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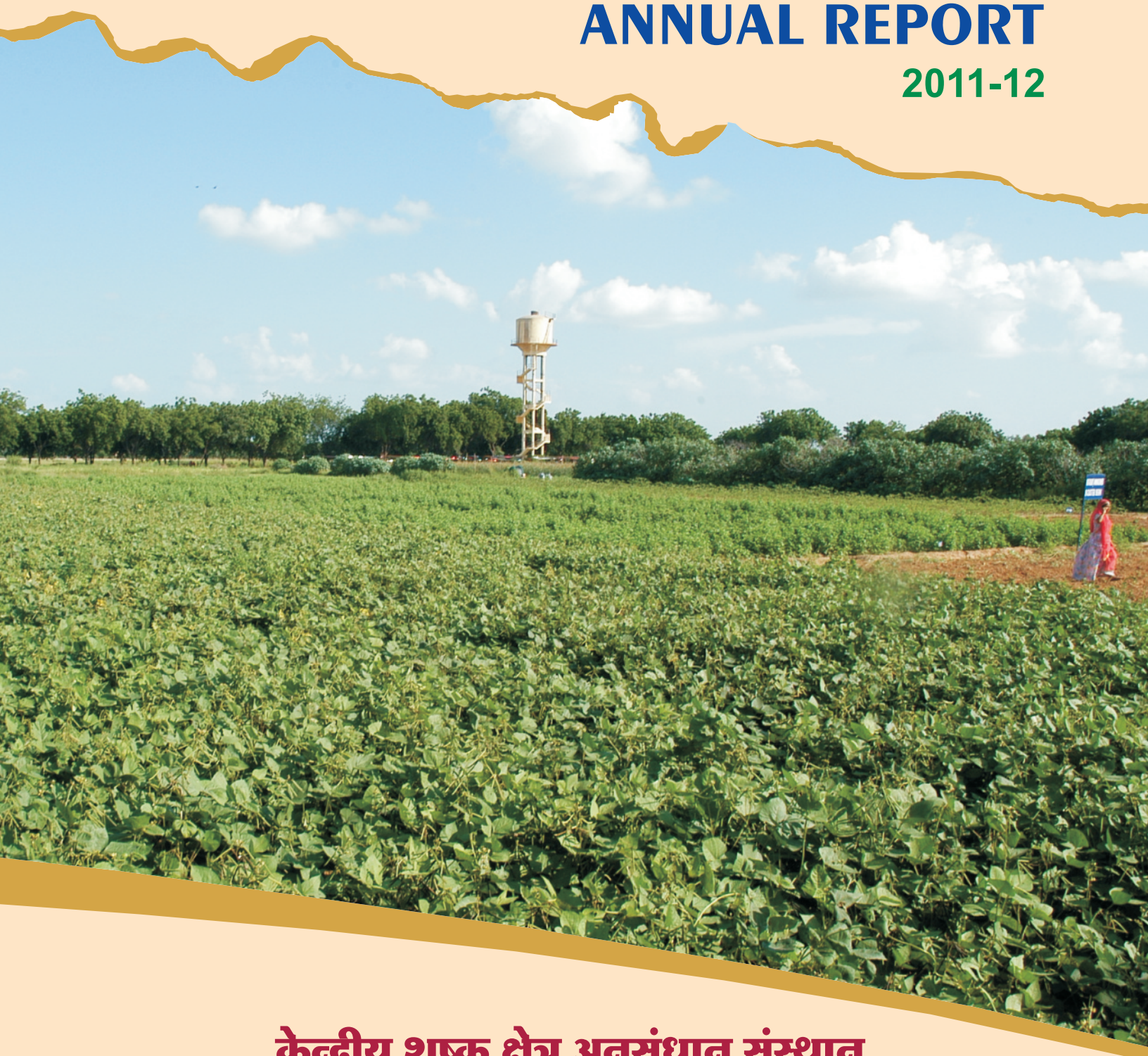
ANNUAL REPORT
2011-12



केन्द्रीय शुष्क क्षेत्र अनुसंधान संस्थान
(भारतीय कृषि अनुसंधान परिषद्)

CENTRAL ARID ZONE RESEARCH INSTITUTE
(Indian Council of Agricultural Research)

JODHPUR 342 003 INDIA

भाकृअनुप
ICAR

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CAZRI

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Back cover: Cattle Grazing in Silvipasture

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PREFACE

The Institute (established 1959) mandated to serve the arid regions of the country continued to conduct research and development activities in the field of natural resource monitoring, biodiversity conservation, plant improvement, integrated pest management, livestock production and management, value addition to plant and animal products, non-conventional energy resources, integrated farming systems, technology assessment/transfer, and socio-economic and gender issues.

Like previous year, rainfall was good in most parts of the Indian arid zone, and it was 20% (Nagaur) to 90% (Churu) higher than the normal during June-September in arid districts of Rajasthan. Seasonal rainfall was 337.6 mm at Anantpur, 265.7 mm at Bellary, 396.2 mm at Bikaner, 264.8 mm at Jaisalmer, 390.6 mm at Hisar and 305.2 mm at Jodhpur.

A Hot Arid Network was established, involving five SAUs from Karnataka, Maharashtra, Andhra Pradesh and Tamil Nadu, to further enhance our efforts in the peninsular India. Similarly, a Cold Arid Network was established with four partners, including three SAUs having field sites in cold deserts in the states of Jammu & Kashmir and Himachal Pradesh. Establishment of a Regional Research Station of the institute at Leh (Jammu and Kashmir) is now in the advanced stage.

The assessment of natural resources in Tharad and Vav tehsils covering 3410 km^2 areas in Banaskantha District of Gujarat has been completed. This region has large areas of aeolian sand deposits, especially as low sandy hummocks and low fence line dunes. Soils are mainly medium to fine textured (Tharad and Rampura series) in 75-80% of the area. Another study on geo-morphological mapping in the northern part of Rajasthan showed dominance of landforms of aeolian origin. A soil hydraulic property database was generated for validation of the pedo-transfer functions (PTFs) to estimate soil water retention in arid western India.

Five pearl millet hybrids (CZH-218, CZH-224, CZH-223, CZH-221 and CZH-222) were contributed to All India Coordinated Trials. High yielding and disease resistant genotypes of mung bean, moth bean and clusterbean were identified. Thirteen germplasm of guggul were collected from different sites. Forty-three cacti (*Opuntia ficus-indica* L.) were introduced from Italy. More than 60 q truthfully labelled seed of various crops was produced.

Seed inoculation in clusterbean with *Bacillus coagulans* influenced acid phosphatase and phytase activity, which mobilized P from unavailable native P sources and enhanced the production. Seed treatment with phosphorus solubilizing microbes increased dry fodder yield of *Clitoria* by 20.2% at Bhuj. Mycorrhizae inoculated plants resulted up to 25-fold improvement in saponin content at critical growth stage (45 days) and up to 4-fold improvement at crop harvest as compared to non-inoculated plants of *Safed Musli*.

Improved silvipasture systems enhanced average daily body weight gain in both sheep and goat. The feeding of *ardu* and *neem* leaves to goat showed high acceptability

and palatability. The technology of processing *Prosopis juliflora* pod flour based cheaper concentrate feed has been transferred to industrial partners of NAIP, who are processing and marketing it with the brand name CAZRI *Pashu Aahar*.

Aloe shaving cream and gel in good looking semi-transparent form were developed with comparable lather quality, moisturizing effect and emollient properties. Technique for oleo-gum resin extraction from *Commiphora wightii* was developed and standardized.

For rehabilitation of degraded rangelands and stabilization of production in arable arid lands improved technologies like high yielding varieties, soil and water conservation, use of improved weeding implements, *in-situ* budding with the buds of *Z. mauritiana* in wild *ber*, gum induction in *Acacia senegal*, supplementation of vitamin-mineral mixture in animal feed, enrichment of poor-quality dry fodder through urea treatment and use of animal feed solar cooker were demonstrated at farmers' fields.

Agricultural Technology Information Centre (ATIC) of the Institute provided seeds, planting material, value-added products, services, technologies and information to different stakeholders through a single window delivery system. The facility of soil and water testing was also provided to the farmers through this centre.

During the year 300 training programmes (on and off-campus) were organized for farmers, farm-women, students and agriculture/extension officers of state governments etc., involving 8600 trainees. A *Kisan Mela* (400 farmers) and a National Symposium (130 participants, including international) were successfully organized. 25 exhibitions were held to demonstrate and popularize CAZRI technologies. More than 5000 visitors came to this institute and were shown the technologies at the research farm/laboratories of the Institute.

I thank all the scientists of this institute whose contribution is reflected in this report and also the chairman and members of the editorial and publication committees for their sincere efforts in production of this report.

I believe that this compilation will provide useful information to researchers, extension agencies, farmers and other stakeholders involved in sustainable development of the arid regions. We look forward to have greater interaction with the stakeholders in coming years for meeting their expectations.

M.M. Roy
Director

CONTENTS

EXECUTIVE SUMMARY

Weather During 2011

The southwest monsoon arrived one week late in eastern districts of Rajasthan on 23rd June and in western parts on 8th July, and withdrew from most parts of Rajasthan by 26th September. In August and first fortnight of September, monsoon was very active and rainfall in all the districts of arid Rajasthan was more than normal. During January, the lowest minimum temperature was on 16th January at Jodhpur (4.1°C), Bhopalgarh (1.0°C) and Pali (0.9°C). However, lowest minimum temperature at Jaisalmer (-4.0°C) was recorded on 24th February, on 7th and 8th January at Bikaner (-3.0°C) and on 1st January at Chandan (-2.5°C). Seasonal rainfall was 337.6 mm at Anantpur, 265.7 mm at Bellary, 396.2 mm at Bikaner, 264.8 mm at Jaisalmer, 390.6 mm at Hisar and 305.2 mm at Jodhpur. Rainfall was well distributed at Hisar, but its distribution was erratic at Bellary, Jaisalmer and Anantpur.

Integrated Natural Resources Appraisal, Monitoring and Desertification

Assessment of natural resources in Tharad and Vav tehsils of Banaskantha District in 3410 sq. km area revealed that this region has large areas of aeolian sand deposits, especially as low sandy hummocks and low fence line dunes. Soils are mainly medium to fine textured (Tharad and Rampura series) in 75-80% area. Surface water is in the form of ponds (952 nadis) which store 43.5 mcm water. About 60% area has deep to very deep (>50 m bgl) groundwater. Quality of the ground water is largely brackish to saline with average EC of 4.684 dS m^{-1}. About 96% area has water with EC >2.0 dS m^{-1}. During the last several years, groundwater level in the state is declining. Higher rate of depletion is observed in the area where quality of ground water is relatively better. The discharge varies from low of <3.0 m^3 day^{-1} to high of 150 m^3 day^{-1} with an average of 125 m^3 day^{-1}. The western part of Vav tehsil has the problem of natural salinity due to the proximity of Great Rann of Kachchh. Both salinity and calcrete pans are the natural constraints. Simulation modelling for water erosion revealed moderate soil erosion potential (5-10 t ha^{-1}) in the eastern part of Tharad tehsil and in the southern and western fringes of Vav tehsil. More than 75% area in both tehsils is under rainfed crops. Saline wastes cover more than 12% area. Canal irrigated area may increase significantly as the Naramada Canal distributaries start operating in the two talukas.

Geomorphological mapping in the northern part of Rajasthan showed dominance of landforms of aeolian origin. At Agolai, water erosion process in the form of channel bedloads were measured using sediment catchers during major rain events in September. Similarly, at Beriganga research farm, sand filled check-dams on the channel and half-moon terraces (200 numbers) on the hill slopes were constructed to improve the catchment hydrology. At RRS, Kukma, catchment hydrology was evaluated based on assessment of elevation, slope and infiltration rate. Study was carried out in Jaisalmer to assess wind eroded soil loss from two major land uses i.e. agricultural land and fallow pasture land. Sensitivity analysis of climate variability and productivity of pearl millet and wheat relationship in arid Rajasthan revealed maximum temperature had negative

effect, while rainfall amount had positive correlation with yield. Seasonal rainfall had positive correlation with yield in all the districts.

In the impact study of canal irrigation in IGNP-2 and Narmada command area, pH, EC and organic carbon of the soil in the irrigated area showed increasing value. At Bikaner, effects of landuses on physical (BD, porosity) and chemical properties (EC, pH and SOC) of soil were assessed.

For Leh district in cold arid region, long term weather data (1980-2002) and crop acreage data (2000-2010) were analyzed. The long term average of precipitation is 400.93 mm.

Spatial variability of soil sulphur in different land-use-systems in transitional plain of Luni basin showed that total sulphur content in surface soil varied widely from 51-639. The available sulphur varies from 0.6-30.3 ppm with a mean of 6.0 ppm.

Evaluation of soil biodiversity in *L. sindicus* based land uses showed that the silvi-pasture systems, managed pasture and natural grassland with controlled grazing have higher values for most of the parameters in comparison to the reference soil.

Biodiversity Conservation and Improvement of Annuals and Perennials

Ten genotypes of *Cenchrus ciliaris* were evaluated at three locations, and IMTCC-10-2 (21322 kg ha^{-1}) at Jodhpur, IMTCC-10-8 (12809 kg ha^{-1}) at Bikaner, and IMTCC-10-10 (14026 kg ha^{-1}) at Pali were the highest yielders for green forage. In CVT of seven genotypes, CE 08-5 was the highest yielder for green (6757.8 kg ha^{-1}) and dry matter (1630.8 kg ha^{-1}). In case of *C. setigerus*, there was no significant variation among the eight entries evaluated in IVT, VTCS-8 had maximum green fodder, and VTCS 4 had highest dry matter yield. In case of *Lasiurus sindicus,* IVTS-7 had maximum green forage (8411.1 kg ha^{-1}) and dry matter yield (3228.0 kg ha^{-1}) at Jodhpur, and IVTS-6 (green fodder, 5600 kg ha^{-1}, and dry matter yield 3050 kg ha^{-1}) at Jaisalmer.

In pearl millet, CZH-218, CZH-224, CZH-223, CZH-221 and CZH-222 hybrids were contributed to All India Coordinated Trials. In different hybrid trials highest grain yielders were CZMS 002A x CZI 2004/7 (4429 kg ha^{-1}, 54 days) in HT I, CZMS 008A x CZI 2000/24 (3057 kg ha^{-1}, 52 days) in HT II, 841A x CZI 9623A4 (3610 kg ha^{-1}, 52 days) in HT III, IHT 106 (5342 kg ha^{-1}) in IHT I, AHPT 801 (5023 kg ha^{-1}) in AHPT. Under ICAR-ICRISAT collaborative programme, early B line, early maturing restorer, CPBLT, A5 Restorer line, high Fe Inbred and Marker Assisted Breeding trials were conducted.

In moth bean, 21 genotypes out of 121 had 37 to 165% more seed yield than CZM-1. Gamma rays affected the germination and seed yield parameters of two genotypes. In mung bean genotype KM11-573 was the maximum seed yielder (875 kg ha^{-1}). The mutants CZM-9, CZM-11, CZM-16, CZM-18, CZM-25, CZM-29 and CZM-34 (seed yield of 677-833 kg ha^{-1}) were better than the checks (365-469 kg ha^{-1}). In clusterbean, 11 genotypes were evaluated at Jodhpur and Jaisalmer in CVT. GR-111 (503 kg ha^{-1}) was the highest seed yielder at Jodhpur and GR-101 (1008 kg ha^{-1}) at Jaisalmer.

In moth bean, IC-311435, IC-323451, IC-39796, IC-39800, IC-370508, IC-329037, IC-329077, IC-333212, IC-39814, IC-39730, IC-39778, IC-39693, IC-39725, IC-311400, IC-39759, IC-311416 and IC-39811 lines were free from YMV. In clusterbean, 11 genotypes were evaluated for incidence of *Myrothecium* leaf spot, bacterial blight and dry root rot, and none of the genotypes

was free from all the three diseases. 22 varieties of coriander molecularly characterised by nine RAPD primers showed intraspecific variation in banding patterns.

Twenty-four accessions of *Salvadora oleoides* had significant variation for survival, height and incidence of WBD. In case of guggal, germplasm from 13 individual shrubs from different sites were collected. Genotypes and stem thickness affected the sprouting. About one-third of the cuttings of 14 genotypes callused for four days sprouted within 20 weeks, and more than 50% of the cuttings in case of Dholavira-2, Moolsagar and SKN-2 sprouted. Stem thickness of sprouted cuttings was more than the unsprouted cuttings. Seed size affected the seed germination, 10% of large, and 5% of medium and small seeds germinated. 25-year-old plants of *P. cineraria* raised from seeds and air layering were evaluated for off-season flowering/fruiting. Flowering was in more trees raised vegetatively. Tree height, collar diameter and DBH were more in flowering trees than the non-flowering ones in both the cases. Forty-five accessions of kair collected from Jaisalmer and Barmer districts had wide range of variability for fruit and seed traits, seed germination and seedlings mortality.

Four Rhizobium cultures identified from *A. senegal* and *P. cineraria,* affected the seed germination, nodulation and seedlings health of two different genotypes of *A. senegal*. Treating the seeds with rhizobia reduced the seed germination but enhanced the seedling biomass, and this effect was more with *Sinorhizobium kostiense* (PC-4). One isolate from *A. senegal* rhizosphere was identified as *Stephyllococus hominis* and from root nodules as *S. saheli* De Lajudie. Isolates from *P. cineraria* included *Lysinibacillus sphaericus* and *Bacillus subtilis* from rhizosphere and *S. kostiense* and *S. saheli* from root nodules. *S. saheli*, *S. kostiense, L. sphaericus*, *B. subtilis* and S. *hominis* were identified as the major PGPR associated with the rhizospheres of *A. senegal* and *P. cineraria* in the arid region of western Rajasthan.

Among forty-three cacti (*Opuntia ficus-indica* L.), introduced from Italy in collaboration with ICARDA, Seedless Santa Margherita Balice, Rossa Castel Sardo, RojaxRoja-4, Pianta 25, Trunzara Red san cono, A Giant and Militelo White showed 100% survival. Healing-over-period affected the survival of plants, plant height, number and weight of new leaves. Cladodes planted after four weeks of healing-over-period had better chances of survival. High yielding gonda genotypes, CAZRI-G 2021 and CAZRI-G 2025 with 23.5 26.0 kg average fruit yield per tree, have been identified for release as varieties. Twenty-five selections of watermelon were evaluated for seed yield and related traits at Jaisalmer. SKNK-138 showed maximum seed yield.

Seasonal variation and different soil depths showed considerable change in the mean number of seeds in fully protected, controlled and open grazing rangelands at Jaisalmer. 14 plant species were identified and maximum number of seeds was of *Lasiurus sindicus*.

Twenty accessions of clitoria, four species of wild groundnut (*Arachis glabrata*, *A. prostrata*, *A. rigonii* and *A. pusilla*) and 51 selections of sesame were evaluated for their growth and yield at Kukma, Bhuj. The dry fodder yield ranged from 2861 to 4606 kg ha^{-1} in clitoria, and seed yield from 32.8 to 113.1 g m^{-2} in sesame.

The seed quality of variety RZ-209 of cumin after pre-storage treatment with fungicide, biocontrol agent, irradiation and storage in different containers showed that seeds treated with bavistin and stored in tin containers were the best for seed germination and seedlings health.

Foliage cutting showed significant effect on quantity of seed but no effect on dry matter yield and seed purity in three genotypes (CAZRI 75, CAZRI 2178 and CAZRI 2221) of *C. ciliaris*. Maximum green fodder, dry matter and pure seed yield were in CAZRI 2221. Sixty kg breeder seed of open-pollinated variety CZP 9802 of pearl millet, 625 kg breeder seed of moth bean var. CAZRI Moth 2, and 29.3 kg nucleus seed of moth bean var. CAZRI Moth 2 and CAZRI Moth 3 were produced. In addition to this, 5170 kg truthfully labeled seed of various crops was also produced under ICAR Mega Seed Project and National Seed Project.

Integrated Arid Land Farming Systems Research

Recommended dose of N gave 24.6% higher seed yield than control in pearl millet. Application of 20 and 40 kg N ha^{-1} produced 1957 and 1991 kg grain ha^{-1}, which was significantly more than that obtained without fertilizer. The maximum grain yield (2904 kg ha^{-1}) was obtained with the application of 5 t FYM along with 40 kg N ha^{-1}. Soil organic carbon, labile carbon, available phosphorous and potassium increased slightly up to 15-30 cm depth; thereafter, as depth increases the values decreased.

Application of N in split doses had significant influence on the seed and straw yield of clusterbean. Maximum seed and straw yield were with the application of 10 kg N as basal dose along with spraying of 1% urea at vegetative stage and 1% at flowering stage. The clusterbean based cropping systems were mainly infested with broad leaved weeds which contributed 78% of total weed flora. The proportion of grassy weeds and sedges was 21 and 1% respectively. The highest pearl millet grain equivalent yield (2255 kg ha^{-1}) and net returns (Rs.10266) were recorded in clusterbean + pearl millet in 2:1 row ratio.

Sole pearl millet recorded 41% higher grain yield over highly dense ratio of 1:1 crop and colocynth live mulch. Highest clusterbean yield was with 3:1 crop: colocynth live mulch ratio (14.7%) among the different crop: colocynth ratio.

Mulching and supplementary irrigation caused significant improvement in canopy area, mean fruit weight, fruit yield and TSS and reduction in weed population in ber. The weed population was almost absent where ever black polythene mulch was applied. The highest fruit yield of about 34 kg per plant was recorded with irrigation at 60 CPE and with polythene mulching.

Clusterbean and sesame showed improvement in yield with manure application in combination with neem cake and biopesticide spray. The magnitude of change was higher in sesame as compared to clusterbean. Summer lady finger under drip irrigation produced 15% higher yield and saved 30% water over check basin irrigation. Fruit yield (5.8 t ha^{-1}) was 68% higher with 2.5 t vermi compost compared with yield (3.5 t ha^{-1}) at 2.5 t FYM ha^{-1}.

Green chilli fruit yield decreased with the decrease in water supply from 1.0 to 0.6 ETc through drip irrigation system. The maximum fruit yield was with 50% NPK as fertilizers + 50% N as VC (21.76 t ha^{-1}). The mean per cent gravimetric moisture content was maximum for 0.8 ETc (11.74%) and minimum for 0.6 ETc (11.19%) irrigation level while cone index showed reverse trend with the irrigation levels.

Seed treatment with phosphorus solubilizing microbes increased dry fodder yield of *Clitoria* by 20.2%, followed by seed treatment with PGPR (3.87%) over the control. Similarly, micronutrient application also increased the fodder production of clitoria.

Foliar spray of iron and zinc as the aqueous solution of their sulphate salts at post flowering stage of both wheat and mustard reflected concentration and species dependent response. Wheat and mustard were subjected to high temperature at flowering stage and at maturation stage. Such an exposure at flowering stage resulted in plant water deficit and at maturation stage resulted in further reduction in plant water potential in both the crops which was associated with reduced total soluble carbohydrates and starch in wheat leaves. In contrast mustard reflected an opposite trend. Exposure to high temperature at vegetative stage imparted tolerance with respect to metabolite/process against water stress imposed at later stage in clusterbean and pearl millet. The deleterious effect of high temperature was more in clusterbean with respect to nitrate reductase and starch accumulation.

Application of sulphydryl compounds showed significant influence on relative water content, water potential, membrane stability, lipid peroxidation, total chlorophyll content and the activity of antioxidant enzymes i.e. catalase, ascorbate peroxidase, guiaicol peroxidase, superoxide dismutase and glutathione reductase in clusterbean.

Three perennial grass species: *Lasiurus sindicus*, *Panicum antidotale* and *Cenchrus ciliaris* showed bimodal distribution in their diurnal photosynthetic rates with first peak in morning hours and second but bigger peak during afternoon hours. The magnitude of physiological responses of grass species differed largely to the given microclimatic regime.

