Jodhpur and other stations across the arid western India are regularly compiled and matched with CAZRI's own station data to monitor the spatio-temporal patterns of climate change, frequencies of extreme events like droughts and floods, and for providing agro-advisory twice a week to the farming communities. The Institute is also a part of the nation-wide network of stations to monitor daily weather pattern for medium-range weather forecasting.

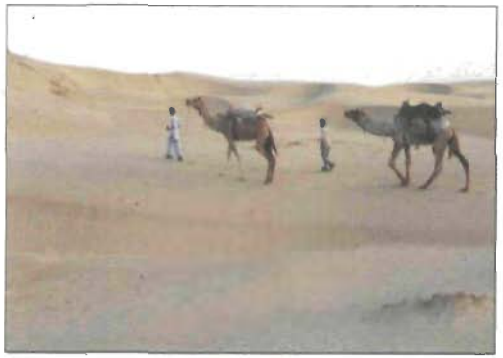


Water logging along paleochannel

Stabilized dune

Sand dunes

Sand dunes in the Thar Desert have been classified into nine major categories under the old (mostly 10-100 thousand years old) and the new (mostly less than 2000 years old) dune systems. Recent human-induced sand mobility is about 3 times faster than the geological rates, calling for urgent stabilization. Technologies to stabilize the dunes through plantation of grasses, shrubs and trees have been identified, and transferred to the State Government for large-scale adoption. Based on these technologies over 3 m ha dunes have been stabilized. Shelterbelts have been designed and trees and shrubs identified to effectively reduce wind velocity, soil nutrient losses and to increase crop production on leeward side.



Barren dune

Management of land irrigated with high RSC water

Doses of gypsum for reclaiming soils degraded by irrigation with high RSC water have been standardized. It has been found that incorporation of 50% of soil gypsum requirement plus the quantity of gypsum needed to neutralize RSC in excess of 10 me L^{-1} is the best for grain yield and high benefit:cost ratio. Now this is a state Government recommendation.

Rainwater management

Improved designs of traditional rainwater harvesting structures like tanka (cistern), nadi (pond), and khadin (for crop cultivation on conserved soil moisture) have been developed to maximize the collection, efficient conservation and judicious use of meager rainfall. Several improved tankas, nadis and khadins have been designed and constructed in western Rajasthan for storage of rainwater for drinking and supplemental irrigation purposes. This has provided assured crop production and generated additional income to farmers. Roof rainwater harvesting technique has been demonstrated at CAZRI buildings at Jodhpur and at villages, where 85% of effective rainfall could be stored. Technologies like percolation tank, pond with infiltration well and sub-surface barrier for artificial ground water recharge have been developed and demonstrated in western Rajasthan to rejuvenate the

Floods are not uncommon

Shelter belt along canal

Shelterbelt along railway track

depleted aquifers and miximize water availability under various Institute and Government programmes including Rajiv Gandhi Drinking Water Mission.

Watershed management

For holistic management of natural resources the concept of integrated watershed management for areas having well defined drainage system with single outlet, index catchment for duny and rocky complexes, and Land Resources Development Area (LRDA) approach for sandy undulating and plain lands have been developed. Model watersheds with people's participation have been developed at Sar, Jhanwar, Baorli-Bambore, Salodi and Kukma (Bhuj). The watershed management technologies have markedly improved socio-economic conditions and overall livelihood of target groups. The institute was awarded 'SAVING THE DRYLAND' appreciation certificate for work on Jhanwar watershed by UNEP in the year 1996.

Anicut

Rehabilitation of rangelands and mine spoils

Technologies to establish pasture grasses like *Cenchrus ciliaris*, *C. setigerus*, etc., on the degraded rocky and shallow gravelly rangelands have been developed. Technologies have also been developed for rehabilitation of mine spoils of lime stone, gypsum, lignite, etc., through optimum combination of land shaping, rainwater harvesting, soil amendment and planting adopted plants. The work on gypsum mined area was commended and 'Mine Safety Award' given by the State Government.