P. cineraria showed favourable effect on the growth and yield of pearl millet and increased the yield by 12.8%, while in case of clusterbean no such difference was observed, as compared to sole crop. The net returns and B:C ratio were also higher in *P. cineraria* + pearl millet var. ICPT-8203 (Rs. 32290, 2.42) and *Z. mauritiana* + mung bean var. SML-668 (Rs. 17555, 2.01) systems. The height and canopy area of *C. mopane* were higher when grown in association with cowpea and grasses in strip cropping however, the growth of *H. binata* was variable with cropping system.

Highest plant height of citrus and mopane were with intercropping of clusterbean, where as in shisham it was highest with intercropping of mung bean. Growth and yield attributing characters of mung bean and clusterbean were lowest in intercropping with mopane whereas these were highest with intercropping in citrus followed by shisham.

The tree management practices with gum inducer application can be effective for gum arabic exudation from *A. senegal*. The slight decrease in temperature resulted in about 30% reduction in gum arabic production.

Pretreatment of mustard residues with either actinomycetes or H_3PO_4 increased their decomposition. Mustard residues pretreated with orthophosphoric acid decomposed faster than the untreated residues (control) or those treated with any species of actinomycetes.

Lignin content in leaf litters of tree species ranged from 12.6% to 34.1%, with highest value in Mopane. Application of leaf litters @ 2.5 t ha^{-1} has a significant effect on increase in yield and yield attributing characters of clusterbean as compared to control.

Seed inoculation in clusterbean with *Bacillus coagulans* influenced acid phosphatase and phytase activity. *B. coagulans* produces phosphatases and phytase, which mobilized P from unavailable native P sources and enhanced the production of clusterbean and may be used as P biofertilizer under loamy sand soil. Mycorrhizae inoculated plants resulted up to 25-fold improvement in saponin content at critical growth stage (45 days) and up to 4-fold improvement at crop harvest compared to non-inoculated plants of Safed Musli. A new technique was developed for production of nanoparticles from respective salt solution after preparation of fungal ball.

Integrated Land and Water Resources Management

Both *Z. rotundifolia* and *A. indica* showed better growth and productivity under manured condition (5 kg compost + 2 kg neem cake). *A. indica* exhibited better growth, while *Z. rotundifolia* gave higher production and produced 116.2 kg fruits ha^{-1}. The productivity of sown pastures of *C. ciliaris* and *C. setigerus* on degraded lands was higher than the natural pasture having *Aristida* and *Dactyloctenium* species of annual grasses. At rocky site of Bhopalgarh, maximum fodder yield was given by *C. ciliaris* (1333 kg ha^{-1}) followed by *D. annulatum* (1035 kg ha^{-1}).

A total of 23282 m^3 runoff was generated by the Block-I of Beriganga and 17.3% of it was retained by check-dams. A soil hydraulic property database consisting of soil particle size distribution, soil organic carbon content (SOC), soil water retention at 0.3 bar and 15 bar, soil infiltration characteristics, and soil biological activity under different land use systems of the hot arid drylands of western Rajasthan was created. A user friendly interface was also prepared to quickly estimate soil water content at FC and PWP with the input of only sand and clay contents.

Reduction in dose of nitrogen by 25% significantly reduced the yield of wheat crop. In another experiment, harvesting of fodder sorghum in kharif season at 60 DAS significantly reduced rabi taramira yield compared to harvesting at 50 DAS. Application of gypsum to taramira significantly improved seed yield by 23.6%. The relationship between relative grain yield of wheat, barley, chick pea, mustard, cumin, coriander and fenugreek, and irrigation water deficit was linear and significant at Kukma, Bhuj. The least reduction in grain yield under deficit water supply of less than 40% of field capacity was recorded in cumin (6.5%) followed by barley (24%) and fenugreek (33%). The wheat and chickpea were more sensitive to moisture deficit.

More than 50% area of the western Rajasthan comes in the ET range of 1900-2100 mm and about 30% in the range of 1700-1900 mm. The increase in ET with 1°C increase in temperature was highest in Jaisalmer (96 mm) and least in Ganganagar (35.1 mm) district. The increase in temperature by 1°C will cause an additional annual water demand of 1570.9 mcm for the western Rajasthan based on net irrigated area of 3164512 ha.

Improvement of Animal Production and Management

An animal shelter with east-west orientation (10 m long, 5 m wide with 3 m height from centre and 2.5 m from sides) was designed for small ruminants. The microclimate of the shelter improved due to insulation by reduction of the inside temperature up to 4ºC in comparison to the outside environment. Longer heat stress period was observed in the year, which was from 2nd week of March to 2nd week of November. Most critical Temperature Humidity Index values were more than 85 between 4th week of April and 1st week of August. Kids of conventional shelter with extra concentrate ration and of improved shelter with extra concentrate ration had higher body weight gain than the kids of conventional shelter with grazing in warmer part of day and of improved

shelter with grazing in cooler part of day. Kids of conventional shelter group felt maximum stress while kids of other groups tried to adjust against stress.

An experiment was conducted to compare nutrient availability in sheep and goat on the natural and improved silvipasture. Improved silvipasture enhanced average daily body weight gain in both sheep and goat. The feeding of ardu and neem leaves to goat showed high acceptability and palatability, however, dry matter intake and average daily gain were more in animals fed on ardu leaves. Steaming-up of Marwari and Parbatsari goats was done under different shelter systems. Steamed-up goats yielded highest milk (1.4 kg) per day in improved animal shelter, and had highest level of blood glucose (57.3 mg dl^{-1}) just after parturition. All the animals were found negative for ketosis around kidding. Average birth weight of kids from steamed up goat was higher. A group of Tharparkar cows was maintained on *Cenchrus* spp. dominated pasture along with supplementation of concentrate. Average age at first calving was 46.9 months and milk yield 7.2 litres per day with peak yield of 10.3 litres. Balanced concentrate mixture prepared using *P. juliflora* pods did not adversely affect the health, growth and reproduction of the animals.

Preliminary survey of four districts of Rajasthan was conducted under ICARDA project to study the migration pattern of livestock. The people from Barmer district generally follow the routes leading to Gujarat state and from Jodhpur and Pali migration is towards Punjab, Haryana, Madhya Pradesh and Uttar Pradesh. In general, three kinds of livestock migration i.e. within district, semi-migration and permanent migration are prevalent in the western Rajasthan.

Plant and Animal Products and Value Addition

Aloe shaving cream and gel in good looking semi-transparent form were developed with comparable lather quality, moisturizing effect and emollient properties, but the shaving cream has longer shelf life than shaving gel.

Neutral cellulose fraction from *Aloe* leaf waste was processed for bioethanol conversion. Aloe substrate 1, 2 and 5%, produced 0.339, 0.672 and 1.133% ethanol, respectively.

Technique for oleo-gum resin extraction from *Commiphora wightii* was developed and standardized. The fat content of the seeds of *Salvadora oleoides* procured from Araba area in Barmer was 48.84%.

Managed stands of *Prosopis juliflora* showed 40% increase in pod production in target villages. The technology of processing *P. juliflora* pod flour based cheaper concentrate feed has been transferred to industrial partners of NAIP, who are processing and marketing it with brand name CAZRI Pashu Aahar. In feed trials of this product, the milk yield of cattle increased by 15-25%. Similarly, concentrate animal feed mixture with *P. juliflora* pods powder was developed for growing calves. Feeding trial of this mixture on growing Tharparkar cattle showed no negative effect on the health of animals. Process for making complete feed block based on *P. juliflora* was standardized. Efforts are being made to develop a small industry to make such complete feed blocks in rural areas.

Mesquitol was extracted and isolated from sap/heart wood of *P. juliflora* with a new process which has fewer steps than the prevailing processes. In target villages, 60 households, which were involved in activities under the project "Value chain on value added products derived from *Prosopis juliflora*", got additional income of Rs. 1388 per month (average). The villagers of target

villages also gained employment for 750 man-days per month in *P. juliflora* plantation and wood collection activities.

Animal feed blocks were prepared from the pearl millet bran, which generally goes unutilized. The quality of blocks prepared from wheat bran only and those from wheat and pearl millet bran combination was comparable. To supplement critical nutrients including provitamin-A, calcium and phosphorus to the desert livestock during summer season, lucerne leaf meal blocks were prepared. These blocks contained good amount of crude protein, total carbohydrates and minerals. A simple technology for production of 25-30 kg mineral block has also been developed to supplement macro- and micro-minerals, vitamins along with non-protein nitrogen and fermentable sugars for range foraging community livestock.

Integrated Pest Management

A new bio-formulated product of two native biocontrol agents viz., *Bacillus firmus* and *Tricoderma harzianum* by using cheap and readily available food substrate and carrier has been developed in which both the bioagents can survive for 120 days. Higher level of moisture holding capacity (100 and 70%) of the food substrate significantly enhanced the survival of *B. firmus*, while, the population of *T. harzianum* survived better at lower (30 and 50%) moisture gradients. Under field conditions, incidence of dry root rot on clusterbean was least with application of *T. harzianum* enriched *P. juliflora* compost combined with weed compost than the other composts (Neem, Indian mustard) and non-amended control.

In pearl millet cv. *Nokha local*, a combination of seed treatment of skimmed milk 2% + *Gliocladium virens* (0.6%) provided highest protection (39.3%) against downy mildew followed by seed treatment with *G. virens* with its application in soil. Under laboratory conditions SM (10%) + *G. virens* (0.6%) treated seeds showed maximum germination (62.5%) and vigour index followed by SM 2% + *G. virens*.

Bacillus cultures Az-2 and Az-7, which were identified to be carrying cry1 Ac gene effective against lepidopteron insects, were exposed to high concentrations of novobiocin and kanamycin and resistant colonies obtained at a frequency of 0.001%. These cultures could tolerate temperature up to 42°C in agar medium plates and liquid medium.

Significant reduction in the population of jassids and whiteflies in mung bean crop was with two sprays of 0.25, 0.5 and 1.0% azadirachtin, at 15-day interval. In organic farming system for high value crops, perennial components (jujube, henna and *Calotropis*) supported a good diversity and number of beneficial insects, viz., ladybird beetles, syrphid flies, yellow jacket wasps, houseflies and bumble bees.

The spider population increased from July to September in clusterbean and Amaranthus, and declined as the crop matured and the weed began shedding leaves. Most of the spiders spotted were non-web spinning and majority of the spider types thrived on the soft-bodied insects.

There was significant improvement in fresh and dry weight of shoot and fresh weight of root over nematode check for two levels (500 and 1000 spore/500 cc of soil) of *Glomus fasciculatum* inoculum in 45-day-old *Meloidogyne incognita* infected seedlings of chilli. AM fungus had significant suppressing effect on gall numbers over nematode check. Both the levels of *G.*

fasciculatum drastically reduced the total population and fecundity of *M. incognita* with maximum reduction in 1000 spores/500 g soil inoculum.

In pot trials, increasing inoculum levels of *M. incognita* nematode resulted in progressive decrease in fresh and dry weights of shoot and root on RCH-1 variety of chilli. Maximum reduction in the weights was at 10,000 larvae/500 g of soil. Two larvae/g of soil was the damaging threshold level of *M. incognita* on RCH-1 variety of chilli.

Bait shyness period in squirrels was reduced from 20 days to 8 days by exposure of conspecific odour treated pearl millet bait for three days at low temperature (18 to 25°C). However at higher temperature (28 to 35°C), similar treatment with conspecific odour treated bait, mitigation of bait shyness took longer duration of 13 days.

Rodent damage to pea, gram, and cucurbit vegetables ranged between 6-8.5% in IGNP command areas. In case of wheat, 8.53% tillers were damaged in periphery of fields. In cotton and sugarcane fields in Kukma village, 13.1% canes and 3.4% bolls of cotton were damaged especially in the blocks near bunds. Indian bush rat (*Golunda ellioti*), Indian gerbil (*Tatera indica*) and house rat (*Rattus rattus*) were the predominant species.

In young plantations of date palm cultivar Barhee at farmers' fields, serious rodent damage caused death of 2-10% plants. *T. indica* and *Meriones hurrianae* were the main pest species.

At the CR Farm CAZRI, Jodhpur, *T. indica* population increased from 60% in 2005 to 84% in 2011, but in case of *F. pennanti* the population reduced from 16-17 to 12%. Xeric species like *M. hurrianae*, *Gerbillus gleadowi* and *G. nanus* have been completely replaced during the last four decades. In different cropping systems, rodent population was maximum in silva fields (42.16%) followed by horticultural orchards (36.76%) and crop fields/grasslands (21.08%).

Non-Conventional Energy Sources, Farm Machinery and Power

A solar desalination device, with capacity of 8.22 litres distilled water per day, was designed and fabricated. A solar energy based thermal unit was developed and tested to heat 25 L tumba oil to more than 60°C in 3-4 hours for use in bio-diesel production through trans-esterification. A photovoltaic (PV) mister was fabricated for creating mist from circulating water and incorporated in a Quonset type green structure (5.3 m long and 4.0 m wide with a volume of 33 m^3). Improved passive cool chamber (surface area 5 m^2 and volume 6 m^3) with additional holes drilled in side walls for larger evaporating area was tested. Maximum depression in temperature was attained within one hour compared to 2-3 hours in old chamber. The composite PV device was found useful for illumination in addition to ensured functioning for winnowing and drying of agricultural produce during cloudy days. The payback period for the PV–thermal integrated device was about 2 years.

Moth bean (CAZRI-2) and mung bean (GM-4) crops sown with three furrows (six rows) seed drill gave about 17-18% higher seed yield compared to the yield obtained with traditional sowing method at farmers' fields. Pearl millet, mung bean, moth bean and clusterbean crops sown by using another improved seed drill gave 12-15% higher yield compared to conventional method of sowing. The field capacity of single slot improved weeder was 193.4 $m^2\ h^{-1}$ with 94.5% weeding index while for traditional weeder it was only 160.5 $m^2\ h^{-1}$ with 91.8% weeding index.

The pearled pearl millet flour deteriorated much less compared to flour prepared from unpearled grain under ambient conditions (41°C and 60% RH) in 20 days. However, there was practically no change in the quality of flour kept under refrigerated conditions in both the cases.

Socio-economic Investigation and Evaluation

Economic analysis of camel breeding enterprise in Udaipur, Banswara, Chittorgarh and Dungarpur districts of Rajasthan showed camel breeding as the main occupation. Human labour is the major item of total maintenance cost. The commonly occurring diseases in camel are trypanosomiasis (surra), pox (mata), pneumonia, mange, enteritis (diarrhea) and abortion. The camel calves suffer from enteritis, pica and pox. On an average, fixed investment per household was Rs. 4,22,284. The average cost of maintaining a camel unit (21.06 animals) was Rs. 1,02,935. Camel production was financially viable at 12% discount rate in terms of both NPV and BCR criteria.

In Jodhpur district MGNREGA, female workers dominated the workforce. Majority of works included renovation and earthen works, and about 74.0% of budget money was spent on labor wages. Further, 65% income of disadvantaged group of population was from this programme.

In a study on the economic evaluation of sand dune cultivation in Bikaner and Jaisalmer districts, use of sprinkler irrigation system was prominent among all the irrigation systems. The cost and returns per hectare for cultivation of wheat and groundnut were economically viable on both sand dunes and sandy plains. In Jaisalmer district, productivity of groundnut, cumin, azwain and clusterbean was higher in the plain areas as compared to dunes. The major constraints include; inadequate and irregular supply of power, lack of Government support and non-availability of labour in time.

Assessment of food security in Jodhpur district showed that 80% of households were having sufficient aggregate daily per capita calorie availability, 70% of total households found food secure and 30% were having lower supply for protein.

In Pali district, the average depth of open wells was 31.5 m and 106.3 m for tubewells, 43.2% wells/tubewells had electric motor pumps. As an impact of depleting groundwater, rabi and zaid crops like cotton, chilli, wheat, mustard, vegetables have been replaced by cumin, wheat, mustard and isabgol. Pearl millet, sorghum, clusterbean, mung bean are the major kharif crops now. At district level, between 1982 and 2007, cumin and isabgol showed continuous increasing trend. The knowledge index of the farmers indicates their preferences for efficient methods of farm mechanization and cropping.

Technology Assessment and Transfer

For rehabilitation of degraded rangelands and stabilization of production in arable arid land of Thar Desert, various improved technologies were demonstrated at farmers' fields in villages Bhujawar and Rohilla Kalan of Jodhpur district and Bharmasar of Jaisalmer district. These technologies included improved varieties, soil and water conservation, use of improved weeding implements, *in-situ* budding with the buds of *Z. mauritiana* on wild ber, gum induction from *A. senegal*, supplementation of vitamin-mineral mixture in animal feed, enrichment of poor-quality dry fodder through urea treatment and use of animal feed solar cooker.

Apart from these, a rainfed farming-system-model with budded ber (*Z. mauritiana*), *Cordia myxa* and seedlings of *Dalbergia sisso*, *Pongamia pinnata*, *Ailanthus excelsa* and *A. senegal* was developed. Farmers were trained for seed collection techniques and development of pastures of Sewan (*Lasiurus sindicus*).

Gum inducing technology of CAZRI was adopted on a large scale and number of trees treated with CAZRI gum inducer reached to 22600 during 2010 in Barmer, Jodhpur, Nagaur and Pali districts resulting in production of 6.7 t of gum arabic, generating a revenue of Rs. 38.0 lakh.

Dissemination of improved farm technologies viz., seed varieties, improved agricultural practices including recommended seed rate, seed treatment, time and method of sowing, nutrient and water management was done at Bheenjwadia village of Osian tehsil of Jodhpur district. Seed yield of moth bean CZM-3 was 210% higher compared to local variety. In clusterbean, the average seed yields of RGM-112 and RGC-936 were 67.4 and 60.5% higher than the local check. The mean seed and fodder yield of improved varieties of dual purpose pearl millet (CZP-9802) was 55% and 28% higher than local variety. Groundnut variety Girnar-2, along with improved package of practices gave 35% higher seed yield as compared with farmers' practices.

The seed yield of improved variety of cumin RZ-209 was 26.1% higher than local variety and application of neem cake @ 400 kg ha^{-1} increased seed yield 24.4% in variety RZ-209. Seed treatment of cumin RZ-209 with marusena (*Aspergillus versicolor*), a bio-control agent increased seed yield by 4.13% and higher net returns of Rs. 2376 in RZ-209.

In cumin and wheat, rodent control success (on the basis of burrow count) in various crops was high with zinc phosphide whereas single baiting with bromadiolone gave lower success, on 4^{th} day after treatment. However after two weeks fields treated with bromadiolone had lesser number of rodents. Double baiting with both acute and chronic rodenticides gave highest rodent control success in cumin and wheat on 15^{th} DAT.

Rodent control success with zinc phosphide was 50 to 67.27% in pearl millet, mung bean, moth bean, clusterbean and groundnut on 4th day after treatment. Control success in groundnut was the least (50%) and required repeat applications. Increase in grain yield due to rodenticide treatment ranged between 8-16% in different crops.

Under FPARP field demonstrations of improved varieties of wheat, mustard and cumin and integrated nutrient management increased total productivity of cropping systems by 16 to 38% as compared to farmers' practices in villages Birai, Rajaband and Benan. An increase of 14.8 to 28.1% as compared to local checks was recorded with the use of high yielding varieties of different crops during kharif season. Integrated application of 50% RDF + 50% FYM gave maximum grain yield of pearl millet, which was 38.6% higher than farmers practice. Among all the cropping systems, mung bean-cumin gave highest additional net return (Rs. 24507 ha^{-1}).

After popularization of technologies through demonstrations, trainings and field days in the villages, the knowledge level and practice wise knowledge of most of beneficiary farmers was high for both kharif and rabi crops whereas knowledge of non-beneficiary farmers was low to medium. Adoption level of most of beneficiary farmers was medium to high and that of non-beneficiary farmers was low to medium.

The main constraints as perceived by majority of the farmers were the non-availability of improved seeds in time; high cost of seeds, pesticides and fertilizers and low market price of the produce. Other problems cited by the farmers were poor soil health, low soil moisture, lack of knowledge and operational skill in seed treatment and plant protection measures.

Among different traditional methods of grain storage in the arid region methods, sieved ash mixed at 10% rate with clean and dried wheat grains showed least weight loss and gave maximum protection (up to 97%) from insect pests.

Agricultural Technology Information Centre (ATIC) of the Institute effectively provided seeds, planting material, value-added products, services, technologies and information to different stakeholders through a single window delivery system. The facility of soil and water testing was also provided to the farmers at the centre.

Empowerment of Women and Mainstreaming of Gender Issues

For capacity building of farmwomen, they were given demonstrations on improved technologies of crops and vegetable production. Due to improved practices, the seed yield increased by 34 to 92% in various kharif crops viz. pearl millet, mung and clusterbean in Umaidnagar village in Jodhpur District. KVK Jodhpur also conducted demonstrations on improved crop and livestock production technologies, training programmes and extension activities for farmwomen.

Assessment of women empowerment indicators such as gender activity and decision-making profile reflected that majority of agricultural and livestock activities (70-75%) were performed jointly. Involvement of women in weeding, threshing and winnowing operations was very high as compared to men. In case of livestock production, women participated less in health care and marketing of produce. Contribution of women was very high (91.67-100%) in different household works. Male members dominated decision making related to agricultural and livestock activities, whereas participation of women in decision-making was low and related to household/domestic matters.

कार्यकारी सारांश

2011 के दौरान मौसम

राजस्थान के पूर्वी जिलों में दक्षिण पश्चिम मानसून एक सप्ताह की देरी से 23 जून को और पश्चिमी भागों में 8 जुलाई को पहुँचा और 26 सितंबर तक राजस्थान के अधिकांश भागों से वापस चला गया। अगस्त और सितंबर के पहले पखवाड़े में मानसून बहुत सक्रिय था और शुष्क राजस्थान के सभी जिलों में वर्षा सामान्य से अधिक थी। जनवरी के दौरान सबसे कम न्यूनतम तापमान 16 जनवरी को जोधपुर (4.1° से.), भोपालगढ़ (1.0° से.) और पाली (0.9° से.), में दर्ज किया गया। हालांकि जैसलमेर में सबसे कम न्यूनतम तापमान (–4.0° से.) 24 फरवरी को, बीकानेर (–3.0° से.) में 7 और 8 जनवरी और चान्दन (–2.5° से.) में 1 जनवरी को दर्ज किया गया। मौसमी वर्षा अनंतपुर में 337.6, बेल्लारी में 265.7, बीकानेर में 396.2, जैसलमेर में 264.8, हिसार में 390.6 और जोधपुर में 305.2 मिमी दर्ज की गयी। वर्षा का वितरण हिसार में तो नियमित रहा परन्तु बेल्लारी, जैसलमेर तथा अनंतपुर में अत्यधिक अनियमित देखा गया।

एकीकृत प्राकृतिक संसाधन मूल्यांकन, निगरानी और मरुस्थलीकरण

बनासकांठा जिले के थारड और वाव तहसीलों के 3410 वर्ग किलोमीटर क्षेत्र के प्राकृतिक संसाधनों के आंकलन बताते है कि इस क्षेत्र में वायूढ़ बालू जमा बड़े क्षेत्रों में विशेष रूप से कम रेतीली टीलों और निम्न बाड़ लाइन टीबें मौजूद है। मिट्टी 75–80% क्षेत्र में मुख्य रूप से चिकनी और मध्यम है। सतह का पानी तालाबों (952 नाडियाँ) के रूप में संग्रहित है जिनमें 43.5 एमसीएम जल संग्रह होता है। लगभग 60% क्षेत्र में भूजल स्तर बहुत गहरा है। भू–जल काफी हद तक (4.684 डीएस प्रति मीटर के औसत विद्युत चालकता के साथ) खारा है। लगभग 96% क्षेत्र में पानी की विद्युत चालकता 2.0 डीएस प्रति मीटर से अधिक है। पिछले कई वर्षो के दौरान राज्य में भू–जल स्तर घट रहा है। जहां भू–जल की गुणवत्ता अपेक्षाकृत बेहतर है, वहां भू–जल स्तर घटने की दर अधिक है। पानी का बहाव 125 एमङ प्रति दिन के औसत के साथ 3.0 एमङ प्रति दिन और 150 एमङ प्रति दिन के मध्य था। वाव तहसील के पश्चिमी भाग में, कच्छ के रण की निकटता के कारण लवणता की समस्या है। लवणता और केलक्रीट क्षेत्र दोनों प्राकृतिक बाधाएँ है। पानी के कटाव के लिए अनुकार माडलिंग से पता चला कि थारड तहसील के पूर्वी भाग और वाव तहसील के दक्षिण और पश्चिमी किनारों में मिट्टी का कटाव मध्यम है। दोनों तहसीलों में 75% से अधिक क्षेत्र वर्षा आधारित फसलों के अन्तर्गत आता है। लवणीय कचरा 12% से अधिक क्षेत्र में फैला हुआ है। चूंकि नर्मदा नहर की वितरिकाओं का संचालन दो तालुकों में हो रहा है, इसलिए नहरी सिंचित क्षेत्र में काफी वृद्धि हो सकती है।

राजस्थान के उत्तरी भाग में भू–आकृतिक मानचित्रण में वातज मूल की भू–आकृतियों का प्रभुत्व पाया गया। अगोलाई में कटाव की प्रक्रिया के तहत् सितम्बर में प्रमुख बारिश की घटनाओं के दौरान तलछट ट्रैप का उपयोग करके चैनल बेडलोड मापा गया। इसी तरह, बेरीगंगा अनुसंधान क्षेत्र में, चैनल में रेतीले चैक डेम और पहाड़ी ढ़लानों पर अर्ध–चंद्र टैरस (200 संख्या) का जल ग्रहणीय क्षेत्र में सुधार करने के लिए निर्माण किया गया। क्षेत्रीय अनुसंधान प्रक्षेत्र, कुक्मा भुज में जल ग्रहण क्षेत्र की ऊँचाई, ढ़लान और घुसपैठ दर के आंकलन के आधार पर मूल्यांकन किया गया। जैसलमेर के दो प्रमुख भू–उपयोग, कृषि भूमि और परती चारागाह भूमि में हवा क्षरित मिट्टी के कटाव का आंकलन किया गया। वानस्पतिक आच्छादन क्षेत्र की निगरानी हेतु मोडिस उत्पन्न एनडीवीआई उत्पादन द्वारा पवन कटाव सेम्पलर का उपयोग किया गया। पीडोट्रांस्फर कार्यो के सत्यापन तथा पश्चिमी भारत की शुष्क कृषिय भूमि की मृदा–जल प्रतिधारण हेतु मृदा–हाइड्रोलिक गुणों का डेटाबेस विकसित किया गया। कृषि योग्य खेती के तहत् 0–90 सेमी मृदा की गहराई तक मृदा जैविक कार्बन मात्रा अधिकतम 16 टन/हे दर्ज की गई।

बाजरा और गेहूँ के संबंध में शुष्क राजस्थान की जलवायु परिवर्तन के संवेदनशीलता विश्लेषण से पता चला कि अधिकतम तापमान का इन फसलों की उत्पादकता पर नकारात्मक प्रभाव पड़ा, जबकि बारिश की मात्रा का उपज के साथ सकारात्मक संबंध था। सभी जिलों में मौसमी वर्षा का उपज के साथ सकारात्मक संबंध देखा गया।

इंदिरा गाँधी नहर परियोजना (द्वितीय चरण) और नर्मदा कमांड क्षेत्र में नहर की सिंचाई के प्रभाव के अध्ययन में, पीएच, विद्युत चालकता और जैविक कार्बन के मूल्य में वृद्धि का पता चला। बीकानेर में भू–उपयोगो का मृदा के भौतिक (बी.डी., पोरोसिटी) और रासायनिक गुणों (ईसी, पीएच और मृदा जैविक कार्बन) पर प्रभाव का मूल्यांकन किया गया।

शीत शुष्क क्षेत्र के लेह जिले के लिए, दीर्घ अवधि के मौसम (1980–2002) और फसली क्षेत्र (2000–2010) के आंकड़ो का विश्लेषण किया गया। दीर्घावधि की वर्षा का औसत 400.93 मिमी है।

तिल में वाष्पोत्सर्जन और उत्पादन संबंधों पर किए अध्ययन में तनाव रहित तिल की फसल का मौसमी वाष्पोत्सर्जन 315 मिमी, उपज 1041 किग्रा/हे के साथ पानी के उपयोग की दक्षता (3.3 किग्रा/हे/मिमी) पायी गई।

लूनी बेसिन के संक्रमणकालीन मैदानों में विभिन्न भू–उपयोग प्रणालियों के अन्तर्गत मृदा गंधक की स्थानिक परिवर्तनशीलता से पता चला की सतही मिट्टी में कुल गंधक मात्रा 51–639 के मध्य थी। उपलब्ध गंधक 6.0 पीपीएम के औसत के साथ 0.6 से 30.3 पीपीएम के मध्य पायी गई।

बुवाई पूर्व बीज उपचार का जीरा की फसल के प्रदर्शन पर प्रभाव के तहत् बुवाई के 14 दिन बाद सिंचाई की अपेक्षा 7 दिन बाद सिंचाई से फसल का उच्च उद्भव सूचकांक, कुल जैव भार और बीज की उपज प्रभावी रूप से अधिक रही।

सेवण आधारित भू–उपयोग में मृदा जैव विविधता के मूल्यांकन से पता चला कि वनीय चारागाह, प्रबन्धित चरागाह पद्धति और नियंत्रित चराई वाले प्राकृतिक घास के मैदान में संदर्भ मृदा की तुलना में अधिकांश मापदंडों के मूल्य अधिक पाये गये।

जैव विविधता संरक्षण और वार्षिक एवं बहुवार्षिक पादप सुधार

सेंक्रस सीलियरिस के दस जीनोटाइप का तीन स्थानों पर परीक्षण किया गया, जिसमें आईएमटीसीसी 10–2 द्वारा जोधपुर में सर्वाधिक हरा चारा (21,322 किग्रा/हे), आईएमटीसीसी 10–8 द्वारा, बीकानेर में (12,809 किग्रा/हे) और पाली में आईएमटीसीसी 10–10 (14,026 किग्रा/हे) प्राप्त किया गया। सात जीनोटाइप के सीवीटी में हरे और शुष्क पदार्थ का सर्वोच्च उत्पादन सीई 08–5 द्वारा क्रमशः 6757.8 किग्रा/हे तथा 1630.8 किग्रा/हे रहा। सेटीजेरस के मामले में, वहाँ आठ आईवीटी में मूल्यांकन प्रविष्टियों के बीच कई महत्वपूर्ण बदलाव किया गया। वीटीसीएस–8 में हरा चारा अधिकतम था, और वीटीसीएस–4 में शुष्क पदार्थ की उपज उच्चतम थी। *लैसियूरस सिन्डीकस* के मामले में, आवीटीएस–7 में हरा चारा अधिकतम (8411.1 किग्रा/हे) और शुष्क पदार्थ उपज जोधपुर में (3228.0 किग्रा/हे), और आईवीटीएस–6 हरा चारा (5600 किग्रा/हे) और जैसलमेर में शुष्क पदार्थ उपज (3050 किग्रा/हे) थी।

बाजरा में, सीजेडएच–218, सीजेडएच–224, सीजेडएच–223, सीजेडएच–221 और सीजेडएच–222 प्रजातियों को अखिल भारतीय समन्वित परीक्षण के लिए भेजा गया। विभिन्न संकर परीक्षणों में अनाज की उच्चतम उपज देने वाली सीजेडएमएस–002ए x सीजेडआई 2004/7 (4429 किग्रा/हे, 54 दिन) एचटी प्रथम् में; सीजेडएमएस–008ए x 2000 सीजेडआई/24 (3057 किग्रा/हे, 52 दिन), एचटी द्वितीय; 841ए x में सीजेडआई 9623ए 4 (3610 किग्रा/हे, 52 दिन), एचटी तृतीय; आइएचटी–106 (5342 किग्रा/हे); आईएचटी में, एएचपीटी–801 (5023 किग्रा/हे) एएचपीटी में प्रजातियाँ थी। आईसीएआर – इक्रीसैट सहयोगी कार्यक्रम में अगेती बी लाईन के तहत, जल्दी परिपक्व होने वाली रेस्टोरर, सीपीबीएलटी की, ए 5 रेस्टोरर लाइन के लिए, उच्च एफई के अर्न्तप्रजनित और मार्कर असिस्टेड प्रजनन परीक्षण किये गए।

मोंठ के, 121 में से 21 जीनोटाइप में बीज की उपज सीजेडएम–1 की तुलना में 37 से 165% अधिक पायी गई। गामा किरणों के उपचार ने दो जीनोटाइप के बीज अंकुरण और उपज मापदंडों को प्रभावित किया। मूंग में, केएम 11–573 जीनोटाइप ने अधिकतम बीज उपज (875 किग्रा/हे) दी। म्यूटेंट सीजेडएम–9, सीजेडएम–11, सीजेडएम–16, सीजेडएम–18, सीजेडएम–25, सीजेडएम–29 और सीजेडएम 34 (677–833 किग्रा/हे की बीज उपज), चेक (365–469 किग्रा/हे) की तुलना में बेहतर पाये गये। सीवीटी के अन्तर्गतं, ग्वार के 11 जीनोटाइप का जोधपुर तथा जैसलमेर में मूल्यांकन किया गया। जोधपुर में जीआर–111 (503 किग्रा/हे) और जैसलमेर में जीआर–101 (1008 किग्रा/हे) सर्वाधिक बीजोत्पादक प्रजाति रही।

मोंठ में, आईसी–311435, आईसी–323451, आईसी–39796, आईसी–39800, आईसी–370508, आईसी–329037, आईसी–329077, आईसी–333212, आईसी–39814, आईसी–39730, आईसी–39778, आईसी–39693, आईसी–39725, आईसी–311400, आईसी–39759, आईसी–311416 और आईसी–39811 लाइने पीतमौजेक वायरस बीमारी से मुक्त पायी गई। ग्वार की 11 जीनोटाइप का मारोथिसियम, पत्ता दाग, बैक्टीरियल ब्लाइट और शुष्क जड़ गलन के प्रकोप का मूल्यांकन किया गया, और सभी जीनोटाइप इन तीनों रोगों से मुक्त पाये गये। धनिया की 22 किस्मों का आणविक करेक्टराइजेशन, नौ आरएपीडी प्राइमरों द्वारा किया गया और बैंडिंग पैटर्न में इंट्रास्पेसिंफिक भिन्नता पायी गई।

जाल (*सैल्वाडोरा ओलाइड्स*) के 24 एक्सेशनों में, जीवितता, ऊंचाई, और डब्ल्यूबीडी की घटनाओं के लिए महत्वपूर्ण विभिन्नता पायी गयी। विभिन्न स्थलों से गुग्गल के 13 जर्मप्लाज्म व्यक्तिगत झाड़ियों से एकत्र किए गए। जीनोटाइप और तना मोटाई ने फुटान को प्रभावित किया। 14 जीनोटाइप की एक तिहाई कलमें, जिन्हें 4 दिनों तक कैलस किया गया था, में 20 सप्ताह के भीतर फुटान देखी गई और धोलावीरा–2, मूलसागर, एसकेएन–2 के मामले में 50% से अधिक कलमें अंकुरित हुई। फुटान वाली कलमों की तना मोटाई गैर–फुटान वाली कलमों से अधिक थी। बीज आकार ने बीज अंकुरण को प्रभावित किया, 10% बड़े और 5% मध्यम और छोटे बीज ही अंकुरित हुए। बीज से तैयार खेजड़ी के 25 वर्षीय पौधों का ऑफ सीजन फूलने/फलने के लिए मूल्यांकन किया गया। वानस्पतिक तौर पर उगाये गये पौधों में अधिक पुष्पन देखा गया। दोनों ही मामलों में पुष्पित वृक्षों की ऊंचाई, कॉलर व्यास और डीबीएच आदि गैर–पुष्पित वृक्षों की तुलना में अधिक पायी गयी। जैसलमेर और बाड़मेर जिलों से एकत्र केर के, पैंतालीस एक्सेशनों में फल और बीज लक्षणों, बीज अंकुरण और पौध मृत्यु में विस्तृत तौर पर विभिन्नता पायी गई।

कुमट और खेजड़ी से पहचाने गये चार राइजोबीयम कल्चरों ने कुमट के दो विभिन्न जीनोटाइप में बीज अंकुरण, जड़ गांठ विकास और पौध स्वास्थ्य को प्रभावित किया। राइजोबीया से उपचारित बीज में बीज अंकुरण कम लेकिन नवांकुरों का जैविक भार अधिक पाया गया, और यह प्रभाव *साइनोराइजोबीयम कोस्टिएन्स* (पीसी–4) के साथ अधिक था। कुमट के राइजोस्फेयर के एक आइसोलट की पहचान *स्टेफाइलोकोकस होमीनिस* के रूप में तथा मूल गांठों से *एस. सहेली* के रूप में पहचान की गयी। इसी प्रकार खेजड़ी के राइजोस्फेयर से *लाइसीनीबैसिलस स्फेरिकस* और *बैसिलस सबटिलीस* तथा मूल गांठों से *एस. कोस्टीएन्स* तथा *एस. सहेली* नामक सूक्ष्म जीवों की पहचान की गयी। अतः पश्चिमी राजस्थान के शुष्क क्षेत्रों से कुमट एवं खेजड़ी के राइजोस्फेयर से जुड़े प्रमुख पीजीपीआर के रूप में *एस. सहेली, एस. कोस्टीएन्स, एल. स्फेरिकस, बी. सबटीलिस* और *एस. होमीनिस* आदि की पहचान की गयी।

इकार्डा के सहयोग से इटली से लाये गये तैंतालीस नागफनी (*ओपंशिया फाइकस इंडिका*) की प्रजातियों में, बीज रहित सेन्टा मार्गहेरिटा बैलिस, रोजा केसल सारडो, रोजा x रोजा–4, पियांटा–25, और ट्रुनजारा रेड सान कोनो, एक जायंट और मिलिटेलो सफेद में 100% जीवितता पायी गयी। हीलिंग ओवर अवधि का, पौधों की ऊँचाई, संख्या और नई पत्तियों का वजन और जीवितता पर प्रभाव पड़ा। चार सप्ताह की हीलिंग अवधि के बाद लगाये गये क्लेडोड्स के जीवित रहने की बेहतर सम्भावना पायी गई। उच्च उपज वाले गूंदा के जीनोटाइप, काजरी जी–2021 और काजरी जी–2025 से क्रमशः 23.5 और 26.5 किग्रा प्रति पेड़ औसत फल उपज प्राप्त हुई और इन्हें किस्मों के रूप में निस्तारण हेतु पहचान की गई। जैसलमेर में तरबूज के पच्चीस चयनों का बीज उपज और संबंधित लक्षणों के लिए मूल्यांकन किया गया। एसकेएनके–138 ने अधिकतम बीज उपज दिया। जैसलमेर में पूरी तरह से संरक्षित, नियंत्रित और खुली चराई के चारागाहों में मौसमी परिवर्तन और विभिन्न मृदा की गहराई का औसत बीज संख्या पर काफी भिन्नता पायी गयी। इनमें 14 पौधे की प्रजातियों की पहचान की गई और सेवन घास के बीज की संख्या अधिकतम थी।

कुक्मा, भुज में क्लाइटोरिया के बीस एक्सेशनों, जंगली मूंगफली की चार प्रजातियाँ (*एरेकिस गलेब्राटा, ए. प्रोस्ट्रेटा, ए. रिजोनी* और *ए. प्युसिला*) और तिल के 51 चयनों का उपज वृद्धि एवं बीजोत्पादन के लिए मूल्यांकन किया गया। क्लाइटोरिया में सूखा चारा उपज 2861–4606 किग्रा/हे और तिल में बीज उपज 32.8–113.1 ग्राम प्रति मी^{2} थी।

जीरा आरजेड–209 किस्म के बीज की अच्छी गुणवत्ता बनाये रखने हेतु भण्डारण पूर्व उपचारों (फंफूदीनाशक, जैव नियन्त्रक, विकिरण तथा विभिन्न भंडारण पात्रों के उपयोग) से ज्ञात हुआ कि वेविस्टिन द्वारा बीज उपचार और टिन कंटेनर में भण्डारण करना बीज अंकुरण और अंकुर स्वास्थ्य के लिये श्रेष्ठ रहता है।

सी. सीलियरिस के तीन जीनोटाइप, काजरी–75, काजरी–2178 और काजरी–2221 में पत्ते काटने का बीज की मात्रा पर महत्वपूर्ण प्रभाव पड़ा लेकिन शुष्क पदार्थ उपज और बीज की शुद्धता पर कोई प्रभाव नहीं पड़ा। काजरी–2221 जीनोटाइप से, अधिकतम हरा चारा, शुष्क पदार्थ और शुद्ध बीज उपज प्राप्त हुआ। बाजरा के खुले परागण वाली किस्म (सीजेडपी–9802) का 60 किग्रा और मोंठ के काजरी मोंठ–2 का 625 किग्रा ब्रीडर बीज तथा काजरी–2 और काजरी–3 के 29.3 किग्रा नाभिक बीज पैदा किये गये। इसके अलावा आईसीएआर मेगा बीज परियोजना और राष्ट्रीय बीज परियोजना के अंतर्गत विभिन्न फसलों के 5170 किग्रा ट्रुथफुली लेबल बीज का उत्पादन किया गया।

एकीकृत शुष्क भूमि कृषि पद्धति अनुसंधान

बाजरा में नाइट्रोजन की अनुशंसित खुराक देने से नियंत्रण की तुलना में 24.6% अधिक उपज प्राप्त हुई। 20 और 40 किग्रा नाइट्रोजन प्रति हेक्टेयर के प्रयोग से उत्पादन 1957 और 1991 किग्रा अनाज प्रति हेक्टेयर प्राप्त हुआ,

जो कि उर्वरक के बिना प्राप्त की गई उपज की तुलना में काफी अधिक था। 40 किग्रा नाइट्रोजन प्रति हेक्टेयर के साथ 5 टन एफवाईएम के प्रयोग से अधिकतम अनाज की उपज (2904 किग्रा/हे) प्राप्त हुई। मृदा जैविक कार्बन, अस्थायी कार्बन, मृदा उपलब्ध फॉस्फोरस और पोटेशियम में 15–30 सेमी की गहराई तक थोड़ी वृद्धि हुई, उसके बाद, गहराई बढ़ने के साथ साथ इन तत्वों में कमी पायी गई।

नाइट्रोजन के विभाजित खुराक में प्रयोग से ग्वार के बीज और पुआल की उपज पर महत्वपूर्ण प्रभाव पड़ा। 10 किग्रा नाइट्रोजन बेसल खुराक के रूप में तथा वानस्पतिक और पुष्पन की अवस्था पर 1% यूरिया का छिड़काव करने से अधिकतम बीज और पुआल उपज दर्ज की गई। ग्वार आधारित फसल प्रणालियों में प्रमुखतः चौड़ी पत्ती वाले खरपतवारों का प्रकोप देखा गया जो कुल खरपतवार वनस्पति का 78% था। घासीय खरपतवार और सेजेज का अनुपात क्रमशः 21 और 1% पाया गया। ग्वार और बाजरा पंक्ति अनुपात (02:01) अर्न्तफसल में अधिकतम बाजरा तुल्यांक उत्पादन (2255 किग्रा/हे) और शुद्ध रिटर्न (रू. 10266) दर्ज किये गये।

बाजरा एवं तुम्बे (मल्च के रूप में) की अत्यन्त घने अर्न्तफसल अनुपात (1:1) की तुलना में केवल बाजरे की खेती में बाजरा का उत्पादन 41% अधिक रहा। फसल एवं तुम्बा (मल्च के रूप में) अर्न्तफसल के विभिन्न अनुपातों में 3:1 के अनुपात के अन्तर्गत ग्वार का सर्वोच्च उत्पादन (14.7%) प्राप्त किया गया।

पलवार (मल्च) और अनुपूरक सिंचाई से बेर के आच्छादन क्षेत्रफल, औसत फल का वजन, औसत फलोत्पादन, कुल घुलनशील शर्करा एवं खरपतवार नियन्त्रण में महत्वपूर्ण सुधार हुआ। जहां काला पॉलिथीन पलवार (मल्च) का प्रयोग हुआ वहां खरपतवार का प्रकोप लगभग नगण्य था। 60 सीपीई पर सिंचाई और पॉलिथीन पलवार के साथ 34 प्रति कि.ग्रा. प्रति पौधा उच्चतम फल उपज दर्ज की गई।

नीम केक और जैव कीटनाशक स्प्रे के साथ संयोजन में देशी खाद के प्रयोग से ग्वार और तिल की उपज में सुधार हुआ। यह सुधार ग्वार की अपेक्षा तिल में अधिक पाया गया। बूंद–बूंद सिंचाई के अंतर्गत ग्रीष्मकालीन भिंडी में 15% अधिक उपज का उत्पादन हुआ और चेक बेसिन सिंचाई की तुलना में 30% पानी की बचत हुई। केचुए वाली कम्पोस्ट खाद (2.5 टन/हे) के उपयोग से फल उत्पादन 5.8 टन/हे) रहा जो देशी खाद (3.5 टन/हे) के उपयोग की तुलना में 68% अधिक रहा।

बूंद बूंद सिंचाई प्रणाली के माध्यम से पानी की आपूर्ति में 1.0 से 0.6 इटीसी में कमी के साथ हरी मिर्च के फलोत्पादन में कमी दर्ज की गयी। खाद के रूप में 50% एनपीके + वर्मीकम्पोस्ट के रूप में 50% नत्रजन देने से अधिकतम फलोत्पादन (821.76 टन/हे) प्राप्त हुआ औसत ग्रेवीमेट्रिक नमी की मात्रा 0.8 इटीसी सिंचाई स्तर पर अधिकतम (11.74%) तथा 0.6 इटीसी सिंचाई स्तर पर न्यूनतम (11.19%) दर्ज की गई जबकि शंकुसूचकांक ने सिंचाई स्तरों के साथ विपरीत प्रकृति दर्शायी।

फोस्फोरस विलायी सूक्ष्म जीवों तथा पादप वृद्धि कारक राइजोवैक्टीरिया द्वारा बीजोपचार करने से क्लाइटोरिया के शुष्क चारा उत्पादन में क्रमशः 20.2% तथा 3.87% की वृद्धि दर्ज की गई। इसी प्रकार सूक्ष्म पौषक तत्वों के उपयोग से भी क्लाइटोरिया में चारा उत्पादन में वृद्धि हुई।

लोह एवं जस्ते के सल्फेट लवण के जलीय घोल का गेहूँ तथा सरसों की पश्च पुष्पन अवस्था में छिड़काव करने से उसकी सान्द्रता तथा फसल आधारित प्रतिक्रिया परिलक्षित हुई। गेहूँ एवं सरसों की फसल को पुष्पन एवं परिपक्वता अवस्था में उच्च तापमान पर रखा गया। पुष्पन अवस्था में इस प्रकार की परिस्थिति में दोनों ही फसलों में पादपजल की कमी तथा परिपक्वता अवस्था में पादप जलीय क्षमता में और भी कमी दर्ज की गई, जो गेहूँ की पत्तियों में कुल घुलनशील कार्बोहाइड्रेट एवं स्टार्च की कमी से संबंधित था। सरसों में तो इसके विपरीत प्रवृत्ति पायी गयी। वानस्पतिक वृद्धि अवस्था में उच्च तापमान पर रखने पर बाजरा एवं ग्वार में उपापचयी प्रक्रियाओं के कारण, बाद की अवस्था में जलीय तनाव प्रदान करने के विरूद्ध तापमान के लिए सहनशीलता देखी गयी। नाइट्रेट रिडक्टेज तथा स्टार्च संचयन के हिसाब से ग्वार में उच्च तापमान का कुप्रभाव अधिक रहा।

सल्फाइड्रिल यौगिकों के प्रयोग से ग्वार में सापेक्ष जल मात्रा, जल क्षमता, झिल्ली स्थिरता, लिपिड पराक्सिडेशन, कुल क्लोरोफिल मात्रा और एंटी आक्सीडेंट एंजाइमों यानी, केटेलेज एस्कॉर्बेट पराक्सिडेज, गुवाईकॉल पराक्सिडेज, सुपरआक्साइड डिस्मूटेज और ग्लूटाथियोन रिडक्टेज की प्रक्रियाओं पर महत्वपूर्ण प्रभाव दिखा।