Alternate land use systems

Alternate land use systems, including agroforestry, agrohorticulture, hortipastoral and silvopastoral systems, have been developed for sustainable biomass production. Trees like *Hardwickia binata*, *Colophospermum mopane*, *Acacia senegal*, *Tecomella undulata*, *Ailanthus excelsa* and *Ziziphus mauritiana* have been found to be most compatible with crops and grasses. Management practices and productivity of rangelands in different agroclimatic zones have been developed and their carrying capacity quantified.

Improved tanka

Water pond

Agroforestry

Arid horticulture

Horticulture involving indigenous drought hardy fruit crops, cucurbits and legumes is an integral part of rainfed farming system. Besides locally growing fruits and vegetables, a large number of fruit crops like improved ber, pomegranate, aonla, date palm, gonda, karonda, bael, phalsa, etc., have been successfully introduced for cultivation in arid regions through standardization of agrotechniques. Suitable varieties of different fruit crops like Gola, Seb and Umran of ber, Jalore Seedless, Mridula and Ganesh of pomegranate, Dhara Road and Faizabadi Local of bael; Chakaiya, Kanchan and NA7 of aonla and Halawy, Barhee and Khadrawy of date palm have been delineated for *growing in the arid and semi-arid regions*. Technologies for several value added products from the fruits, especially fruit juice and candy have been standardized and demonstrated. Rapid multiplication of female plants of date palm through RSE process has also been standardized.

Rangelands

Forest trees

A *number of tree and shrub species* from isoclimatic regions of the world have *been evaluated for fuel, fodder and other* economic products. The most promising ones are *Acacia tortilis*, *Colophospermum mopane*, *Prosopis juliflora*, *Acacia bivenosa*, *Simmondsia chinensis*, etc. Scientists working on improvement and multiplication of *Prosopis* (Khejri) trees were awarded for Team Work by ICAR. Germplasm of forest trees like khejri, rohida, kumat, neem, etc., collected from different parts were evaluated and plus *trees identified to produce superior quality* planting material. Air layering of khejri tree *for development of true to type plants* standardized. Formulation on pruning for fodder and fruit trees is also a major contribution. Protocols for mass multiplication of selected strains of *Tecomella undulata*, *Prosopis cineraria*, ker, henna using axillary bud proliferation method has been developed.

Hortipasture system

Plant biodiversity and conservation

Thar desert is endowed with number of unique endemic plant species. Due to overexploitation their existence is threat-

Dates

Date products

ened. These include *Commiphora wightii*, *Barleria acanthoides*, *Calligonum polygonoides* (phog), *Haloxylon salicornicum* (lana), etc. Efforts are being made to conserve and multiply these plants.

Gum production from *Acacia senegal*

Acacia senegal (locally called Kumat) tree is a good source of gum, but its exudation is slow under natural settings. Technology to enhance gum exudation through ethephon injection without endangering the plants survival has now been developed so that it is possible to get annually 0.25 to 1.00 kg good quality gum from each tree. The technology is fast getting popular among farmers. This technology has spread to over 500 ha area in Rajasthan. This is being popularized by NGOs. It has a great potential especially in dry prone drought areas of the country.

Ber

Forest produce

Tree/shrubs have much potential to produce products of high economic value that may generate livelihood and improve income of rural people. Squash, Jam, dry dates and wine have been prepared from fruits of *Salvadora oleoides* (Pilu). The wood of *Acacia tortilis*, *Prosopis juliflora* after seasoning and treatment has a great potential in handicraft industries. From the pods of *Prosopis juliflora* different products viz., coffee, algarobin, biscuits, proso-protenex, etc., can be prepared for human consumption.

Crop production

Technologies for sustainable crop production under rainfed conditions have been developed. These include application of FYM on sowing lines to prevent crust formation, optimum tillage to capture sufficient rainwater, paired row planting for

Ber products

efficient utilization of soil moisture, intercropping to reduce risk of crop failure during aberrant weather, rainwater harvesting, incorporation of amendments and composted crop residues to improve soil moisture and fertility, application of life saving irrigation, and use of pressurized irrigation where resources permit, and adoption of pearl millet-clusterbean rotation under rainfed and pearl millet-

Micropropogation of fruit & forest trees

Gum from *Acacia senegal*

mustard crop rotations under irrigated arid conditions.