तीन बहुवार्षिक घास प्रजातियों, *लैसियूरस सिन्डीकस, पैनिकम एन्टीडोटेल* तथा *सेन्क्रस सीलियरिस* में उनके दैनिक प्रकाश संश्लेषण दर में द्विकालिक (बाइमोडल) वितरण की प्रवृत्ति दर्ज की गयी। अर्थात् प्रथम उच्चतम दर

(पीक) प्रातःकाल में तथा द्वितीय उच्चतम दर (पीक) अपराह्न बेला में देखी गयी। घास की प्रजातियों की कायिकीय प्रतिक्रियाओं के परिमाण मोटे तौर पर सूक्ष्म जल वायु के हिसाब से अलग पाये गये।

केवल बाजरा की फसल की तुलना में खेजड़ी के साथ बाजरा के अर्न्तफसल ने उनकी उपज पर अनुकूल प्रभाव दिखाया और बाजरा उत्पादन में 12.8% की वृद्धि हुई, जबकि ग्वार के मामले में ऐसा कोई उल्लेखनीय अन्तर नहीं पाया गया। शुद्ध आय तथा लाभ लागत अनुपात में भी खेजड़ी + बाजरा किस्म आइसीपीटी–8203 (32,290 रुपए, 2.42) और *जिजीफस मोरेसीयाना* + मूंग किस्म एसएमएल–668 (17,555 रुपए, 2.01) सिस्टम में श्रेष्ठतम रहे। लोबिया और पट्टी में घास के साथ *कोलोफोस्पर्मम मोपेन* की ऊँचाई और आच्छादन क्षेत्र अधिक थे जबकि *हार्डवीकिया बिनाटा* का विकास फसल प्रणाली के साथ परिर्वतनशील था।

ग्वार की अन्तर्फसल नींबू और मोपेन के साथ लेने पर नीबू और मोपैन की ऊँचाई अधिकतम पायी गई, जबकि शीशम में यह मूंग की अन्तर्फसल के अन्तर्गत सवीच्च दर्ज की गई। मूंग और ग्वार का विकास और उपज मोपेन के साथ अन्तर्फसल में न्यूनतम थे, जबकि नींबू के साथ सबसे अधिक और उसके बाद शीशम के साथ देखे गये।

गम प्रेरक के प्रयोग के साथ वृक्ष प्रबंधन की विधियाँ कुमट से अरबी गोंद स्त्राव के लिए प्रभावी हो सकती है। तापमान में मामूली गिरावट के परिणामस्वरूप अरबी गोंद उत्पादन में लगभग 30% की कमी आई।

वृक्ष प्रजातियों से गिरी पत्तियों के लिटर में लिग्निन की मात्रा 12.6–13.1% के मध्य रही, जो मोपेन में सर्वाधिक देखी गयी। इन पत्तियों का 2.5 टन प्रति हेक्टेयर की दर से उपयोग करने पर अनुपचारित की तुलना में ग्वार के उत्पादन में प्रभावी वृद्धि दर्ज की गयी।

एक्टिनोमाइसीटीज अथवा फास्फोरिक अम्ल द्वारा सरसों के अवशेषों का उपचार करने से उनके विघटन में वृद्धि दर्ज की गयी। आर्थोफास्फोरिक अम्ल से पूर्व उपचारित सरसों अवशेषों का विघटन अनुपचारित अवशेषों या *एक्टिनोमाइसीटीज* के किसी भी प्रजाति से उपचारित अवशेषों की तुलना में तेजी से हुआ।

ग्वार में *बेसिलस कोएगूलन्स* द्वारा बीज टीकाकरण करने से एसिड फॉस्फेटेज और फाइटेज एन्जाइमो की गतिविधि प्रभावित हुई, *बी. कोएगूलेन्स* फास्फेटेज और फाइटेज का निर्माण करता है जो अनुपलब्ध स्थानीय फास्फोरस स्रोतों से फास्फोरस को लामबन्द कर ग्वार का उत्पादन बढ़ाता है और फास्फोरस का जैविक उर्वरक के रूप में बलुई दोमट मृदा में इस्तेमाल किया जा सकता है। सफेद मूसली के माइकोराजी उपचारित पौधों में अनुपचारित पौधों की तुलना में फसल की क्रान्तिक वृद्धि अवस्था (45 दिन) में सैपोनिन की मात्रा में 25 गुणा तथा फसल कटाई अवस्था में 4 गुणा सुधार देखा गया। कवकीय बाल निर्माण के पश्चात संबंधित घोल से नैनोपार्टिकल उत्पादन हेतु एक नयी तकनीक विकसित की गयी।

एकीकृत भूमि और जल संसाधन प्रबंधन

बेर (*जिजीफस रोटेन्डीफोलिया*) और नीम दोनों ने कम्पोस्ट खाद प्रयोग की स्थिति (5 किग्रा कम्पोस्ट + 2 किग्रा नीम खल) में बेहतर विकास और उत्पादकता दर्शाया। नीम ने बेहतर वृद्धि का प्रदर्शन किया, जबकि बेर ने अधिक फल उत्पादन (116.2 किग्रा/हे) दिया। *सी. सीलियरिस* और *सी. सेटीजरस* के अवह्रासित भूमि पर लगाये गये चारागाह की उत्पादकता वार्षिक घासों के *(एरिस्टिडा* एवं *डैक्टाइलोक्टेनियम*) के प्राकृतिक चारागाह से अधिक थी। भोपालगढ़ के चट्टानी स्थलों पर *सेन्क्रस सीलियरिस* द्वारा अधिकतम चारा उपज (1333 किग्रा/हे) तत्पश्चात् *डी. एनिलेटम* द्वारा (1035 किग्रा/हे) चारा उत्पादन प्राप्त हुआ।

बेरीगंगा के ब्लॉक–I में कुल 23,282 एम^3 का जलीय अपवाह उत्पन्न हुआ जिसको 17.33% चेक बाँध द्वारा रोका गया। पश्चिमी राजस्थान के शुष्क बारानी क्षेत्रों के विभिन्न भू उपयोग प्रणाली के तहत मृदा हाइड्रोलीक गुण डेटाबेस तैयार किया गया, जिसमें मिट्टी के कण का आकार, वितरण, मृदा जैविक कार्बन मात्रा, 0.3 बार और 15 बार में मिट्टी का जल प्रतिधारण, मृदा छनन विशेषताओं, और मृदा की जैविक गतिविधि शामिल रहे। एक उपयोगकर्ता अनुकूलित इंटरफेस जो केवल रेत और क्ले मात्रा के आदानों के साथ मृदा में जल की मात्रा, का शीघ्र अनुमान लगा लेता है, भी तैयार किया गयाा।

नाइट्रोजन की खुराक में 25% की कमी करने से गेहूँ के उत्पादन में प्रभावी कमी दर्ज की गयी। एक अन्य प्रयोग में, खरीफ के मौसम में चारा ज्वार की बुवाई के 60 दिन बाद कटाई से रबी, तारामीरा का उत्पादन ज्वार के 50 दिन बाद कटाई की तुलना में काफी कम हुई। जिप्सम के उपयोग से तारामीरा की उपज में प्रभावी (23.6%) वृद्धि प्राप्त

हुई। कुक्मा भुज में गेहूं, जौ, चना, मटर, सरसों, जीरा, धनिया और मेथी फसलों के लिए सिंचाई पानी की कमी और सापेक्ष अनाज उपज के बीच प्रभावी रैखिक सम्बन्ध पाया गया। अल्प जलापूर्ति के अन्तर्गत क्षेत्र क्षमता से 40% कम जल द्वारा सिंचाई करने पर जीरा उत्पादन में न्यूनतम कमी (86.5%) रही। तत्पश्चात क्रमंशः जौ (24%) तथा मैथी (33%) में कम उत्पादन मिला। गेहूँ और चना नमी में कमी के प्रति अधिक संवेदनशील थे।

पश्चिमी राजस्थान का 50% से अधिक क्षेत्र 1900–2100 मिमी, जबकि लगभग 30% क्षेत्र 1700–1900 मिमी वाष्पोत्सर्जन की रेंज में आता है। तापमान में 1^{o} से. वृद्धि के साथ जैसलमेर में वाष्पोत्सर्जन उच्चतम (96 मिमी) और गंगानगर में न्यूनतम (35.1 मिमी) था। पश्चिमी राजस्थान के 3,164,512 हेक्टेयर के सिंचित क्षेत्र के लिए तापमान में 1^{o} से. की वृद्धि से पानी की अतिरिक्त वार्षिक मांग 1570.9 एमसीएम तक बढ़ेगी।

पशु उत्पादन सुधार और प्रबंधन

भेड़ व बकरियों के आवासन हेतु पूर्व–पश्चिम अभिविन्यास 10 मी. लम्बा, 5 मी. चौड़ा, केन्द्र में 3 मी. तथा किनारो पर 2.5 मी. उँचा) वाले पशु आवास की डिजायन तैयार किया गया। आवास के अन्दर की सूक्ष्म जलवायु में, कुचालक के प्रयोग से बाह्य वातावरण की तुलना में अन्दर का तापमान 4^{o} से. कम होने से सुधार हुआ। दीर्घतर ग्रीष्म तनाव अवधि मार्च के दूसरे सप्ताह से नवंबर के दूसरे सप्ताह के मध्य मापी गयी। सर्वाधिक महत्वपूर्ण तापमान आर्द्रता सूचकांक, 85^{o} से. से अधिक पाया गया, जो अप्रैल के चौथे सप्ताह से अगस्त के प्रथम सप्ताह तक था। पारम्परिक आवास एवं अतिरिक्त सान्द्र आहार तथा उन्नत आवास एवं अतिरिक्त सान्द्र आहार वाले मेमनों की शारीरिक भार वृद्धि पारम्परिक आवास एवं दिन के गर्म भाग में चराई तथा उन्नत आवास एवं दिन के ठण्डे भाग में चराई वाले मेमनों की तुलना में अधिक पायी गयी। पारम्परिक आवास में रहे मेमनों ने सर्वोच्च तनाव अनुभव किया जबकि अन्य समूह के मेमनों ने तनाव के खिलाफ समायोजित करने की कोशिश की।

प्राकृतिक और उन्नत वनीय चारागाह पर भेड़ और बकरी में पोषक तत्वों की उपलब्धता की तुलना करने के लिए एक प्रयोग किया गया। उन्नत वनीय चारागाह में भेड़ और बकरी दोनों का औसत दैनिक शारीरिक वजन बढ़ा। बकरियों में आरडू और नीम के पत्तों की खाद्य के रूप में उच्च स्वीकार्यता और सुपाच्चता का पता चला है, तथापि, शुष्क पदार्थ का सेवन और औसत दैनिक लाभ आरडू के पत्ते खाने वाले पशुओं में अधिक था। मारवाड़ी और परबतसरी बकरियों पर स्टीमिंग अप विभिन्न आवास पद्धति के तहत् किया गया। स्टीम्ड–अप बकरियों ने उन्नत पशु आवास में प्रतिदिन अधिकतम दूध (1.4 किग्रा) दिया और प्रसवोपरान्त रक्त शर्करा उच्चतम स्तर (57.3 मिग्रा/डेसीलीटर) पर थी। सभी पशु प्रसव के आस–पास कीटोसिस के लिए नकारात्मक पाए गए। स्टीम्ड–अप बकरी के बच्चों का जन्म के समय औसत वजन अधिक पाया गया। थारपारकर गायों के समूह को *सेन्क्रस* की चराई व कान्सेन्ट्रेट राशन (बाँटा) पर रखा गया। प्रथम बार प्रजनन की औसत उम्र 46.9 महीने और अधिकतम 10.3 लीटर दूध के साथ औसतन 7.2 लीटर प्रतिदिन दूध प्राप्त हुआ। विलायती बबूल की फलियों से तैयार सन्तुलित कान्सेन्ट्रेट मिश्रण का पशुओं के स्वास्थ्य, विकास और प्रजनन पर कोई प्रतिकूल प्रभाव नहीं पड़ा।

इकारडा परियोजना के तहत पशुओं के प्रवास पैटर्न का अध्ययन करने के लिए राजस्थान के चार जिलों में प्रारंभिक सर्वेक्षण किया गया। बाड़मेर जिले के लोग आमतौर पर गुजरात राज्य और जोधपुर और पाली के लोग प्रवास के लिए पंजाब, हरियाणा, मध्य प्रदेश और उत्तर प्रदेश की ओर जाते है। सामान्यतः पश्चिमी राजस्थान में तीन प्रकार के पशुधन प्रवास, (जिले के भीतर, अर्द्ध प्रवास और स्थायी प्रवास) प्रचलित हैं।

पादप और पशु उत्पाद एवं मूल्य संवर्द्धन

ग्वार पाठा से देखने में अच्छी, अर्द्ध पारदर्शी एलो शेविंग क्रीम और जेल, जिसमें अच्छी गुणवत्ता का साबुन का झाग, मॉइस्चराइजिंग प्रभाव मोजूद थें, विकसित किये गये। शेविंग क्रीम की शैल्फ लॉइफ जेल की तुलना में अधिक पाई गयी। ग्वार पाठे की पत्ती के कचरे से तटस्थ सेलूलोज़ का अंश बायोइथेनाल में रूपांतरण के लिए संसाधित किया गया। 1, 2 और 5% ग्वार पाठा सब्स्ट्रेट से क्रमशः 0.339, 0.672 और 1.133% इथेनॉल प्राप्त हुआ।

गुग्गल से ओलियो गम राल निष्कर्षण के लिए एक तकनीक विकसित और मानकीकृत की गयी। बाड़मेर के अराबा क्षेत्र से लाये गये जाल *(सेलवाडोरा ओलाइडस)* के बीज में वसा की मात्रा 48.84% पायी गयी। लक्षित गाँवों में प्रबंधित विलायती बबूल के फली उत्पादन में 40% की वृद्धि पाई गई। विलायती बबूल की फली पर आधारित सस्ता फीड आटा की प्रौद्योगिकी एनएआईपी के औद्योगिक भागीदारों, जो इसका प्रसंस्करण करके काजरी पशु आहार के ब्रांड

नाम से विपणन कर रहे है, को स्थानांतरित की गयी है। इस उत्पाद के फीड परीक्षणों में, पशुओं के दूध उत्पादन में 15–25% की वृद्धि हुई। इसी तरह बढ़ते बछड़ों के लिए, विलायती बबूल फली पाउडर युक्त फीड मिश्रण तैयार किया गया। इस मिश्रण के परीक्षण में थारपारकर पशुओं के स्वास्थ्य पर कोई नकारात्मक प्रभाव नहीं दिखा। विलायती बबूल पर आधारित सम्पूर्ण फ़ीड ब्लॉक बनाने के लिए एक प्रक्रिया को मानकीकृत किया गया। ग्रामीण क्षेत्रों में सम्पूर्ण फीड ब्लॉक के निर्माण के लिए लघु उद्योग विकास हेतु प्रयास किए जा रहे हैं।

विलायती बबूल के सैप/हार्ट बुड से एक नई प्रक्रिया द्वारा मेस्क्वीटोल निकाल गया जो प्रचलित प्रक्रियाओं की तुलना में आसान था। लक्षित गाँवों के, 60 घर, जो विलायती बबूल से मूल्य संवर्धित व्युत्पन्न उत्पादों पर मूल्य श्रृंखला गतिविधियों की परियोजना में शामिल थे, में औसतन 1388 रूपये की अतिरिक्त औसत मासिक आय प्राप्त हुई। लक्षित गाँवों के ग्रामीणों को भी विलायती बबूल रोपण एवं लकड़ी एकत्रित करने से प्रति माह 750 श्रम दिवस के रोजगार प्राप्त हुए।

बाजरा चोकर, जो आम तौर पर अप्रयुक्त चला जाता है, से पशु आहार बट्टिका तैयार की गयी। केवल गेहूं और बाजरा चोकर के संयोजन से तैयार बट्टिका गेहूं की भूसी से तैयार बट्टिका की गुणवत्ता के बराबर थी। गर्मी के मौसम में रेगिस्तानी पशुओं में आवश्यक पूरक पोषक तत्वों (प्रोविटामिन, कैल्शियम, फास्फोरस आदि) प्रदान करने हेतु लूसर्न (रिजका) पत्तियों से पशु आहार बट्टिका तैयार की गई। इनमें कच्चे प्रोटीन, कुल कार्बोहाइड्रेट और खनिजों की एक अच्छी राशि निहित है। 25–30 किग्रा खनिज ब्लॉक के उत्पादन के लिए एक सरल तकनीक भी विकसित की गई, इससे सामुदायिक चराई वाले पशुधन को दीर्घ एवं सूक्ष्म खनिज तत्वों, और प्रोटीन युक्त नत्रजन सहित विटामिन एवं उफानने योग्य शर्करा का पशु आहार के पूरक के रूप में प्राप्त होता है।

समन्वित नाशीजीव प्रबंधन

दो स्थानीय जैव नियंत्रण कारको *बेसिलस फर्मस* और *ट्राइकोडरमा हरजियानम* से सस्ती एवं आसानी से उपलब्ध खाद आधार उपयोग करके एक नया जैविक सूत्र उत्पाद तैयार किया गया जिसमें दोनों जैविक कारक 120 दिनों तक जीवित रह सकते हैं। उच्च नमी धारण क्षमता (100 और 70%) के द्वारा *बैसिलस फर्मस* की जीविता में आशातीत वृद्धि हुई जबकि *ट्राइकोडरमा हरजियानम* कम नमी (30 और 50%) पर भी बेहतर जीवित रही। क्षेत्र परिस्थितियों में *ट्राइकोडरमा हरजियानम* युक्त विलायती बबूल और खरपतवार संयोजित कम्पोस्ट के ग्वार में उपयोग करने पर (अन्य कम्पोस्टों (नीम, सरसों) और अनुपचारित कन्ट्रोल की अपेक्षा) शुष्क जड़ गलन बीमारी का प्रकोप न्यूनतम रहा।

बाजरा की नोखा लोकल नांमक कल्टीवर, क्रीम रहित दूध (2%) + *ग्लायोक्लैडियम विरेन्स* (0.6%) के संयुक्त बीज उपचार से फसल को जोगिया बीमारी से अधिकतम सुरक्षा (39.3%) मिली जबकि *जी. विरेन्स* द्वारा बीजोपचार तथा मृदा में उपयोग से अपेक्षाकृत कम सुरक्षा मिली। प्रयोगशाला में क्रीम रहित दूध (10%) + *जी. विरेन्स* (0.6%) से उपचारित बीजों में क्रीम रहित दूध (2%) + *जी. विरेन्स* (0.6%) से उपचारित बीजों की तुलना में अंकुरण (62.5%) अधिक था।

बेसिलस एजेड–2 और एजेड–7, जिनमें क्राई-1 एसी जीन होने की पहचान की गयी जो शलभ/तितली समूह के कीड़ों के विरूद्ध प्रभावी हैं, का नोवोबायोसीन और कानामायसीन के उच्च सांन्द्रता पर रखने से 0.001% आवृत्ति की प्रतिरोधी कालोनी प्राप्त की गयी। यह कल्चर अगर माध्यम प्लेट और तरल माध्यम में 42° सेल्सियस तक तापमान बर्दाश्त कर सकते हैं। मूंग की फसलों में 15 दिन के अन्तराल पर 0.25, 0.5 और 1.0% एजाडिरेक्टींन के दो छिड़काव से जैसिड और सफेद मक्खी के प्रकोप में महत्वपूर्ण कमी पाई गयी। उच्च मूल्य वाली फसलों हेतु कृषि पद्धति में बहुवर्षीय पादप (बेर, मेंहदी, और आंकड़ा) जैविक खेती में अच्छी विविधता और लाभप्रद कीड़ों की संख्या वृद्धि में सहायक है।

ग्वार और अमरन्थस फसलों में जुलाई से सितंबर तक मकड़ियों की संख्या में वृद्धि देखी गयी तथा फसल के परिपक्व होने और खरपतवार की पत्तियों के गिरने के दौरान इन की संख्या में गिरावट दर्ज की गयी। अधिकांश बगैर जाल वाली मकड़ियाँ देखी गई और वे नरम शरीर वाले कीड़े पर ही विकसित हुई।

मिर्च के 45 दिन पुराने तथा जड़गांठ सूत्र कृमि (*मेलीडोगाययनी इन्कागनीटा*) द्वारा संक्रमित पौध का *ग्लोमस फैसीकुलेटम* के दो स्तरों (500 और 1000 स्पोर/500 सीसी मृदा) द्वारा टीकाकरण करने पर सूत्र कृमि चेक की तुलना में उपचारित पौध के तनों के ताजा एवं शुष्क भार तथा जड़ों के ताजा भार में महत्वपूर्ण सुधार देखा गया। इसी प्रकार

सूत्रकृमि चेक की अपेक्षा एएम फंफूद द्वारा उपचार का गांठों की संख्या कम करने में महत्वपूर्ण प्रभाव दिखा। *ग्लोमस फैसीकुलेटम* ईनोकुलम के दोनों स्तरों के प्रयोग से जड़गांठ सूत्रकृमि की कुल संख्या एवं उर्वरता को बहुत ही कम कर दिया। यह प्रभाव 1000 स्पोर/500 ग्राम मृदा इनाकुलम से सर्वाधिक रहा।

गमलों में किए परीक्षणों में, *मेलीडोगायनी इन्कार्ग्नीटा* सूत्रकृमि के बढ़ते इनाकुलम स्तरों के परिणाम स्वरूप मिर्च की आरसीएच–1 किस्म पर तने के ताजा और शुष्क भार और जड़ के भार में प्रगतिशील कमी पायी गई। भार में अधिकतम कमी मृदा की 10,000 लार्वा/500 ग्राम मिट्टी पर थी, जबकि इस सूत्रकृमि का क्षति कारक सीमांत स्तर मिर्च की आरसीएच–1 किस्म के लिए 2 लार्वा प्रति ग्राम मृदा था।

गिलहरी में चुग्गा शंकालुता अवधि सजातीय गंध उपचारित बाजरे के चुग्गे के कारण कम तापमान (18–25° से.) पर 20 दिनों से घटकर 8 दिन रह गयी। लेकिन उच्च तापमान पर (28–35° से.), इसी तरह के उपचार से शंकालुता अवधि 13 दिन पायी गई।

इंदिरा गाँधी नहर परियोजना के सिंचिंत क्षेत्रों में मटर, चना और कद्दू सब्जियों में कृंतकों द्वारा क्षति 6–8.5% के बीच थी। कृंतकों ने गेहूं में खेतों की परिधि क्षेत्र में अधिकतम 8.53% तक क्षति पहुँचाई। कुक्मा भुज गाँव में मेडो के नजदीक कपास और गन्ने के खेतों में क्रमशः 3.4% और 13.1% की क्षति हुई। यहाँ पर भारतीय झाड़ी चूहा और भारतीय जरबिल और घरेलू चूहें की प्रमुख कृन्तक प्रजातियाँ थी।

किसानों के खेतों में खजूर (उपजाति बरही) के पौधों में, कृंतक आक्रमण के कारण गम्भीर क्षति हुई जिससे 10% तक पौधे मर गये। इन क्षेत्रों में *टटेरा इंडिका* और *मेरीयोन्स हरियानी* मुख्य कृंतक प्रजातियाँ थी।

काजरी, जोधपुर के केन्द्रीय अनुसंधान प्रक्षेत्र में, भारतीय जरबिल नामंक कृन्तक की संख्या 2005 में 60% से बढ़कर 2011 में 84% हो गयी। पिछले चार दशंकों के दौरान कृन्तकों की विशुद्ध मरू प्रजातियाँ पूरी तरह से प्रतिस्थापित हो गई। इस वर्ष कृंतकों की संख्या सिल्वा क्षेत्र में, 42.16% व बागवानी में, 36.76% और फसल क्षेत्रों/घास में, 21.08% रही।