Soil fertility

Contribution of arid legumes in improving the soil fertility and yield of succeeding pearl millet crop has been quantified. Cultivation of legumes in grasslands improves the productivity of pastures. A simple cost effective technology to screen decomposability of crop residues has been developed and their incorporation in soil improved the crop yields. Application of sulphur-mixed urea, that minimizes volatilization losses of urea has been shown to increase N-use efficiency from 20 to 45%.

Table from *Acacia tortilis* wood

Soil microbes

Efficient N-fixing symbiotic bacteria improving the crop yields by 10-15% have been identified. Nutrient use efficiency and crop yields have been shown to increase by inoculation of phosphate mobilizing micro-organisms. Inoculation of AM-fungi improved the establishment and growth of saplings of both fruit and forest trees.

Stress tolerance

Benefits of high soil fertility in ameliorating the adverse effects of moisture and salinity stress have been established. Thiourea application improved the yield of clusterbean under low rainfall conditions. Clusterbean is recommended for planting in saline soils having EC up to 8 dS m^{-1}. In the *event of late on-set of monsoon* planting legumes rather than pearl millet is a recommended contingency plan. Clusterbean cv. Suvidha and moth bean cv. RMO-40, being shade tolerant, have been identified to be suitable for agroforestry and intercropping systems.

Triplet planting

Crop improvement

High yielding varieties of pearl millet (CZP 9802, CZ-IC923), clusterbean (Maru guar), moth bean (Maru moth-1, CZM-1, CZM-2, CZM-3) and horse gram (Maru Kulthi-1) have been developed, which can give higher yields in arid and semi-arid regions. The dual purpose pearl millet variety CZP 9802 is grown on over 25,000

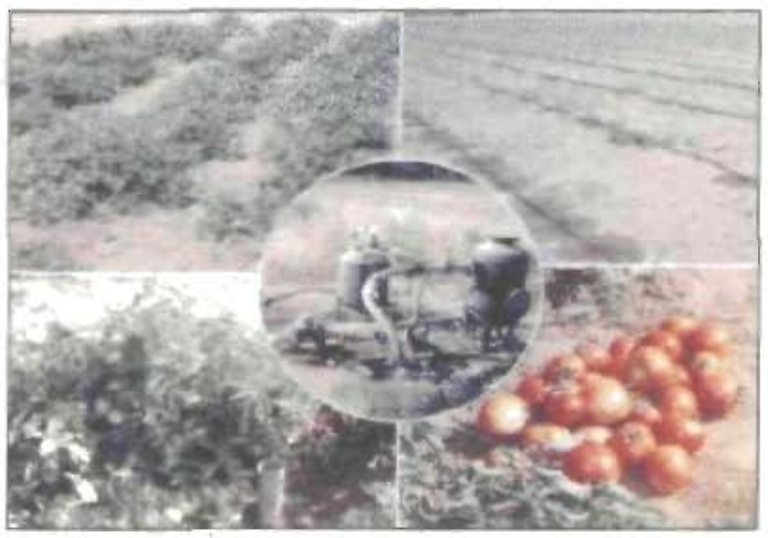
Intercropping

Crop diversification: *Aloe vera*

ha area and getting popular in spite of competition from hybrids.

Grass improvement

Suitable range grasses have been identified and agronomical practices for sustainable yield developed. Simple, low-cost device developed to make pellets having grass seeds, tank silt, sand and FYM that help in grass stand establishment. On an average 10 q seed of these range grasses is produced annually for distribution amongst farmers and other agencies interested in grass establishment. The Institute is known for its quality grass seed.



Drip irrigation

Plant diseases

Soil solarization, incorporation of mustard oil-cake, *Aspergillus versicolor* (fungi) and *Bacillus firmus* (bacteria) in the soil have been found to minimize the soil borne pathogens. Effective control measures of bacterial blight of clusterbean, graphiola disease of date palm and powdery mildew of ber through chemicals have been developed. *Ganoderma lucidum* causing root and butt rot leading to sudden drying of *P. cineraria* tree has been effectively controlled by use of indigenous biocontrol agent (*Trichoderma psuedokoningii*).

Pest management

Insect pests of crops, trees and grasses have been identified and IPM schedules developed. Neem oil emulsion has been found to be effective against pod borer *Heliothis armigera*, castor semilooper, *Achaea janata* and army worm *Spodoptera exigua*. Neem seed pellets that protect pulse crops against termites developed.

Nematodes

A simple and reliable method has been developed for aseptic screening of chilli germplasm against root-knot nematode. Nematodes present in nurseries have been screened and effective control measures through application of nematicides, extracts of plant parts and biological control agents, especially *Paecilomyces eilacinus* and *Pasteuria penetrans* have been developed.

Moth bean var. CAZRI Moth-3

Clusterbean var. Maru guar

Pearl millet: Promising cultivar

Rodent pest management

In the arid zone, of the 18 rodent species found, 3-5 have been identified to be pests that cause considerable damage to grain and vegetation and their bio-ecology, burrowing patterns and food preferences established. These have been effectively controlled through live Sherman traps, and burrow baiting with freshly prepared pearl millet-based zinc phosphide poison baits followed by bromoadiolone (0.005%).

Cenchrus ciliaris

Livestock management

Adoption of scientific management like providing balanced feed, improved housing and health management improved the growth, production and reproductive performance of native breeds like Marwari sheep, Marawari and Parbatsari goats and Tharparkar cattle.

Feed block

Providing complete feed as blocks having mixed rations using local grasses and fodders like *C. ciliaris*, pearl millet straw, tree leaves like loong (*P. cineraria*), pala (*Z. nummularia*) and available concentrates and agro-industrial by-products, like guar churi, tumba (*C. colocynthis*) seed cake given to lactating cows and growing kids effectively economized the cost of feeding.

Animal shelter

Improved animal shelter with east-west orientation with thatched roof prepared from local grass provided comfort, both in summer and winter seasons and improved the growth and production performance of arid goat breeds

Rejuvinated *Prosopis cineraria*

Supplement feeds

Nutrient feed supplements like - urea molasses, mineral blocks/mixtures prepared out of conventional and cheap feed resources - molasses, urea, guar korma, tumba seed cake, wheat bran, mineral mixture and salt relieved the animals from appetite symptoms of mineral deficiency and improved the animal production.

Animal feed block

Tharparkar cow

Solar energy

Plenty of solar energy is available in the arid regions to meet the human needs. Various types of solar cookers to cook food and feed, water heaters and distillation plants designed and developed at the Institute have made a major dent on solar energy utilization in the region. Similarly candle-making machine is also getting popular. To make these devices versatile integrated three-in-one multipurpose devices for drying, heating and cooking have been fabricated. Solar PV-panels have been successfully used to run sprayers and dusters. A PV pump-based drip irrigation system has been designed, developed and being used to grow orchards.

Parbatsari goat

Solar dryers

Dryers to dehydrate agricultural produce are getting popular as the produce retains its color, flavor and the texture. Based on the design developed at the Institute a commercial dryer of 400 kg capacity was installed by an entrepreneur at Village Kakani.

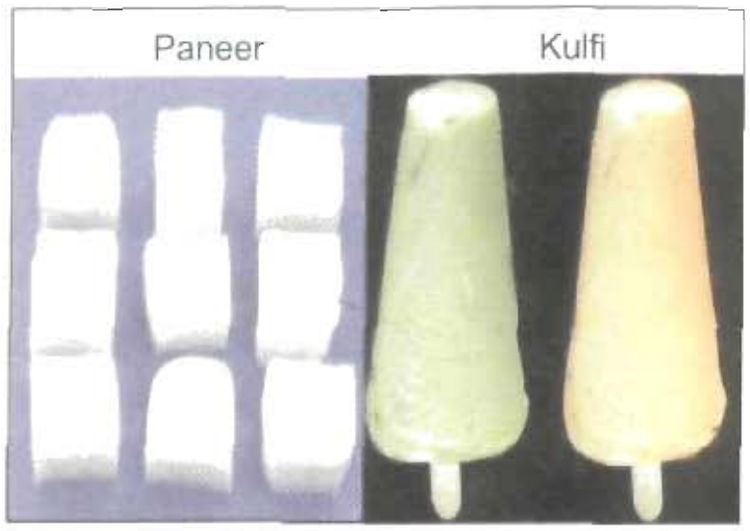
Passive cooling

Low-cost double brick walled passive cool chambers suitable for regions with low RH has been designed and developed to extend shelf life of food materials. In this cool chamber, it is possible to lower ambient temperature by about 15°C and increase of relative humidity to as high as 90-95%.