गैर–पारंपरिक ऊर्जा स्रोत, कृषियान्त्रिकी और शक्ति

प्रति दिन 8.22 लीटर आसुत पानी की क्षमता युक्त एक सौर अलवणीकरण उपकरण बनाया गया। एक सौर ऊर्जा आधारित थर्मल इकाई विकसित की गई जिसको 60° सेल्सियस से अधिक ताप पर तूम्बा तेल को 3–4 घंटे गर्म करके पार एस्टेरिकरण के माध्यम से 25 लीटर जैविक डीजल के उत्पादन का परीक्षण किया गया। पानी से धुंध बनाने के लिए एक फोटोवोल्टिक (पीवी) मिस्टर निर्मित किया गया। जिसका इस्तेमाल एक कोन्सेट टाइप हरित गृह (5.3 मीटर लंबी औरब 4.0 मीटर चौड़ी 33 मी^{3} आयतन) में किया गया। एक उन्नत शीत कक्ष (सतह क्षेत्रफल 5 मी^{2} और आयतन 1.0 एम^3) जिसकी बाहरी दीवारों में छेंद करके वाष्पन क्षेत्र बढ़ाया गया, का परीक्षण किया गया। नये कक्ष में तापमान में अधिकतम कमी 1 घण्टे में प्राप्त की गई जबकि पुराने कक्ष में 2–3 घण्टे लगें। समग्र पी.वी. युक्ति संयन्त्र को ओसाई तथा कृषि उपज को बदली के दिनों में सुखाने के अतिरिक्त रोशनी के लिए भी उपयोगी पाया गया। पीवी थर्मल एकीकृत डिवाइस की लागत मूल्य वापसी की अवधि 2 साल पाई गई।

तीन कूड़ों (छह पंक्तियों) वाली सीड ड्रिल से मोंठ (काजरी–2) एवं मूंग (जीएम–4) की बुवाई करने पर परंपरागत बुवाई की विधि की तुलना में किसानों के खेतों में 17–18% अधिक उपज प्राप्त हुई। एक अन्य उन्नत सीड ड्रिल से बुवाई करने पर बाजरा, मूंग, मोंठ एवं ग्वार की उपज पारम्परिक विधि की तुलना में 12–15% अधिक हुई। एकल स्लॉट उन्नत निराई यन्त्र की क्षेत्र क्षमता 193.4 मी^{2}/घण्टा और निराई सूचकांक 194.6% था, जबकि परंपरागत निराई यन्त्र की क्षेत्र क्षमता केवल 160.5 मी^{2}/घण्टा और निराई सूचकांक 91.8% था।

छिलका रहित बाजरे का आटा (20 दिनों तक) कमरे के परिवेश की स्थिति में (41° सेल्सियस और 60% आर्द्रता) छिलका युक्त बाजरें के आटे की तुलना में कम खराब हुआ, हालांकि, व्यावहारिक रूप से दोनों ही मामलों में फ्रिज में रखे आटों की गुणवत्ता में कोई परिवर्तन नहीं पाया गया।

सामाजिक – आर्थिक जांच और मूल्यांकन

राजस्थान में उदयपुर, बांसवाड़ा, चित्तौड़गढ़, एवं डूंगरपुर जिलों में ऊँट प्रजनन उद्यम का आर्थिक विश्लेषण दर्शाता है कि ऊँट प्रजनन यहाँ का मुख्य व्यवसाय है। मानव श्रम, कुल रखरखाव लागत का प्रमुख मद है। ऊँट में

सामान्यतः होने वाले रोग ट्रिपैनोसोमियासिस (तिबरसा रोग), चेचक (माता), निमोनिया, मांगे, आंत्रशोथ (दस्त) और गर्भपात हैं। ऊँट बछड़े आंत्रशोथ, पिका और चेचक से पीड़ित रहते हैं। औसतन, निश्चित निवेश प्रति घर 4,22,284 रुपए था। एक ऊँट इकाई (21.06 जानवरों) पालन की औसत लागत 1,02,935 रुपए थी। ऊँट उत्पादन 12% की छूट दर पर एनपीवी और बीसीआर मापदंडों के मामले में आर्थिक रूप से व्यवहार्य पाया गया।

नरेगा में जोधपुर जिले में कुल श्रमिक दलों में महिला श्रमिकों का प्रभुत्व पाया गया। अधिकतर नवीकरण और मिट्टी का कार्य किये गये। बजट का 74.0% श्रम मजदूरी पर खर्च किया गया। इसके अलावा, जनसंख्या के वंचित समूह के 65% की आय इसी कार्यक्रम द्वारा हुई।

बीकानेर और जैसलमेर जिलों में रेत टिब्बा खेती के आर्थिक मूल्यांकन के एक अध्ययन में, फव्वारा सिंचाई प्रणाली का उपयोग सभी सिंचाई प्रणालियों में प्रमुख था। प्रति हेक्टेयर लागत एवं आय के आधार पर गेहूं और मूंगफली की खेती के लिए रेतीले टिब्बें और रेतीले मैदान दोनों ही क्षेत्र आर्थिक रूप से व्यवहार्य पाये गये। जैसलमेर जिले में मूँगफली, जीरा, अजवाइन और ग्वार की उत्पादकता टिब्बें की तुलना में मैदानी क्षेत्रों में अधिक पायी गई। बिजली की अपर्याप्त और अनियमित आपूर्ति, सरकारी समर्थन का अभाव और समय से श्रमिकों की अनुपलब्धता आदि प्रमुख बाधाओं में शामिल हैं।

जोधपुर जिले में खाद्य सुरक्षा के आकलन से पता चला है कि 80% परिवारों की दैनिक प्रति व्यक्ति कैलोरी की उपलब्धता पर्याप्त थी। कुल 70% परिवार खाद्य सुरक्षित पाये गये और 30% परिवारों में प्रोटीन की आपूर्ति कम थी।

पाली जिले में खुले कुओं एवं नलकूपो की औसत गहराई क्रमशः 31.5 और 106.3 मीटर थी। 43.2% कुओं और नलकूपों पर विद्युत मोटर पम्प पाये गये। घटते भूजल के प्रभाव के रूप में रबी और जायद की फसलों जैसे, कपास, मिर्च, गेहूं, सरसों, सब्जियों का जीरा, गेहूं, सरसों, इसबगोल द्वारा प्रतिस्थापन हो चुका है। बाजरा, ज्वार, ग्वार और मूंग अब प्रमुख खरीफ फसलें है। जिला स्तर पर, 1982 और 2007 के बीच, जीरा और इसबगोल क्षेत्रफल में निरंतर वृद्धि की प्रवृत्ति देखी गई। किसानों का ज्ञान सूचकांक, खेती तथा फार्म मशीनीकरण के कुशल तरीकें कृषकों की वरीयताओं को इंगित करता है।

प्रौद्योगिकी आकलन और स्थानांतरण

संस्थान द्वारा थार रेगिस्तान के अवह्रासित चारागाहों के पुर्नवसन एवं कृषीय शुष्क भूमि की उत्पादकता के स्थिरीकरण हेतु जोधपुर जिले के भुजावर और रोहिल्ला कलां और जैसलमेर जिले के ब्रहमसर नामक गाँवों में किसानों के खेतों पर कई उन्नत तकनीकों का प्रदर्शन किया गया। इन तकनीकों में किस्मों के सुधार, मृदा और जल संरक्षण, उन्नत निराई यन्त्रों का उपयोग, स्वस्थानीय जंगली बेर पर की उन्नत बेर की बडिंग, कुमट में गोंद प्रेरण, पशु आहार में विटामिन खनिज मिश्रण का अनुपूरण, खराब गुणवत्ता वाले पशु चारे का यूरिया उपचार द्वारा संवर्द्धन और पशु आहार सौर कुकर का उपयोग प्रमुख थें।

इन के अलावा, *जिजीफस मारीशियाना* द्वारा बेर में कलिका प्रस्थापन, करंज, गूंदा, शीशम, अरडू, तथा कुमट वृक्षों युक्त एक वर्षा आधारित खेती – प्रणाली मॉडल विकसित किया गया। किसानों को बीज संग्रह तकनीकों और सेवन चारागाह के विकास के लिए प्रशिक्षित किया गया।

काजरी के गोंद उत्प्रेरण प्रौद्योगिकी को एक बड़ें पैमाने पर अपनाया गया और 2010 के दौरान बाड़मेर, जोधपुर, नागौर, और पाली में काजरी गोंद उत्प्रेरण द्वारा उपचारित पेड़ों की संख्या 22,600 तक पहुँच गई जिसके परिणामस्वरूप 6.7 टन अरबी गोंद का उत्पादन हुआ, जिससे 38 लाख रुपए का राजस्व मिला।

जोधपुर जिले के ओसियाँ तहसील के बींजवाडिया गांव में उन्नत कृषि प्रौद्योगिकियों जैसे उन्नत बीज किस्मों की सिफारिश, बीज दर, बीज उपचार, समय और बुवाई का तरीका, पोषक तत्व और जल प्रबंधन सहित उन्नत कृषि पद्धतियों का प्रसार किया गया। मोंठ (सीजेडएम–3) के बीज की उपज स्थानीय किस्म की तुलना में 210% अधिक थी। ग्वार की, आरजीएम–112 और आरजीसी–936 किस्मों का औसत बीजोत्पादन स्थानीय किस्मों की तुलना में क्रमशः 67. 4% और 60.5% अधिक पाया गया। औसत बीज और अधिक चारा वाली द्विउद्देश्यीय बाजरा की उन्नत किस्म (सीजेडपी–9802) की उपज स्थानीय किस्म की तुलना में 55% और 28% अधिक दर्ज हुई। मूंगफली (गिरनार–2) द्वारा उन्नत पैकेज की प्रथाओं के साथ किसानों की प्रथाओं की तुलना में, 35% से अधिक बीजोत्पादन प्राप्त हुआ।

जीरे की उन्नत किस्म (आरजेड–209) के बीज की उपज स्थानीय किस्म की तुलना में 26.1% अधिक हुई और नीम खली का 400 किग्रा/हे की दर से प्रयोग करने पर उपज में –24.4% की वृद्धि हुई। जैव नियंत्रक मरूसेना द्वारा बीजोपचारित जीरा (आरजेड–209) की उपज में 4.13% की वृद्धि हुई तथा 2376 रूपये का उच्च शुद्ध लाभ मिला।

जीरा और गेहूँ में कृंतक नियंत्रण सफलता जिंक फास्फाइड के साथ उच्च था जबकि ब्रोमाडियोलोन के विष चुग्गा के उपयोग से 4 दिन बाद अपेक्षाकृत कम सफलता मिली। हालांकि इस विष चुग्गा उपचार के दो सप्ताह बाद कृंतक की संख्या प्रभावीरूप से कम हुई। दोनों, तीव्र और मध्यम असर कारक चूहा नाशी विषो के क्रमवार चुग्गा उपयोग द्वारा जीरा और गेहूँ में उपचार के 15 दिन बाद उच्चतम कृंतक नियंत्रण सफलता प्राप्त हुई। इसी प्रकार खरीफ में जिंक फास्फाइड द्वारा कृंतक नियंत्रण सफलता उपचार के 4 दिन बाद बाजरा, मूंग, मोंठ, ग्वार और मूंगफली में 50 से 67,27% थी। मूंगफली में नियंत्रण सफलता (50%) सबसे कम थी और इन अनुप्रयोगों को दोहराने की आवश्यकता थी। विष चुग्गे द्वारा उपचार के कारण विभिन्न फसलों में 8–16% तक अनाज की उपज में वृद्धि हुई।

एफपीएआरपी के अन्तर्गत बिराई, राजाबाद तथा बेनन नांमक गाँवों में गेहूँ, सरसों, जीरे की उन्नत किस्मों के साथ साथ एकीकृत पोषक तत्व प्रबंधन तकनीकों का किसान के खेतों पर क्षेत्र प्रदर्शन लगाया गया। इसके तहत फसल प्रणाली की कुल उत्पादकता में किसानों की प्रथाओं की तुलना में 16 से 38% की वृद्धि मिली। खरीफ के मौसम के दौरान विभिन्न फसलों की अधिक उपज देने वाली किस्मों की उपज में स्थानीय चेकों की तुलना में 14.8–28.12% की वृद्धि दर्ज की गई। अनुशंसित उर्वरक मात्रा का 50% + 50% देशी खाद के एकीकृत अनुप्रयोग से बाजरें की अधिकतम उपज प्राप्त हुई, जो किसानों की प्रथा की तुलना में 38.6% अधिक थी। सभी फसल प्रणालियों में मूंग–जीरा से उच्चतम अतिरिक्त शुद्ध लाभ (24,507 रूपए प्रति हेक्टर) प्राप्त हुआ।

प्रौद्योगिकियों के प्रदर्शनों, प्रशिक्षणों, और क्षेत्र दिवसो के माध्यम से उन्नत तकनीकों को लोक प्रिय बनाने के पश्चात् लाभार्थी किसानों का ज्ञान स्तर एवं अभ्यास खरीफ और रबी दोनों फसलों के लिए उच्च था, जबकि गैर लाभार्थी किसानों का ज्ञान स्तर निम्न से मध्यम के बीच रहा।

इसी प्रकार इन तकनीकों का अंगीकरण स्तर भी मध्यम से उच्च के बीच रहा तथा अधिकांश किसानों ने कथित समय में उन्नत बीज की अनुपलब्धता, कीटनाशक और उर्वरक की उच्च लागत, कम उपज और कम बाजार मूल्य आदि प्रमुख बाधक माना। किसानों द्वारा उद्धृत अन्य समस्याओं में खराब मृदा स्वास्थ्य, मृदा में नमी की कमी, बीज उपचार और पौध संरक्षण के उपायों के बारे में अज्ञानता एवं परिचालन कौशल में कमी आदि प्रमुख रहे।

शुष्क क्षेत्र में अनाज भंडारण के विभिन्न पारंपरिक तरीकों में छनी हुई राख 10% की दर से साफ और सूखे गेहूं के साथ मिलाकर भण्डारण करने से कीटों से अधिकतम संरक्षण (97%) मिला।

संस्थान के कृषि तकनीकी सूचना केन्द्र (एटीक) विभिन्न हितधारकों के लिए प्रभावी ढंग से एकल खिड़की वितरण प्रणाली के रूप में संक्रिय रहा। यहाँ से उन्नत बीज, पौध सामग्री, मूल्य वर्धित उत्पादों, तथा कृषि संबंधित सेवाएँ और विभिन्न प्रौद्योगिकियों की जानकारी प्रदान की गयी। किसानों को मिट्टी और पानी के परीक्षण की सुविधा भी केंद्र पर प्रदान की गई।

महिला सशक्तिकरण और लैंगिक मुद्दों को मुख्य धारा में लाना

महिला श्रमिकों की क्षमता निर्माण के लिए, फसलों और सब्जियों के उत्पादन की उन्नत तकनीकों का प्रदर्शन किया गया। उन्नत प्रथाओं के कारण जोधपुर जिले के उम्मेद नगर गांव में विभिन्न खरीफ फसलों जैसे बाजरा, मूंग और ग्वार के बीज की उपज में 34 से 92% की वृद्धि हुई। कृषि विज्ञान केन्द्र, जोधपुर द्वारा भी महिला कृषको हेतु उन्नत फसल और पशुधन उत्पादन प्रौद्योगिकियों का प्रदर्शन और अन्य प्रसार गतिविधियों का आयोजन किया गया।

महिलाओं के सशक्तिकरण संकेतकों (जैसे, लिंग गतिविधि और निर्णय लेने की रूपरेखा) के आंकलन से परिलक्षित हुआ कि अधिकतर कृषि और पशुधन गतिविधियाँ (70–75%) संयुक्त रूप से की जाती है। निराई, गहाई, एवं ओसाई में महिलाओं की भागीदारी पुरुषों की तुलना में बहुत अधिक पायी गयी। पशुधन उत्पादन के मामले में, महिलाओं ने पशु स्वास्थ्य की देखभाल और उत्पादों के विपणन में कम भाग लिया। विभिन्न घरेलू कार्यो में महिलाओं का योगदान सर्वोच्च (91.67–100%) था। कृषि और पशुधन गतिविधियों से संबंधित निर्णय लेने में पुरूषों का प्रभुत्व देखा गया, जबकि निर्णय लेने में महिलाओं की भागीदारी कम और प्रमुखतः घरेलू मामलों से संबंधित थी।

ABOUT THE INSTITUTE

The Central Arid Zone Research Institute (CAZRI) owes its origin to the Desert Afforestation Research Station, which was established in 1952 at Jodhpur and was upgraded to the Desert Afforestation and Soil Conservation Station in 1957. In order to put appropriate emphasis on arid zone research and development, the Government of India in 1958 sought the advice of an UNESCO expert, Mr. C.S. Christian, upon whose suggestion the Institute came into existence on October 1, 1959. The Institute is a constituent of the Indian Council of Agricultural Research (ICAR), New Delhi.

The Institute conducts multi-disciplinary research to seek solutions to the problems in hot arid zone of the country, covering about 32 million ha area in the states of Rajasthan, Gujarat, Punjab, Haryana, Karnataka and Andhra Pradesh. The cold arid zone, covering about 7 million ha, is located in the states of Jammu and Kashmir, and Himachal Pradesh.

Arid zone, though bestowed with unique resources, has low productivity due to scanty precipitation, high temperature, high wind speed, high potential evapotranspiration and a dominantly sandy terrain with poor soil fertility and low water retention capacity. Increasing population of humans by about 400% and livestock by 200% in last five decades *vis-à-vis* technological break-through has not only induced paradigm shift in the resource use pattern in the region and land productivity, but also put serious strains on the natural resource base, threatening sustainability of the arid ecosystem. The Institute is mandated to address following emerging issues in the changed scenario of arid zone.

Mandate

- To undertake basic and applied research that will contribute to 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 its control, in the form of digital database
- To develop livestock-based farming systems and range management practices for the chronically drought-affected areas depending on livestock species; also aquaculture
- To utilize high and precision technologies in production systems
- To provide scientific leadership and to develop collaboration with State Agricultural Universities, State line departments and other national and international agencies for generating location-specific technologies and transfer of the technologies
- To act as a centre of learning for arid land management technologies
- To provide consultancy and other services for utilizing the available expertise, and to generate financial resources.

Infrastructure

Besides the Institute Headquarters and a Central Research Farm of 241 ha at Jodhpur, CAZRI has four Regional Research Stations at Bikaner (263 ha), Jaisalmer (1331.9 ha) and Pali (454 ha) in Rajasthan, and at Kukma near Bhuj (58 ha) in Gujarat. Five range management and soil conservation areas are located at Chandan (95.1 ha) in Jaisalmer district, Jadan (76.89 ha) in Pali

district, and Bhopalgarh (51.39 ha), Kailana (311.32 ha) and Beriganga (262.68 ha) in Jodhpur district.

Headquarters at Jodhpur is well equipped with laboratories, a research farm, field laboratories and office facilities. A small auditorium (to seat 114 persons), two furnished conference rooms, a museum, an international hostel, one training hostel and one farmers' hostel are the other facilities.

Dr. P.C. Raheja Library has a collection of 21936 books and 56500 back volumes of journals. The library is computerized and renders database and information services to users. It subscribes to 107 Indian journals, 41 foreign journals and two international databases (AGRIS and CABI) on CD ROM from 1975-2011. The ENVIS centre on Desertification publishes a newsletter.

The Institute is a part of the ICAR-wide network of information gathering on human resources. Its computer hub at the Agricultural Knowledge Management Unit is working with the IASRI-developed software PERMISNET. Other softwares, especially for internet bandwidth management, dynamic website and database development and safeguarding the systems from virus, etc., were procured during the year.

The activities of the Institute are guided and reviewed by the Quinquennial Review Team, Research Advisory Committee, Institute Management Committee and Institute Research Council. The following Six Divisions are now in operation:

- Division of Natural Resources and Environment
- Division of Integrated Land Use, Management and Farming Systems
- Division of Plant Improvement, Propagation and Pest Management
- Division of Livestock Production Systems and Range Management
- Division of Agricultural Engineering for Arid Production Systems
- Division of Transfer of Technology, Training and Production Economics

Three Krishi Vigyan Kendras at Jodhpur, Pali and Kukma, Bhuj (with training and residential facilities for farmers) lend additional support to the transfer of technologies and outreach programmes of the Institute. Two All India Network Projects on Rodent and Arid Legumes are also functioning as part of CAZRI.

The financial statement (budget) of the Institute and staff position is given in Table I and II, respectively.

Table I. Budget 2011-12 (Lakh Rupees)

Head of expenditure	Funds allocated		Expenditure	
	Non-plan	Plan	Non-plan	Plan
Establishment charges	3073.41	-	3073.16	-
Wages	27.75	-	27.68	-
Overtime allowance	-	-	-	-
Travelling allowance	15.00	24.00	15.00	24.00
Other charges, including equipment + TSP	262.96	296.00	262.38	295.75
Works, including maintenance	132.00	50.00	131.96	49.95
Total	3511.12	370.00	3510.18	369.70

Table II. Staff position during 2011-12

Post	Number of posts		
	Sanctioned	Filled	Vacant
Director	01	01	-
SCIENTIFIC			
Principal Scientist	16	14	02
Senior Scientist	38	21	17
Scientist	86	52	34
TECHNICAL			
Category-I	187	157	30
Category-II	78	66	12
Category-III	09	08	01
ADMINISTRATIVE			
Class-I	04	04	-
Class-II	57	42	15
Class-III	29	37	+08
SUPPORTING			
Skilled Supporting Staff	279	245	34

Climate

The climate of the region is characterized by highly erratic and sparse rainfall, extreme variations in day and night temperatures and high evaporation. Day temperature in summer reaches 40° to 43°C with peaks up to 45°C or above. Strong wind regime of 8-14 km h^{-1} from April to August, occasionally exceeding 30 km h^{-1}, causes dust storms. Rainfall ranges from 100 mm in the western part of Jaisalmer to about 500 mm to the east of Pali. The potential evapotranspiration is between 1500 and 2000 mm $year^{-1}$. Normal dates of arrival and withdrawal of monsoon are 1st July and 15th September, respectively. Sowing rains during monsoon may occur 15 days in advance or delayed by a month and the withdrawal of monsoon can be as early as by 20 to 25 days. Early, mid-season or late droughts once in three years to consecutive years lead to scarcity and stretching of resources, necessitating higher state assistance.

Soils

Sandy soils associated with dunes and interdunes (typic Torripsamments) occupy about 31% area of arid zone. These soils are deep, fine sandy with uneven relief in a sandy plain. The light brown sandy soils (coarse loamy Calcids) have calcic horizon at 60-70 cm depth and the hardpan soils have petrocalcic horizon at 30-50 cm. These soils are characterized by 85-90% sand, low water retention capacity (50-70 mm m^{-1}) and low fertility status, moderate to severe wind erosion, surface crusting and high water infiltration. In the south-eastern part, medium textured, greyish brown soils (fine loamy Cambids/Calcids) occupy 13.5% area. These soils have medium available water retention capacity (150-200 mm m^{-1}) and better fertility status. High salinity in soil and groundwater are associated with these soils. Other soils (15.7%) include Gypsids, rocky/gravelly and natural salt-affected types, which are very low in organic carbon, low to medium in available phosphorous and high in available potassium.

Land Degradation

Wind erosion of fine sediments and its deposition leading to dune formation pose threat to cultivated areas, pasture lands, residential areas, roads and rail network. Water logging in the IGNP Command area has caused rise in water table at the rate of 0.43-0.83 m $year^{-1}$ while elsewhere, depleting groundwater is an alarming concern. Common property resources are turning into wastelands due to abuse and over-exploitation. Industrial effluents to the ephemeral streams and mine spoils, especially in sandstone, limestone, gypsum and other mining areas, are becoming environmental threats.

Socio-economic Conditions

The human as well as livestock population in hot arid zone of Rajasthan has increased fast during the last few decades. The present population density is 108 persons km^{-2} against 84 persons km^{-2} in 1991. In spite of the Indira Gandhi Canal network, groundwater exploitation and creation of large-scale pipe water supply grids through government efforts, potable water is still scarce over large areas. Acute water and fodder scarcities manifest during the drought years. Illiteracy, low-income opportunities and rural indebtedness, coupled with child marriage and various taboos, are still to be dealt with effectively.