Farm implements

A number of farmer-friendly implements have been designed and developed. These include a tractor drawn three furrow (six row) multi-crop seed-cum-fertilizer drill for sowing of seeds on specially created slant surfaces to use conserved moisture, and tractor-operated two-row planter for kharif crops. A fruit plucker to collect fruits to minimize human drudgery and fruit pricker for pricking aonla fruits has been developed. An electricity operated *Aloe vera* gel (fillet) extractor has been developed.

Animal shelter house



Value-added milk products

Ber grader

Socio-economic aspects

The socio-economic viability of the technologies developed at the Institute have been evaluated and the socio-economic aspects of the desert dwellers surveyed. The cost-benefit analyses of various land use systems have established that pasture-based livestock system has positive net present value and annuity as compared to arable farming.

Solar PV panel for drip irrigation

Transfer of technologies

Trainings, field days, farmers' fairs scientist-farmer meetings and exhibitions to improve the knowledge of farmers, are organized at periodical interval, both at the Institute and in adopted villages. These events have helped farmers in interacting with the scientists directly and in rapid dissemination of improved technologies developed by the Institute under Institute-village-linkage program (IVLP). The technological interventions have been evaluated and fine-tuned through on-farm research, on-farm trial and verification trials. Field days and on-farm and off-farm trainings are also arranged/organized to increase social awareness amongst the technology users.

IT-aided information transmission

Village Resource Center (VRC) has been developed with the help of ISRO for faster transfer of information from and to farming community. Videoconferencing facility with ICAR and other organizations has also been established at the institute.

ATIC

Agricultural Technology Information Center (ATIC), a single window system to meet the farmers' need for various materials, including seeds of improved varieties, as well as to advice them is in operation. Since 2001 ATIC has attended over 8,000 farmers and generated income

Solar dryers

of over Rs.12.50 lakh through sale of seeds, plants, farm produce, etc.

Value-added farm produce

A large number of technologies for preparing value-added products from farm produce have been developed for income generation. These include preserves, juices, candies, pickles, etc., from ber,

Multipurpose solar device

Passive cool chamber for vegetables

dates, colocynthis. Technologies for preparing clearing agents, moisturizing and tightening creams/lotions have been prepared from *Aloe vera* juice. Ice-cream, paneer and paneer whey prepared from goat milk getting popular amongst people both in the rural and urban areas. These value added products may generate livelihood and addition income to farmers.

Improved and traditional Kassi

Success story: Ber

Adopting improved ber cultivars identified and nursery and management practices developed by the Institute, a farmer in the region helped in spread of the ber cultivation in Gujarat, Karnataka and other arid regions. This has improved nutritional security, livelihood and income generation of the farmers in these regions. The farmer was awarded with Appreciation Certificate by UNCCD in 2001, Krishi Shiromoni Award of Ministry of Agriculture in 2003, and ICAR N.G. Ranga Farmers award for diversified a agriculture in 2005.

Trainings

Apart from trainings to grass root workers specialized national and international trainings are given to scientists on different themes. These include both in group trainings and trainings to individuals. A number of training courses for research officers of Afro Asian Countries sponsored by International institutions like UNESCO, UNEP, FAO, DANIDA, etc., have been successfully organized. In recent years scientist have come to institute from Sri Lanka, Egypt, Iraq and Afghanistan, etc.

Beneficiaries

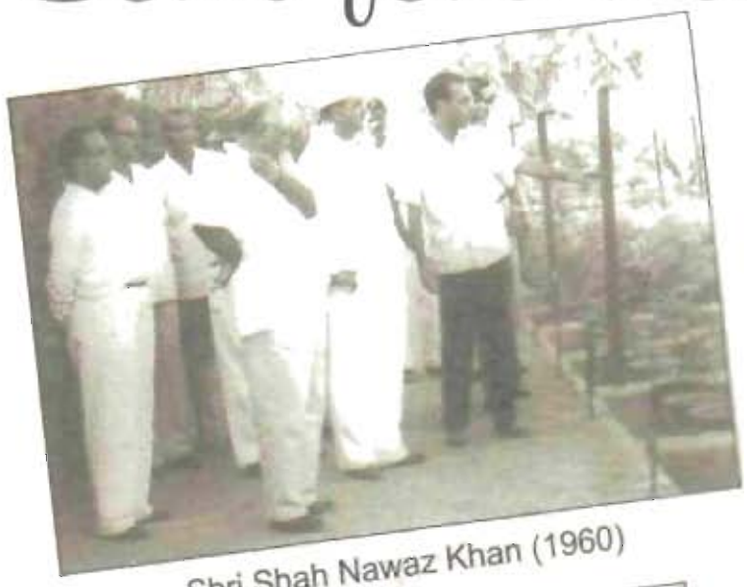
The technologies and expertise developed by the Institute are in great demand both by GOs and NGOs. The measures to control rodents are getting popular and trainings to official from Post and telegraph and Railways are being

Pearl millet group on farmer's field

trained for rat control. Railway with the help of Institute scientists have developed technology for cooling the coaches during summer. Apart from this shelterbelts to prevent encroachment of railway tracks, roads, and Indira Gandhi canal established. Scientist are continuously interacting and providing support to official of IGNP and Narmada River Project.

Farmers observing millet varieties

Some fond memories.....



Shri Shah Nawaz Khan (1960)

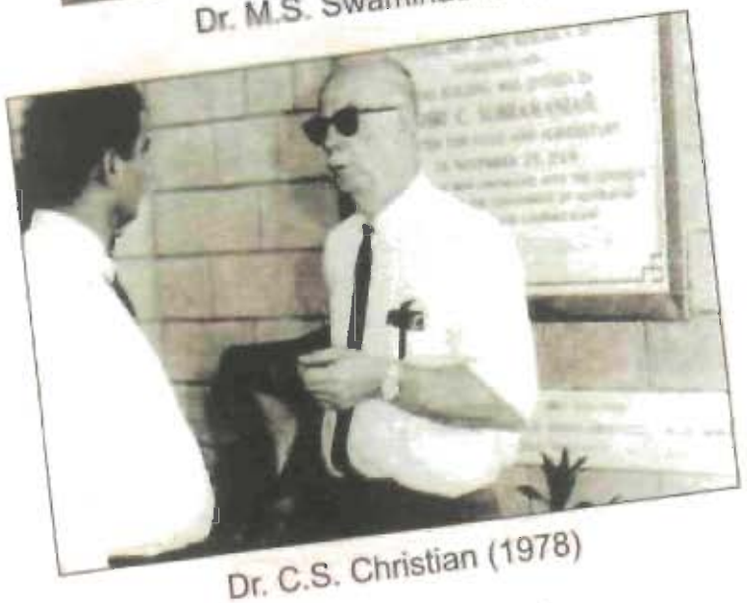
Dr. O.P. Gautam (1979)

Shri Buta Singh (1985)

Dr. M.S. Swaminathan (1976)

Shri Rao Birendra Singh (1981)

Dr. N.S. Randhawa (1986)



Dr. C.S. Christian (1978)

Hon'ble Gyanee Zail Singh (1982)

Ambassador, USA (1991)

Dr. V.L. Chopra (1992)

Hon'ble Shri Sam Nujoma, President of Namibia (1997)

Shri Ajit Singh (2003)

Dr. Manmohan Singh (1992)

Dr. Panjab Singh (2002)

Hon'ble Mrs. Pratibha Patil (2005)

Shri C. Misra (1997)

Penny Winsale, High Commissioner, Australia (2003)

Shri Sharad Pawar (2007)