Weather During 2011

The southwest monsoon arrived in eastern districts of Rajasthan on 23rd June while the normal date of monsoon to enter Rajasthan is 15th June. The monsoon reached western parts of Rajasthan by 8th July. However, substantial amount of pre-monsoon rainfall was received in 2nd fortnight of June in Churu (156.8 mm), Sikar (117.4 mm), Jhunjhunu (98.0 mm), Nagaur (55.6 mm) and Hanumangarh (47.4 mm) districts. During first fortnight of July, monsoon remained week in most parts of western Rajasthan and rainfall was low in Ganganagar (11.9 mm), Hanumangarh (14.0 mm), Bikaner (25.5 mm), Churu (29.0 mm), Jodhpur (35.0 mm) and Sikar (39.3 mm) districts during this period. During second fortnight of July, rainfall was low in Jaisalmer (7.9 mm), Ganganagar (17.9 mm) Barmer (24.3 mm) and Hanumangarh (33.1 mm) districts. In August and first fortnight of September, monsoon was very active and rainfall in all the districts of arid Rajasthan was more than normal. As a result, monsoon rainfall during this year was 20.0% (Nagaur) to 89.9% (Churu) higher than normal JJAS rainfall in arid districts of Rajasthan (Table 1, Fig. I). Southwest monsoon withdrew from most parts of Rajasthan by 26th September.

Monthly weather data of six observatories of CAZRI is given in Tables 2-7. January was the coldest month and lowest minimum temperature was recorded on 16th January at Jodhpur (4.1°C), Bhopalgarh (1.0°C) and Pali (0.9°C). At Jaisalmer, Chandan and Barmer minimum temperature reached sub-zero level and lowest minimum temperature was recorded on 24th February at Jaisalmer (-4.0°C), on 7th and 8th January at Bikaner (-3.0°C) and on 1st January at Chandan (-2.5°C). During summer, the highest maximum temperature was recorded on 8th June at Jodhpur (48.3°C), Bikaner (48.5°C), Bhopalgarh (47.9°C) and Pali (47.8°C), on 23rd June at Jaisalmer (48.0°C) and on 15th May at Chandan (49.6°C). During kharif season, first wetting rains were received on 11th July at Pali (49.5 mm), on 15th July at Chandan (24.8 mm), on 16th July at Jodhpur (45.4 mm) and Bhopalgarh (63.2 mm) and on 1st August at Bikaner (140.0 mm). Rainfall during kharif season was normal or above normal at all the six observatories.

Table 1. District average monthly and seasonal rainfall of arid Rajasthan, 2011

District	Month				Total (mm)	Normal (mm)	Departure (%)	Classification
	June	July	August	September				
Barmer	0.0	76.4	208.3	145.6	430.3	243.4	76.8	Excess
Bikaner	11.8	84.4	123.4	92.1	311.7	228.7	36.3	Above Normal
Churu	168.8	101.7	216.0	109.2	595.7	313.7	89.9	Excess
Jaisalmer	4.7	60.8	124.9	98.8	289.2	158.4	82.6	Excess
Ganganagar	12.5	29.8	159.0	127.0	328.3	201.4	63.0	Excess
Hanumangarh	48.5	47.1	141.6	127.5	364.7	252.5	44.4	Above Normal
Jalor	0.0	179.8	288.4	200.4	668.6	394.2	69.6	Excess
Jodhpur	10.4	104.3	158.6	105.6	378.9	274.5	38.0	Above Normal
Jhunjhunu	112.9	122.3	210.6	147.1	592.9	410.0	44.6	Above Normal
Nagaur	64.7	133.7	148.9	71.0	418.3	348.5	20.0	Normal
Pali	21.6	159.9	272.2	176.4	630.1	446.7	41.1	Above Normal
Sikar	122.4	145.0	179.3	120.7	567.4	402.5	41.0	Above Normal

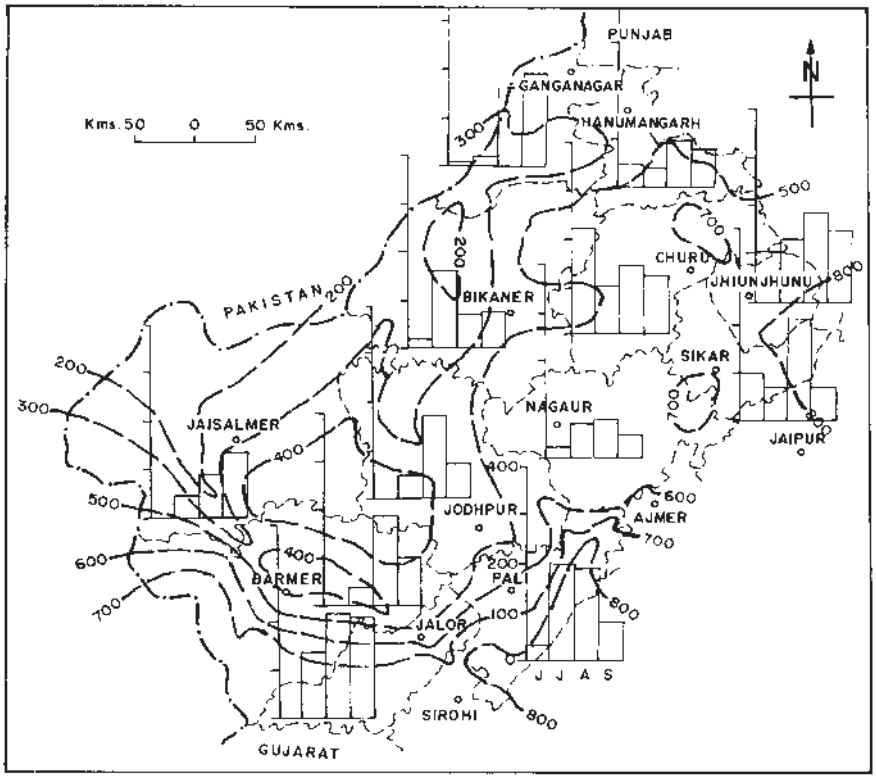


Fig. I. Monsoon rainfall (mm) over western Rajasthan during June-September, 2011.

Weekly variations in rainfall, maximum and minimum temperatures during kharif season at six stations of Indian arid zone are given in Fig. II. Seasonal rainfall was 337.6 mm at Anantpur, 265.7 mm at Bellary, 396.2 mm at Bikaner, 264.8 mm at Jaisalmer, 390.6 mm at Hisar and 305.2 mm at Jodhpur. Rainfall was well distributed at Hisar, but its distribution was erratic at Bellary, Jaisalmer and Anantpur.

Institute Technology Management Unit

The Institute Technology Management Unit was established in 2006 as per the ICAR Guidelines. Its prime objective is the management of IPR portfolio, transfer/commercialization of technologies, and capacity building through training of scientific personnel and technical officials on IPR related issues.

Table 2. Summary of weather conditions at Jodhpur

Month	Rainfall (mm)	Rainy days	Temperature (^{0}C)		Evaporation (mm day^{-1})	RH (%)		Wind speed (km h^{-1})	Sunshine (h day^{-1})
			Max.	Min.		I	II		
January	0.0	0	24.5	9.1	3.4	69	20	2.8	8.6
February	14.8	2	27.5	13.6	4.2	70	29	3.5	8.8
March	0.0	0	35.0	18.4	7.8	47	16	4.1	10.0
April	0.0	0	38.7	22.8	10.4	36	13	4.1	9.8
May	0.3	0	41.4	28.2	13.5	57	22	8.9	10.6
June	0.0	0	41.0	29.8	12.9	60	31	10.1	8.7
July	92.3	5	37.1	27.6	8.2	74	47	7.1	6.6
August	118.8	7	34.0	26.4	4.8	84	63	4.2	5.6
September	93.8	6	32.9	24.0	4.4	88	59	4.3	7.2
October	0.3	0	36.0	19.3	5.9	61	24	2.6	9.5
November	0.0	0	33.2	16.7	4.3	64	25	1.8	8.7
December	0.0	0	27.5	11.8	3.5	62	23	2.6	8.3
Total/Mean	320.3	20	34.1	20.7	7.0	64	31	4.7	8.5

Table 3. Summary of weather conditions at Bikaner

Month	Rainfall (mm)	Rainy days	Temperature (^{0}C)		Evaporation (mm day^{-1})	RH (%)		Wind speed (km h^{-1})	Sunshine (h day^{-1})
			Max.	Min.		I	II		
January	0.0	0	21.3	4.4	4.0	78	33	3.1	7.6
February	13.1	2	26.3	10.9	3.3	76	46	4.5	7.3
March	5.8	1	33.5	16.8	6.3	55	21	5.0	8.8
April	1.0	0	37.8	20.8	11.5	44	15	5.4	8.4
May	13.0	1	43.8	28.2	11.4	41	17	8.8	8.2
June	15.0	1	42.2	30.0	11.4	49	27	9.0	5.9
July	168.2	3	39.4	26.7	7.8	69	41	7.8	7.1
August	86.8	5	36.6	24.9	8.1	80	57	5.8	7.5
September	113.2	4	35.3	24.7	7.6	82	49	6.3	6.5
October	0.0	0	35.2	18.7	7.3	63	33	3.4	9.6
November	0.0	0	32.3	14.2	5.9	67	26	2.0	8.1
December	0.0	0	25.9	5.7	4.0	63	33	2.2	8.0
Total/Mean	416.1	17	34.2	18.9	7.4	64	33	5.3	7.8

Table 4. Summary of weather conditions at Bhopalgarh

Month	Rainfall (mm)	Rainy days	Temperature (^{0}C)		RH (%)		Wind speed (km h^{-1})	Sunshine (h day^{-1})
			Max.	Min.	I	II		
January	0.0	0	24.3	5.4	46	10	2.4	8.6
February	39.2	3	27.4	11.5	54	17	3.4	8.5
March	0.0	0	35.0	16.7	36	12	4.5	9.9
April	0.0	0	38.5	21.3	27	6	3.9	9.2
May	6.6	1	41.8	28.5	46	14	11.1	9.8
June	9.6	1	40.8	30.0	46	22	12.1	7.7
July	129.4	7	36.8	27.5	59	36	8.1	5.8
August	152.6	9	34.0	24.9	67	49	4.5	5.9
September	128.6	7	32.8	22.0	71	46	4.2	7.8
October	0.0	0	35.9	15.9	47	13	2.3	9.8
November	0.0	0	33.3	12.9	45	14	1.2	8.7
December	0.0	0	27.7	7.3	44	11	1.6	8.4
Total/Mean	466.0	28	34.0	18.7	49	21	4.9	8.4

Table 5. Summary of weather conditions at Chandan

Month	Rainfall (mm)	Rainy days	Temperature (^{0}C)		RH (%)		Wind speed (km h^{-1})	Sunshine (h day^{-1})
			Max.	Min.	I	II		
January	0.0	0	25.5	3.1	69	35	1.3	7.1
February	0.0	0	28.2	7.9	66	37	2.1	7.2
March	0.0	0	37.6	13.6	73	23	2.7	8.5
April	0.0	0	41.5	17.7	55	25	4.3	8.6
May	1.0	0	44.4	26.1	61	30	13.3	8.9
June	0.0	0	44.0	28.4	61	27	14.6	7.2
July	48.5	4	43.0	27.3	66	30	10.7	7.2
August	85.5	7	39.1	26.7	75	51	6.9	3.8
September	31.0	4	35.4	24.0	82	61	5.7	4.5
October	0.0	0	38.9	17.0	80	45	2.8	8.5
November	0.0	0	37.0	12.8	66	27	1.2	7.7
December	0.0	0	28.3	4.5	73	37	1.0	7.4
Total/Mean	166.0	15	36.9	17.5	69	36	5.6	7.2

Table 6. Summary of weather conditions at Jaisalmer

Month	Rainfall (mm)	Rainy days	Temperature (°C)		RH (%)		Wind speed (km h^{-1})	Sunshine (h day^{-1})
			Max.	Min.	I	II		
January	0.0	0	23.0	3.1	39	20	4.3	8.0
February	1.0	0	27.2	8.6	53	24	5.9	7.5
March	0.0	0	34.4	15.3	58	40	6.6	8.7
April	0.0	0	37.7	18.3	49	32	8.5	9.4
May	0.0	0	41.5	24.8	65	27	15.7	7.2
June	6.6	1	41.1	27.1	63	37	18.4	N.A.
July	33.8	7	39.2	26.0	67	42	14.3	N.A.
August	109.0	6	36.4	25.2	80	56	11.3	N.A.
September	115.4	5	32.9	23.5	88	63	9.4	N.A.
October	0.0	0	36.0	19.0	70	43	5.6	8.4
November	0.0	0	32.2	14.2	73	47	3.2	8.3
December	0.0	0	25.8	5.0	60	47	3.2	7.8
Total/Mean	265.8	19	34.0	17.6	64	40	9.0	6.4

Table 7. Summary of weather conditions at Pali

Month	Rainfall (mm)	Rainy days	Temperature (°C)		Evaporation (mm day^{-1})	RH (%)		Wind speed (km h^{-1})	Sunshine (h day^{-1})
			Max.	Min.		I	II		
January	0.0	0	25.5	5.9	3.5	77	36	4.0	8.8
February	11.0	1	29.0	12.2	4.2	67	27	5.1	9.0
March	0.0	0	35.8	17.7	7.8	60	39	6.2	9.6
April	0.0	0	39.2	21.7	10.5	52	36	6.3	9.2
May	54.5	3	41.9	27.8	14.5	64	31	12.8	10.6
June	4.7	1	41.0	29.7	13.4	64	38	13.7	7.6
July	191.6	8	36.1	26.9	7.7	80	56	9.6	6.0
August	295.7	10	33.2	25.7	4.9	89	75	5.7	5.9
September	96.7	7	32.4	23.6	4.3	91	70	5.1	6.8
October	0.7	0	35.2	17.4	4.4	73	42	3.1	9.5
November	0.0	0	33.3	14.1	3.5	66	41	2.7	8.9
December	0.0	0	28.6	7.3	3.0	75	41	3.2	8.8
Total/Mean	654.9	30	34.3	19.2	6.8	71	45	6.5	8.4

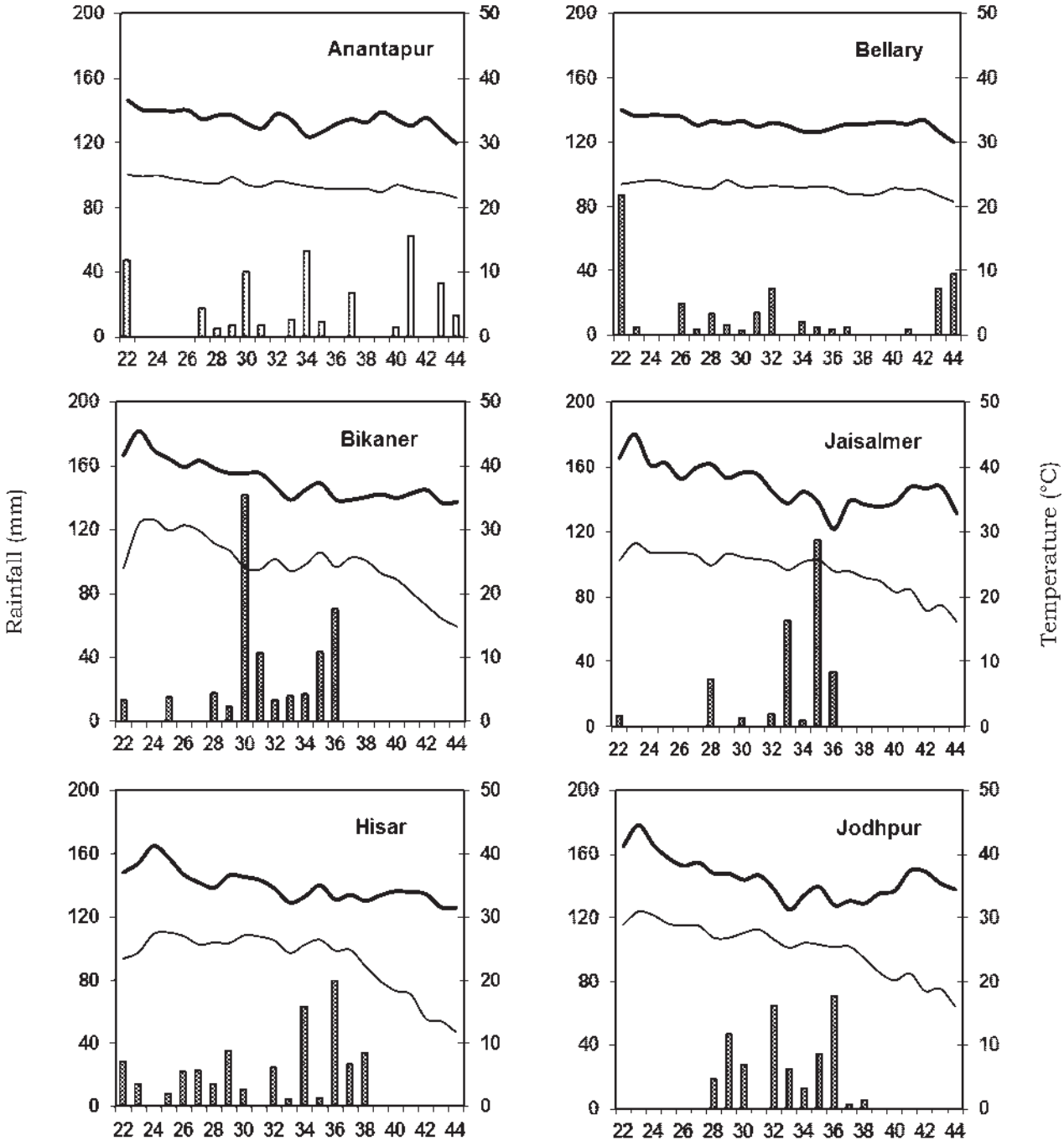


Fig. II. Weekly maximum and minimum temperatures (°C) and rainfall (mm) at representative stations of the Indian arid zone.

INTEGRATED NATURAL RESOURCES APPRAISAL, MONITORING AND DESERTIFICATION

Natural Resources Assessment of Banaskantha District (Tharad and Vav Tehsils)

Landform: The major units in Tharad tehsil are older alluvial plains (58.1%) and sand dunes (29.7%), while in Vav tehsil, the landforms are sandy undulating older alluvial plains (51.9%), older alluvial plains (19.6%), sand dunes (18.6%) and saline depressions or ranns (9.8%) (Plate 1). The terrain beyond Mota Mesra, Tharad, Karbon and Marikha has low to medium (7-12 m) parabolic dunes, some of these landforms are now leveled to flat plains for both rainfed and irrigated crops. The salt ranns/saline depressions dominate the western part of Vav near Dayap-Mafsari-Kundaliya-Rachena-Suigaon-Modhpura sector. The southern part of Vav tehsil has narrow belts of saline depressions near Uchasan-Harshad-Sedav flanked by 7-10 m sand dunes. Older alluvial plains occur in extensive area.

Soil and land capability: Four soil series; Sanchore, Tharad, Rampura and Dune complex have been identified. Medium to fine textured soils of Tharad and Rampura series cover 75-80% area of both the tehsils. These soils are formed on nearly level to gently sloping alluvial plains. The soils of Tharad series are well to excessively drained, light yellowish brown to brown in colour, very deep, weak sub-angular blocky to medium moderate sub-angular blocky in structure, loamy sand to sandy loam in texture and non- to slightly effervescent in reaction. The solum is more than 100 cm deep. Soils of Rampura series are fine textured alluvium, slight to strong in effervescent, dominantly sandy loam to silty clay loam in texture at surface and clay loam at subsurface with mark of stratification. The coarse textured soils of Sanchore and Dune complex constitute 20-25% area. The soils of Sanchore series occur in north and north-western parts of Tharad and Vav tehsils bordering Jalor district of Rajasthan. These soils are well drained with rapid permeability, light yellowish brown to brown in colour, fine sand to loamy sand, non-calcareous with an overburden of loose sand of 10-20 cm thickness with intermittent hummocks of varying heights. Dune soils in north-eastern part of Tharad are devoid of any pedogenic manifestation. The soils are classified under land capability class III c, III c s, IV c s ea, and VI c s ea. The Dune complex soils susceptible to wind erosion are best suited for silvi-pasture and are put under class VI c s ea. Light-textured soils of Sanchore series with hummocky relief are placed in class IV c s ea. Tharad and Rampura soil series are put under land capability class III c s and III c s ea, respectively.

Natural vegetation: In Tharad tehsil, the older alluvial plains had dominance of *Salvadora oleoides* (RIV= 3-8) with *Prosopis juliflora* (RIV= 2-20), *Ziziphus nummularia* (RIV= 1-5). Stabilized dune flanks supported *Acacia jacquemontii* (RIV=6), *P. juliflora* (RIV= 5) and *Z. nummularia* (RIV= 9). *Tephrosia purpurea*, *Capparis decidua* and *Aerva pseudotomentosa* were common on grazing lands. Species richness varied from 18 to 25 with perennials up to 23 and annual to 8. Diversity (H') was 0.86 to 1.89 which is moderate. High evenness index indicated moderately degraded perennial vegetation. Nearly 54% sites were moderately and 45% severely degraded.

In Vav tehsil the alluvial plains had dominance of trees of *S. oleoides* (RIV= 4-19) and *A. nilotica* (RIV= 13-14) associated with *S. persica* and *P. cineraria*. Dominant amongst shrubs were *P. juliflora* (RIV= 42-70) and *C. decidua* (RIV = 4-30). Overall species richness of woody perennials

was 26 and of annuals, 65 on all land uses. Maximum richness was in open scrubs, woody perennials (22) and annuals (58) followed by croplands, water bodies and ranns. Shannon diversity in nearly 70% sites ranged between 0.61 and 1.46 while on rest, it was 1.65 to 1.72, indicating a lower diversity in open grazing lands. Range conditions analysis at 21 grazing lands sites revealed 48% sites had severely degraded vegetation while 52%, moderately degraded. Restoring the condition of vegetation to good silvi-pastoral system would require, land levelling, reseeding with suitable grasses, plantation of MPTS growing shrubs and under shrubs as vegetative barriers and other methods for soil and water conservation especially grassy waterways.

Surface water: Surface water resources in the form of nadis are mostly used for cattle drinking. Some nadis are in good shape and contain water for 7 to 8 months, indicating very little seepage. All the tube wells are electrified and about 80% of the cultivated area is irrigated by sprinkler system. Narmada Canal passes through these two tehsils. Direct lifting of canal water for irrigation by diesel pump set is practiced. In Vav tehsil where groundwater quality is not potable, the government has constructed underground tanka of 25000 litres capacity each, and these tankas are filled through tanker supply from Deesa. Groundwater is falling at a faster rate. Together the tehsils have 952 ponds (Nadis), which store 43.515 mcm water under different capacity ranges (Table 1.1).

Table 1.1. Surface water storage capacity

Tehsil	Large (>50,000 m^3)		Medium (25,000-50,000 m^3)		Small (<25,000 m^3)		Total	
	No.	Vol. (mcm)	No.	Vol. (mcm)	No.	Vol. (mcm)	No.	Vol. (mcm)
Tharad	72	6.548	117	4.467	183	4.575	372	15.590
Vav	108	13.737	143	5.963	329	8.225	580	27.925

Groundwater: Major hydro-geological formations are Quaternary Alluvium comprising of unconsolidated to semi-consolidated sand, gravels, pebbles, boulders and at places clay, in varying proportions. These are mostly windblown sand with fluvial deposits. The occurrence and movement of groundwater in the formation is mainly through significant primary porosity and permeability. About 60% area has deep to very deep (>50 m bgl) groundwater, with an average SWL of 51.09 m bgl (Table 1.2).

Table 1.2. Area under different depth to water below ground level (bgl) in Tharad and Vav tehsils

Depth to water (m)	Area covered (km^2)	Per cent area
<10	224.13	7.34
10-20	333.39	10.92
20-30	180.48	5.91
30-40	225.44	7.39
40-50	329.59	10.80
50-60	559.53	18.33
>60	1200.10	39.31
Total	3052.66	100.00

Water level is deeper in the south and central part of Vav and in southern part of Tharad and decreases towards north and north-west direction. Overall, the average groundwater level is deeper in Tharad (54.6 m bgl) than in Vav tehsil (45.6 m bgl). Quality of the groundwater is largely

brackish to saline with average EC of 4.68 dS m^{-1}. About 96% area has water with EC >2.0 dS m^{-1} (Table 1.3).

Table 1.3. Area under different EC range of groundwater in Tharad and Vav tehsils

EC range dS m^{-1}	Area covered (km^2)	Per cent area
< 2.0	15.78	0.52
2.0-4.0	858.01	28.11
4.0-6.0	1477.93	48.41
6.0-8.0	609.53	19.97
8.0-10.0	75.21	2.46
>10.0	16.20	0.53
Total	3052.66	100.00

Minimum and maximum EC measured in the area are 1.13 dS m^{-1} (at Sidhotara) and 12.23 dS m^{-1} (at Naroli) respectively, with an average of 4.68 dS m^{-1}. The average groundwater quality (Plate 2) is slightly better in Tharad (EC 4.14 dS m^{-1}) compared to Vav (EC 5.54 dS m^{-1}). The groundwater quality deterioration in the area may attribute to presence of higher clay content and clay lenses in the horizons.

During 2007-09, the decline rate of groundwater (Plate 3) is quite high due to insufficient rainfall. The rate of groundwater depletion in Tharad tehsil was 6.10 m yr^{-1} with an average of 2.68 m yr^{-1} during last five years. On the contrary, no water level depletion is reported in Vav tehsil due to poor quality of groundwater. The discharge from the wells in the study area is highly variable. The discharge varies from^{-1} low of <3.0 m^3 day^{-1} to high of 150 m^3 day^{-1} with an average of 125 m^3 day^{-1}. The hydro-geological summary of the two tehsils is given in Table 1.4.

Table 1.4. Hydro-geological summary of Tharad and Vav tehsils

Tehsil	Depth to water (m bgl)			EC (dS m^{-1})			Water level decline (m $year^{-1}$)			Discharge (m^3 d^{-1})		
	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.
Tharad	6.1	137.2	54.6	1.13	12.23	4.13	nil	6.10	2.68	<3	150	125
Vav	5.2	106.7	45.6	2.89	9.75	5.53	nil	nil	nil	<3	150	125

Present land use: Unlike in the eastern arid tehsils of Banaskantha district, >75% area in both Tharad and Vav are under rainfed cropping (Plate 4). Compared to this, double cropped land using groundwater and canal water covers 17% area in Tharad tehsil. Vav tehsil with large area under saline groundwater has only 3% area under irrigation (5014 ha). Despite this dominance of rainfed croplands, the permanent pastures/grazing lands are few: 6% area in Tharad, and 3% area in Vav. Vav tehsil includes 11% of its area under the Great Rann (19310 ha), which is a saline wasteland, but within the mainland of the tehsil, another 1970 ha area (1%) has been identified as saline waste, especially along the fringe of the Great Rann, while 948 ha is under salt pans. Canal irrigated area may increase significantly once the Naramada canal distributaries start operating.

Land degradation: Both Tharad and Vav tehsils have large areas of aeolian sand deposits, in the form of low sandy hummocks and low fence line dunes, intersperse with flat alluvial plains with occasional streams. The aeolian bedforms do not pose any appreciable hazard due to low wind strength and relatively higher rainfall. The agricultural fields fenced mostly with *Euphorbia* and *Prosopis juliflora* thickets resist wind erosion. The western part of Vav tehsil has the problem of natural salinity due to the proximity of Great Rann of Kachchh. A shallow soil with large nodular

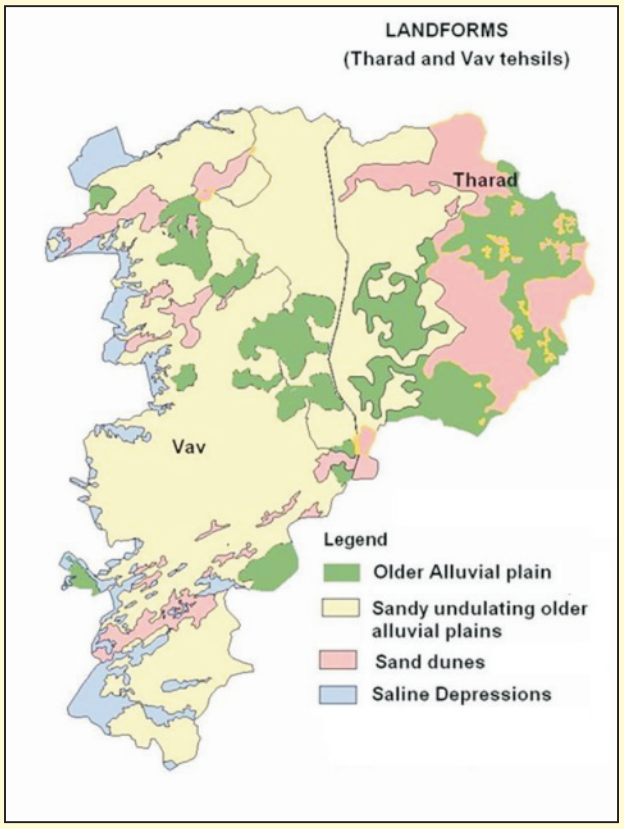


Plate 1. Landforms of Tharad and Vav tehsils.

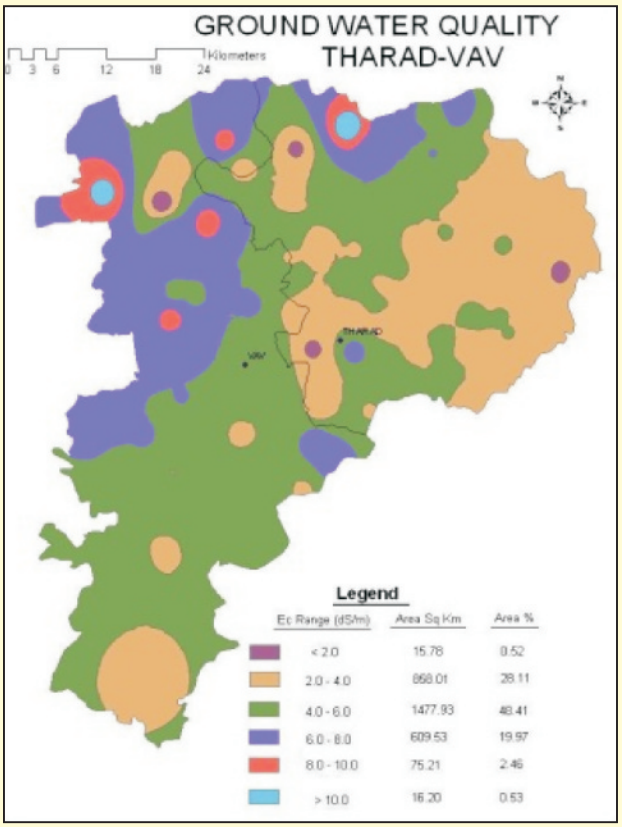


Plate 2. Ground water quality in Tharad and Vav tehsils.

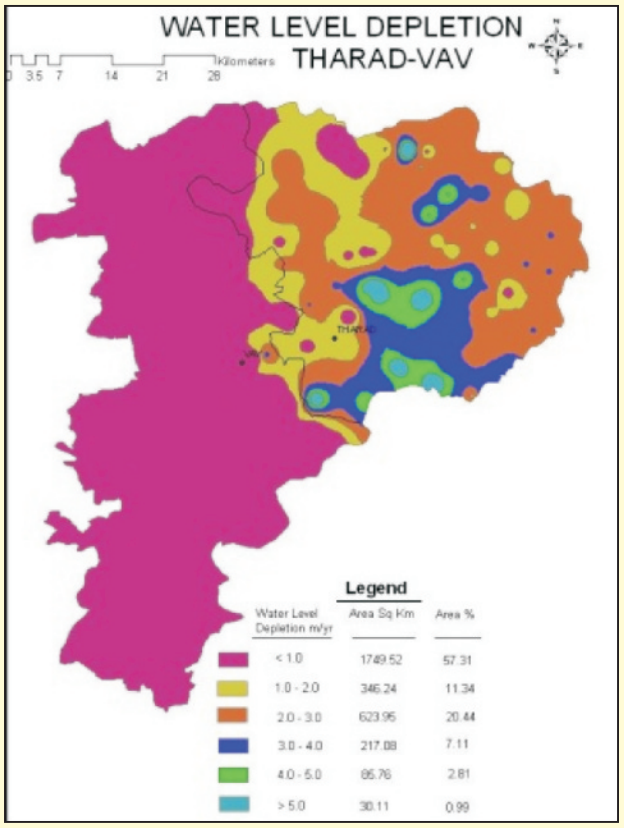


Plate 3. Depletion of ground water in Tharad and Vav tehsils.

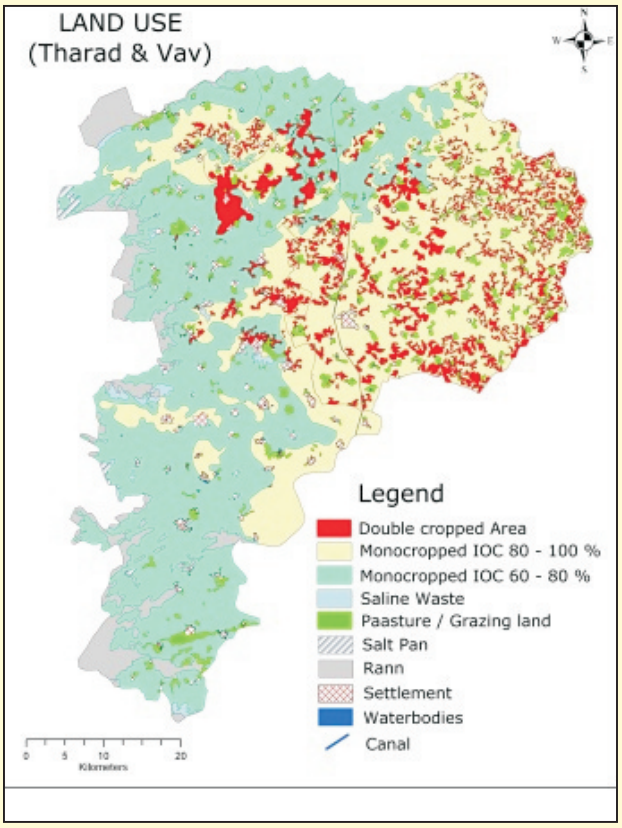


Plate 4. Present land use in Tharad and Vav tehsils.

calcretes due to a shallow water evaporative regime during the recent past adds to the problem. Both salinity and calcrete pans are the natural constraints, and shall remain so till the problems are tackled through irrigation technology mediated agriculture. The other perceived problem is water erosion. Simulation modelling reveals moderate soil erosion potential (5-10 t ha^{-1}) in the eastern part of Tharad tehsil (669 sq. km), and in the southern and western fringes of Vav tehsil (137 sq. km). In the western fringe of Vav tehsil, land is also partly vulnerable to high to severe water erosion (10-80 t ha^{-1}) along the Great Rann fringe due to gullies formed along the land-rann margin. The area thus affected in Vav tehsil covers 79 sq. km. In Tharad tehsil the high soil erosion rate (10-20 t ha^{-1}) is present along the eastern fringe (Plate 5).

Sensitivity Analysis of Climate Variability and Change on Productivity of Pearl Millet in arid Rajasthan

Long-term data (1979-2009) of temperature, average rainfall and district level pearl millet yield of eight districts of arid Rajasthan viz., Barmer, Bikaner, Churu, Ganganagar, Jaisalmer, Jalor, Jodhpur and Pali were used to study crop-weather relationship. In general, maximum temperature had negative effect, while rainfall amount had positive correlation with pearl millet yield. Average maximum temperature for second, third month and entire season had significant negative correlation with yield at Bikaner, Barmer, Jalor, Jodhpur and Pali. Seasonal rainfall had positive correlation with yield in all the districts (0.50 to 0.74), excepting Jaisalmer. Regression analysis of yield with maximum temperature, mean temperature and rainfall accounted for 71% variability in yield at Bikaner, 65% at Barmer, 66% at Churu, 60% at Ganganagar, 48% at Jodhpur, 55% at Jalor and 61% at Pali. Decline in yield ranged from 58.6 kg ha^{-1} (Barmer) to 128.0 kg ha^{-1} (Jodhpur) with each °C higher temperature. In relative terms, the decline in yield with each °C higher temperature was 2.37% at Bikaner, 2.39% at Jalor, 2.55% at Barmer and 2.58% at Jodhpur and Pali.

Impact of Canal Irrigation on Soil Salinity and Water Logging in IGNP-2 and Narmada Command Area

In Bikaner district, about 4.12 lakh ha area is irrigated with Indira Gandhi Canal Project. On the basis of soil survey in the command area in Bikaner, Lunkaransar, Pugal, Khajuwala and Bajju, seven soil series; Lunkaransar, Khajuwala, Charanwala, Badrasar, Shobhasar, Brisalpur and Dune complex series were identified.

The pH values increased by 0.3 to 0.5 units in all the soils. The $CaCO_3$ increased by 1-3% in different soils as compared to non-irrigated fields. Average organic carbon content in the canal irrigated soils (0.103%) was high than the rainfed (0.047%), open scrub (0.070) and dune soils (0.03). This is further attributed to the presence of vegetative cover that prevents loss of SOC from oxidation. The phosphorus content in canal command area, rainfed agriculture and open scrub lands was 8.9, 4.1 and 3.5 kg ha^{-1} respectively. The phosphorus status improved by 117 and 154% in canal irrigated soils over all these soils. Potassium was the highest in open scrub lands (167 kg ha^{-1}) and minimum in canal command areas (142 kg ha^{-1}). About 40-50% samples in canal irrigated fields were below critical limits (<130 kg ha^{-1}). In the command area, about 50-60 samples were deficient in Zn followed by Fe (<4.5 mg kg^{-1}) deficient in 40-50 samples. Soil Biological Quality Index for arthropods (SBQar Index) was higher in canal irrigated fields (22.0) followed by forest soils (20.0), rainfed field (7.0), and was minimum in sand dunes.

About 10-20 ha area was under water logging. Along the main canal from Bajju to Pugal and Mohangarh to Bhikhampur, seasonal water logging (water table less than 1 meter) was observed. Critical area for water logging (water table, 1-1.5 meters) was observed in Bhairupawa and Bhairukhera villages. The pH of the soils varied from 8.7-9.5 and EC from 0.06 to 3.5 dS m^{-1}. Among the cations, Na is dominant and ranged from 40 to 152 (m.e. L^{-1}) followed by calcium 38 to 75 (m.e. L^{-1}). Chlorine followed by sulphate is the dominant anion in the range 15 to 146 m.e. L^{-1} and 12-167 m.e. L^{-1}, respectively. The SAR values ranged from 13 to 38.

Geomorphological and Lineament Mapping in Western Rajasthan

Geomorphological and lineament mapping was carried out in Ganganagar (10978 sq. km), Hanumangarh (9656 sq. km), Churu (16830 sq. km) and parts of Jhunjhunu and eastern part of Bikaner district using IRS-LIII images of three seasons. Major geomorphic units include; sand dunes (dune complex, transverse, parabolic, longitudinal types) and sand sheet classified under landforms of aeolian origin; high and moderately dissected structural and denudation hills, intermontane valleys, valleys, ridges, residual hills, pediments, inselbergs classified under fluvial origin. Lineaments were mapped which were again classified as either geomorphological or structural. GIS based digital database with MDB (geo-database) and FLD (field database) was created. Among the landforms of aeolian origin, dune complex occurred in maximum area (16844.3 sq. km) followed by interdune plains (4144 sq. km) and sand sheet (1069.46 sq. km) while older alluvial plains in 2568.5 sq. km area was dominant of landforms of fluvial origin (Plate 6).

Erosion Process Measurement in Arid Ephemeral Stream Channels

During the year, about 240 mm of rainfall was recorded in Agolai area, distributed in 6 major rainfall events (6 mm, 12.7.11, 12 mm, 19.7.2011, 35 mm, 29.7.2011, 50 mm, 25.8.2011 and 80 mm on 4.9.2011) that enabled quantification of bedload erosion. Bedloads during 4 major rainfall events were measured at upper-middle section (like previous year) and by another additional sediment bed catcher of same dimension (0.90 m x 0.58 m and 1.80 m circumference) installed at the lower section of the channel near a culvert. In the upper-middle section, particles of bigger size (30-40 mm, 40-80 mm and above) dominated the deposits and quantity of sand and gravels was the minimum. In the lower section~98% sediments were sand and <2 mm size. Big boulders of 40 mm and 40-80 mm sizes could not be found (Fig. 1.1). Variation in bedload was not significant between 12th July and 29th July despite having rainfall with higher intensity.

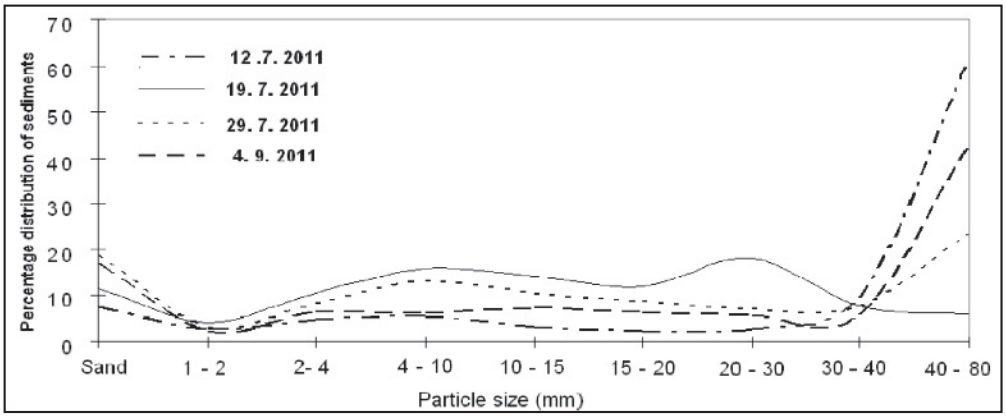


Fig. 1.1. Percentage weight of bedloads collected in upper-middle section of channel at Agolai.

Table 1.5. Measurements at the lower section of the channel from the culvert

Date (Rainfall, mm)	12.7.2011 (12)		19.7.2011 (20)		29.7.2011 (35)	
Particle size (mm)	wt (kg)	% of total	wt (kg)	% of total	wt (kg)	% of total
Sand	503.77	98.14	569.31	78.73	457.99	88.00
1-2	1.51	0.29	29.15	4.03	10.95	2.10
2-4	3.36	0.65	49.78	6.88	19.58	3.76
4-10	2.86	0.56	33.17	4.59	13.31	2.56
10-15	0.39	0.08	23.05	3.19	9.90	1.90
15-20	0.74	0.14	11.06	1.53	5.61	1.08
20-30	0.44	0.09	4.57	0.63	1.98	0.38
>30	0.25	0.05	3.08	0.43	1.10	0.21
	513.32	100.00	723.14	100.00	520.41	100.00

Impact of Weather Variability on Crop Production at Leh and Around Leh in Ladakh

Leh is the largest district in the country with 45,100 km^2 area. Agriculture is the main occupation of the rural people of the district. Barley, locally known as 'grim' is the major food grain crop. Wheat, pulse, oil seeds and other millets are also grown. Cultivated area is irrigated through streams originated from glaciers. Both diurnal and seasonal variation of temperature is very high (from –40°C in winter to 35°C in summer season). Annual precipitation is very low (10 cm) in the form of snow. Snowfall during winter (November to March) is a common weather phenomenon. Only one crop can be grown throughout the year. Barley is sown during mid-May and wheat during last week of April to 2nd week of May. The long term average of precipitation of Leh district for 1980-2002 is 400.9 mm. The highest precipitation (577.6 mm) was recorded in 1990 and the lowest (263.4 mm) in 2000.

Initial analysis of the crop acreage data of Leh during 2000-2010, revealed that the acreage of wheat crop increased during 2003-2007 and a simultaneous decrease in acreage of barley crop. However, during 2007-2009, the cropping pattern again reversed.

Soil Fertility Assessment and Mapping in Arid Region of Rajasthan

Soil samples (432) collected from irrigated, rainfed and grazing lands in Barmer and Bikaner districts using GPS were analyzed and mapped. Results of major nutrient status (Table 1.6) showed wide variability in soil pH. The soils are neutral to alkaline and about 70-90% soil samples had pH more than 8.5 and only 2-5% soils having EC more than 1 dS m^{-1}. There was increase of OC in irrigated soils. Available phosphorus ranged from 1.79-49.2 kg ha^{-1} in Barmer. Available potassium ranged from 62 to 1327 kg ha^{-1}.

Table 1.6. Major nutrients status in Barmer and Bikaner districts

District	Land use(soil Samples)	% OC	Available P kg ha^{-1}	Available K kg ha^{-1}
Barmer	Irrigated (31)	0.04-0.406 (0.125)	1.79-29.2 (8.2)	81.4-821.3 (202.8)
	Rainfed (145)	0.014-0.308 (0.088)	1.2-35.8 (8.7)	90-1327.5 (237)
	Grazing (111)	0.015-0.14 (0.088)	2.05-49.2 (10)	90-675 (225.7)
Bikaner	Irrigated (60)	0.04-0.406 (0.125)	1.79-29.2 (8.2)	81.4-821.3 (202.8)
	Rainfed (50)	0.014-0.147 (0.047)	2.5-8.1 (4.1)	62-393 (142)
	Grazing (35)	0.014-0.320 (0.07)	3.1-8.7 (3.4)	78-573 (167)

Figures in parenthesis are the average values.

Carbon Status in Arid Zone Soils

Organic carbon up to 60 cm deep soil profile was about 8 tons ha^{-1} in area with long term average rainfall of 360 mm y^{-1}. This value decreased to about 6 tons ha^{-1} in area with long term average rainfall of 200 mm. Observations at sites with average rainfall between 360 and 200 mm y^{-1} also supported this trend.

Status of Soil Sulphur, Soil Organic Carbon, Labile Carbon and Soil Biochemical Activities in Transitional Plain of Luni Basin

Geo-referenced soil samples (172) collected from Ahor, Jalor and Sayla tehsils of Jalor district under different land uses i.e., open scrubs (babool, *Capparis* and peelu), pulses, pearl millet, oilseed, and spice based cropping systems (rainfed and irrigated) and agroforestry systems (khejri and peelu) were analyzed.

Soils are alkaline (pH 8.17). The soil organic carbon (SOC) and Labile Carbon (LC) in soil were 2.69 g kg^{-1} and 162.5 ppm, respectively. Dehydrogenase activity and fluorescein diacetate hydrolysis were positively and significantly correlated with LC indicating LC as an important energy source for soil microbial activity in food web. SBQar Index was very low in degraded open scrub areas (0) and rainfed systems (20) in comparison to irrigated (40) as well as agro-forestry systems.

Total sulphur content in surface soil varies widely from 51 to 639 ppm and much of this exists in organic forms. But in surveyed soil, organic sulphur content ranges from 28-423 ppm (40-77% of the total sulphur). The available sulphur varies from 0.6-30.3 ppm with a mean of 6.0 ppm. 63% of soil samples were below 5 ppm available S. With the increase in soil organic carbon content, there is increase in all forms of sulphur.

Forecasting Agricultural Output using Space, Agrometeorology and Land based Observations (FASAL)

The project is a part of the IMD National Network Project to generate crop yield forecast for pearl millet, sorghum, cotton, wheat and mustard. Three approaches viz., statistical relationship between weather and crop yield, simulation models and satellite imagery are proposed to be used for yield forecasting. The CERES-Millet model was tested for our conditions and the simulated yields varied by ± 1-62% of observed yields. Based on statistical models, forecasted yields of pearl millet for Jodhpur during October were 581 and 783 kg ha^{-1}. Similarly, for Pali districts, the corresponding yields of sorghum were 701 and 473 kg ha^{-1}, respectively.

Application of Seasonal Forecasts for Crop Planning and Livestock Management in Arid Rajasthan

Extended Range Weather Forecasts received from IMD/IIT-D, New Delhi for monsoon 2011 were used for crop planning and livestock management in Jodhpur district by preparation of Agro-advisory bulletins for the months of June to September and by disseminating among various users. Verification of the success of extended range weather forecast for western Rajasthan for monsoon 2011 issued in May and the revised forecast issued in June is given in Table 1.7.

Integrated Agrometeorological Advisory Service (IAAS) for Farmers of Arid Rajasthan

Bi-weekly agro-advisory bulletins were issued during kharif and rabi seasons for Barmer, Churu, Jalor, Jodhpur and Pali districts, based on prevailing weather conditions and medium range weather forecast received from IMD. Monthly advisory bulletins were prepared and

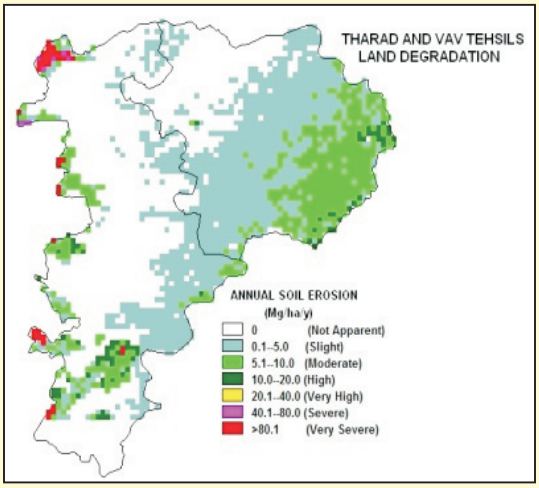


Plate 5. Land degradation in Tharad and Vav tehsils.

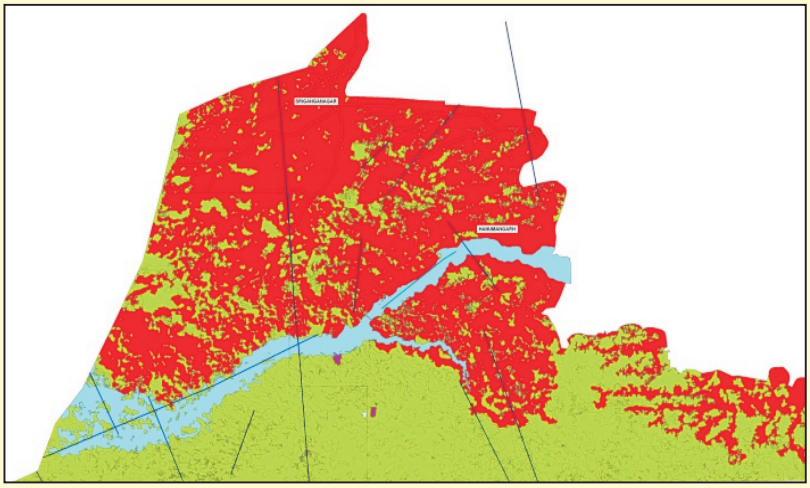


Plate 6. Geomorphology and lineament mapping in north of western Rajasthan.

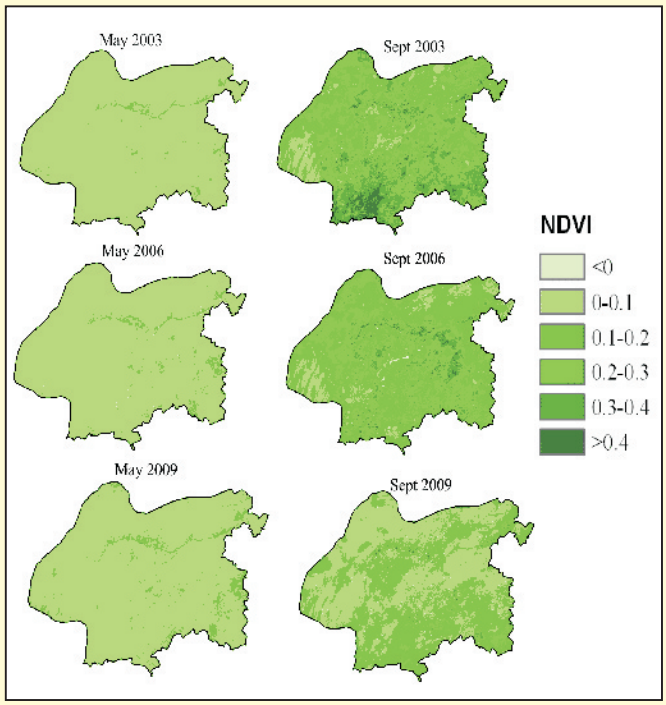


Plate 7. Vegetation coverage change in Jaisalmer district during 2003-2009.

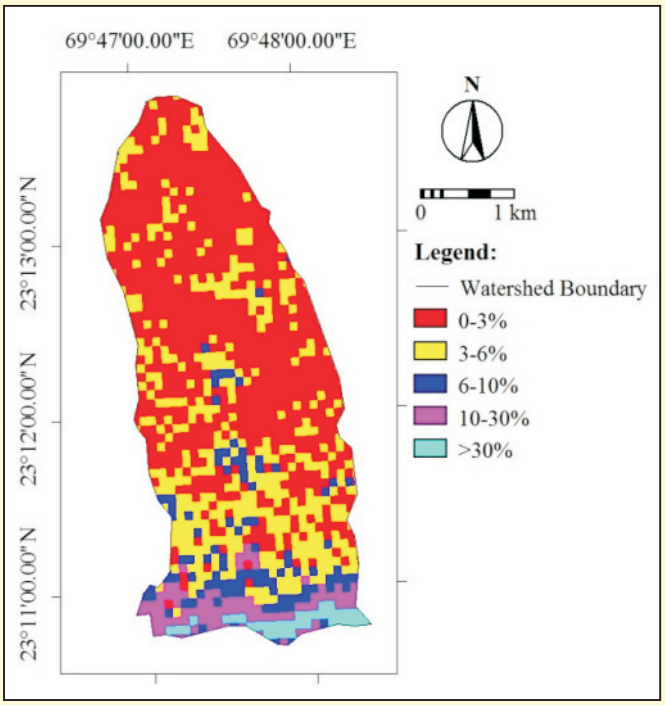


Plate 8. Topographic elevation map of Kukma watershed.

disseminated. The qualitative forecast success for rainfall was 97% during January to March, 92% during summer (April-May), 57% during monsoon (June-September) and 99% during post-monsoon (October-December) season. However, forecast success for maximum temperature ranged from 28 to 39% in different seasons. The success rate of minimum temperature was 27-38%. Forecast success for monsoon season was 34 and 38% in case of maximum and minimum temperatures.

Table 1.7. Verification of seasonal rainfall for kharif-2011 for arid Rajasthan

Month	Observed value (mm)	ERFS predicted value (mm)	Long term normal (mm)	Observed % departure	% departure forecasted in ERFS	Probabilistic forecast issued in ERFS	Observed category
June	45	39.5	31	43.9	27	No signal	Excess
July	88	105.7	120	-27.1	-12	No signal	Deficit
August	150	144.7	110	36.6	31.8	No signal	Excess
September	113	70.7	48	134.5	47.4	No signal	Excess

Soil Biodiversity in Grasslands of Arid Western Plain

Seven *Lasiurus sindicus* based land uses were evaluated on the basis of soil physical, biological and biochemical parameters. The soils were sandy and alkaline in nature with pH range 8.51-8.72. The silvipasture systems (CPI = 2.27; CMI = 1.33, DHA = 9.61; SBQ = 16.67), managed pasture (CPI = 2.09; CMI = 1.12; DHA = 6.67; SBQ = 18.33) and natural grassland with controlled grazing (CPI = 2.65; CMI = 1.07; DHA = 6.39; SBQ = 25.00) have higher values for most of the parameters in comparison to the reference soil (Table 1.8).

Table 1.8. Soil biological and biochemical parameters of *Lasiurus sindicus* based land uses

Land uses	SBQar	Pop	Species	CPI	CMI	DHA
Silvipasture (grass + mopane)	21.0	22.1	7	2.27	1.33	9.61
Managed pasture	21.7	42.4	8	2.09	1.12	6.67
Natural pasture (fenced + controlled grazing)	25.0	38.2	5	2.65	1.07	6.39
Natural pasture (unprotected + over grazing)	16.7	15.3	5	2.24	0.60	4.53
Natural grass from sand dune	16.7	12.7	2	1.77	0.49	1.74
Natural pasture + tree (over grazing)	13.3	45.8	5	2.65	0.65	2.44
Cropped area	16.3	30.5	7	2.11	0.88	4.53
Reference soil				1.00	1.00	5.13

SBQar = Soil Biology Quality Index for microarthropods, Pop = Population of micro arthropods ($102/m^2$), CPI = Carbon Pool Index, CMI = Carbon Management Index, DHA = Dehydrogenase activity (µg TPF g^{-1} soil d^{-1}).

The highest meso-fauna-population was recorded in overgrazed natural grassland + tree followed by managed pasture system. Collembolans were represented by Sminthuridae, Brachystomellidae, Isotomidae and Entomobryidae. The Palaeosomatides, Epilohmanniidae and Rhodocaridae were the dominant mites.

Wind Erosion Assessment

Two sets of wind erosion sampler, each containing four samplers attached to an iron pole at 0.25 m, 0.75 m, 1.5 m, 2.0 m heights were installed to generate database on wind eroded soil loss from two major land uses i.e. agricultural land and fallow pasture land. Vegetation coverage was monitored through MODIS generated NDVI products. Two pre-monsoon (julian day 129 and 145) and two post-monsoon (julian day 257 and 273) NDVI products during each of the year 2003

(normal rainfall), 2006 (surplus rainfall) and 2009 (deficit rainfall) were analyzed. It was found that during the hot summer month of May, the area under NDVI class 0-0.1 is reduced from 98% during 2003 to 95% during 2009 with a simultaneous increase in area under NDVI class 0.1-0.2 from 2 to 5% (Plate 7). This indicates an increase in permanent vegetation in the form of trees as most of the annual herbs and shrubs mostly remain dry during hot summer months. During September, area under NDVI class 0.2-0.3 increased from almost negligible during May to 34-39% during normal or surplus rainfall year but only to 3% during a deficit year.

Energy and Mass Exchange in Landscape

A soil hydraulic property database was generated for validation of the developed pedotransfer functions (PTFs) to estimate soil water retention in arid western India. SOC stock of different land use systems was evaluated with respect to following database (Table 1.9).

Table 1.9. SOC stock of soil profiles under different land use systems in Jaisalmer region

Land use system	Soil depth (m)	SOC stock of soil profile (t ha^{-1})	SOC stock of top soil (t ha^{-1})
Depression area with trees and shrubs	0.9	12.46	0.90
Arable farming	1.0	16.15	2.80
Arable fallow	0.9	12.80	2.18
Deposited sands	0.9	4.87	0.64
Sewan rangeland	0.4	4.44	1.05
Shelterbelts of *Colophospermum mopane*	0.5	13.83	7.03
Grasslands with gravelly soils	0.7	10.69	1.43
Block plantation of *Acacia senegal*	0.9	11.54	1.14
Block plantation of *Acacia tortilis*	0.4	6.41	1.71
Block plantation of *C. mopane*	0.5	7.13	2.57
Block plantation of *Prosopis juliflora*	0.6	8.12	1.14

Highest SOC stock of 16.15 t ha^{-1} in 0-90 cm soil profile was observed under arable farming. The SOC stock in soil profile under tree shelterbelt of *C. mopane* was 13.83 t ha^{-1}. However, the SOC stock of top soil (0-10 cm) was highest under shelterbelt of *C. mopane* (7.03 t ha^{-1}) followed by arable farming (2.80 t ha^{-1}) and block plantation of *C. mopane* (2.57 t ha^{-1}). Further observations on values of soil water retention indicated lower value in topsoil (0-10 cm) than subsurface layers for both at field capacity (0.3 bar) and PWP (15 bar). Results revealed that the specifically developed PTFs for arid western India performed better than established PTFs developed elsewhere in the world.

Land use Effects on Soil Properties in Sandy Arid Plains of District Bikaner

Soil properties of land use systems; cultivated, grazing and woodland (CL, GL and WL) of Lalgarh soil series of district were assessed where soil is sandy skeletal, mixed hyper thermic, and lithic torriorthents.

Physical properties: The Bulk Density (BD) ranges between 1.61 and 1.758 Mgm^{-3}. In general, the BD increases with depth in all land use systems. Averaged across all depths, the BD was highest in CL>GL>WL. Porosity ranged from 36.4 to 40.15% and decreased with soil depth. Averaged over the depths, WL showed higher porosity of 40.15% up to the depth of 45 cm.

Chemical properties: Soil EC varied significantly. For CL and WL, increasing trend was observed except for the depth of 0-15 cm for woodland. EC was highest in GL>WL >CL. Soil pH value ranged from 8.39-8.62 in all land uses. For, 0-15 and 15-30 cm depth, pH was lowest in CL >WL>GL and for 15-45 cm and > 45 cm, pH was lowest in GL>WL>CL.

Soil organic carbon (SOC) decreased with depth. OC ranged between 0.06% and 0.256%. For the surface layer, SOC was highest in WL (0.265%). Averaged across depths, SOC were highest in GL. The total SOC at depth of 50 cm soil profile was maximum (13485 kg ha^{-1}) in woodland, 13409 kg ha^{-1} in grazing land and 11640.25 kg ha^{-1} in cultivated land. The N content in soil decreased with depth, ranges from 0.002% to 0.022%. Averaged across all depths, GL has 17.1% higher nitrogen over cultivated land. The available P content decreases with depth. GL has highest available P of 16.24 kg ha^{-1} at 0-15 cm. Average across 0-30 cm depth, GL has 11.42% higher P_2O_5 over CL. K_2O ranged from 153 to 303 kg ha^{-1} average across all depths and decreased with depth. Highest K_2O content 303 kg ha^{-1} was present in GL system at 15-30 cm depth. Dehydrogenase activity in soil was highest in woodland soil 6.38 p kat g^{-1} soil, followed by 6.33 and 5.21 p kat g^{-1} in grassland and cultivated land, respectively.

Preparation of Topographic Elevation and Slope Maps

Using SRTM DEM data, two maps showing topographic elevation and slope distribution were prepared for the watershed at Kukma. About 6.76 km^2 or 65% of the watershed is 100-150 m MSL existing in middle and downstream. The resulted slope map was classified into five classes (Plate 8). Surface slope is also the highest (>30%) in the south, due to hills compared to rest of the watershed. Majority of the watershed area (8.84 km^2 or 85%) has slope ~ 6%.

Infiltration Rate from Submergence Area of Farm Pond at Bhuj

Double ring infiltrometers were used to conduct infiltration tests at three sites in submergence area of farm pond in Bhuj. The infiltration tests were conducted for 7, 8 and 9 hours. Infiltration rate was zero at most of the time, and were determined as 0.1, 0.2 and 0.05 cm h^{-1}. The very low infiltration rates indicate that percolation rate from the bottom of the farm pond is insignificant in comparison to other components of the water balance model.

BIODIVERSITY CONSERVATION AND IMPROVEMENT OF ANNUALS AND PERENNIALS

IMPROVEMENT OF PASTURE GRASSES

Cenchrus ciliaris

Ten genotypes were evaluated at Bikaner, Jodhpur and Pali for green fodder yield (GFY), dry matter yield (DMY), plant height and leaf stem ratio. IMTCC-10-2 at Jodhpur, IMTCC-10-8 at Bikaner and IMTCC-10-10 at Pali were the highest yielders for green and dry forage (Table 2.1).

Table 2.1. Forage yield of 10 genotypes of *C. ciliaris* at different locations

Entry code	Bikaner		Jodhpur		Pali	
	GFY (kg ha^{-1})	DMY (kg ha^{-1})	GFY (kg ha^{-1})	DMY (kg ha^{-1})	GFY (kg ha^{-1})	DMY (kg ha^{-1})
IMTCC-10-1	8656	5702	20200	3858	13379	3654
IMTCC-10-2	12283	7896	21322	4809	9442	3240
IMTCC-10-3	9943	6580	13437	4058	9166	3159
IMTCC-10-4	10616	7925	11272	3245	12438	3092
IMTCC-10-5	10089	6580	17514	3332	10003	2789
IMTCC-10-6	12049	7808	15319	3142	11823	3146
IMTCC-10-7	9504	7311	21161	4475	10524	3151
IMTCC-10-8	12809	7984	11394	2937	10929	2884
IMTCC-10-9	12136	7311	14256	3830	11562	3154
IMTCC-10-10	7019	4533	10900	3928	14026	4152
CD (5%)	1487	1437	3703	1065	1172	328

In another trial (3rd year) CAZRI 426 recorded maximum dry matter yield (2381.4 kg ha^{-1}) followed by CAZRI 541 (2348.7 kg ha^{-1}), CAZRI 231 (2163.2 kg ha^{-1}) and CAZRI 558 (2159.3 kg h^{-1}). In a coordinated varietal evaluation trial (4th year) consisting of 6 genotypes, significant variation was recorded for dry matter yield kg ha^{-1}/day and plant height. Entry CE 08-5 was the most promising entry. It had maximum plant height (110.0 cm), highest green fodder (6757.8 kg ha^{-1}) and dry matter (1630.8 kg ha^{-1}) yield and per day productivity (110 kg ha^{-1} green fodder and 24.7 kg ha^{-1} dry matter).

Cenchrus setigerus

Initial varietal trial of eight entries established during 2010 was evaluated for forage yield and related traits, and there was no significant variation. VTCS-8 had maximum green fodder (12655.6 kg ha^{-1}), and VTCS 4 had highest dry matter yield (3221.7 kg ha^{-1}).

Lasiurus sindicus

Among the seven genotypes evaluated for fodder yield at Jodhpur, IVTS-7 had maximum green forage (8411.1 kg ha^{-1}) and dry matter yield (3228.0 kg ha^{-1}) followed by IVTS-6 (8133.3 kg ha^{-1}, 3151.0 kg ha^{-1}). At Jaisalmer, IVTS-6 showed the maximum values for green fodder (5600 kg

ha^{-1}), dry matter yield (3050 kg ha^{-1}) and productivity (71.5 kg ha^{-1} d^{-1} for green fodder and 38.9 kg ha^{-1} d^{-1}) during second year of establishment.

Maintenance of germplasm and seed production: Among fifty eight accessions of pasture grasses maintained and evaluated, CAZRI 2170 had maximum green fodder yield (26083 kg ha^{-1}) followed by CAZRI 2221 (25517 kg ha^{-1}) and CAZRI 223 (25267 kg ha^{-1}). From twenty five accessions of *C. ciliaris* re-planted during 2011, CAZRI 355 had maximum green fodder yield (3711 kg ha^{-1}).

PEARL MILLET IMPROVEMENT

Male sterile line maintenance and development: Eighty-five BC_3 progenies were developed. Six BC_3 progenies, had similarity with their maintainers and were identified as new male sterile lines, CZMS 0017A to CZMS 0022A. Seed of thirteen male sterile lines of pearl millet was multiplied by crossing A lines with their corresponding B lines.

Evaluation of CAZRI male sterile lines: Sixteen male sterile lines developed at CAZRI were evaluated along with MS lines from ICRISAT as checks. Significant variability was observed for various traits. The lines, which were better than checks, were CZMS 0008A, CZMS 0015A and CZMS 0013A for grain yield, and CZMS 0016A, CZMS 0009A and CZMS 0010A for early flowering.

Development of inbreds: From 508 promising progenies in advanced breeding material seven new inbred lines were identified and were named CZI 2011/1 to CZI 2011/7. These inbreds will be utilized in crossing programme for developing new hybrid combinations.

Inbred line trial: Among 51 inbred lines, CZI 2000/14, CZI 2010/14, CZI 2004/7, CZI 2007/13 and CZI 2010/3 were high yielders, while CZI 9621, CZI 2000/14, CZI 2004/6, CZI 2010/13 and CZI2004/7 were early flowering. CZI 2000/14 was the most promising for early flowering and yield.

Development of new hybrid combinations: Three hundred fifty four new hybrid combinations were made by crossing 31 ms lines with CAZRI inbreds. Five hybrids were contributed to All India Coordinated trials for 2011 for evaluation in IHT.

Hybrid Trials

Hybrid trial-I: Forty-one experimental hybrids along with three checks (GHB 538, ICMH 356, and HHB 67) were evaluated for grain yield. The range was 2128 kg ha^{-1} (HHB 67) to 4423 kg ha^{-1} (GHB 538) for checks and 1331 kg ha^{-1} to 4299 kg ha^{-1} for the hybrids. CZMS 002A x CZI 2004/7 (4429 kg ha^{-1}, 54 days) was the highest yielder followed by CZMS 001A x CZI 2008/7 (3299 kg ha^{-1}, 47 days) and CZMS 005A x CZI 2007/7 (3288 kg ha^{-1}, 49 days).

Hybrid trial-II: Forty three hybrids were evaluated along with checks GHB 538, ICMH 356 and HHB 67. CZMS 008A x CZI 2000/24 (3057 kg ha^{-1}, 52 days) was the highest yielder and statistically at par with the highest yielding check GHB 538 (3302 kg ha^{-1}, 51 days).

Hybrid trial-III: Grain yield of forty seven hybrids ranged between 1251 to 3942 kg ha^{-1}. 841A x CZI 9623A4 (3610 kg ha^{-1}, 52 days) was the most promising fertile hybrid followed by 89111A x CZI 2008/8 (3553 kg ha^{-1}, 53 days). Early maturing hybrid 841A x CZI 2002/3 (3293 kg ha^{-1}, 48 days) recorded significantly higher grain yield over earliest check HHB 67.

CAZRI advance hybrid trial: Forty one hybrids, selected from 2010 hybrid trials were re-evaluated in 2011 alongwith three checks. GHB 538 (3900 kg ha^{-1}, 50 days) was the highest yielding check while HHB 67 was the earliest check (3078 kg ha^{-1}, 47 days). Grain yield in hybrids ranged from 1558 to 4024 kg ha^{-1} and 92777A x CZI 2004/7 (4024 kg ha^{-1}, 49 days) was the highest grain yielder

Coordinated Trials

Initial hybrid trial-I (IHT-I): Sixteen hybrids were evaluated. IHT 106 (5342 kg ha^{-1}) was the highest grain yielder, followed by IHT 115 (4939 kg ha^{-1}) and IHT 107 (4595 kg ha^{-1}). IHT 103, IHT 105 and IHT 111 were the earliest to flower (44 days).

Advance hybrid and population trial (AHPT): Eleven entries (hybrids and varieties) were evaluated. AHPT 801 was the highest grain yielder (5023 kg ha^{-1}) and flowered in 49 days. Other high yielding entries were AHPT 809 (4887 kg ha^{-1}, 53 days) and AHPT 808 (4560 kg ha^{-1}, 49 days).

Performance of CAZRI, hybrids in Coordinated Trials: Two hybrids based on their performance in IHT have been promoted to the AHPT (Table 2.2).

Table 2.2. Performance of hybrids in coordinated trials

Hybrid	Grain yield kg ha^{-1}	Per cent increase over	
		HHB 67(I) (1640 kg ha^{-1})	ICMH 356 (1952 kg ha^{-1})
93333A x CBI 832 (MH 1695)	2225	35.6	13.9
93333A x CBI 834 (MH 1696)	2195	33.8	12.4

Contribution to the coordinated trials: ICMA 98222 x CZI-2004/7 (CZH-218), ICMA 96666 x CZI 2008/8 (CZH-224), ICMA 92777 x CZI 2004/7(CZH-223), CZMS 4A x CZI 2000/13(CZH-221) and ICMA 88004 x CZI 2008/8 (CZH-222), new hybrid entries were contributed to the IHT for kharif 2011 (Plate 9).

ICRISAT trials: Under ICAR-ICRISAT collaborative program, seven ICRISAT trials, viz., early B line trial (22 entries), early maturing restorer trial (40 entries), CPBLT trial (22 entries), A5 Restorer line trial (25 entries), High Fe inbred trial (44 entries) and two MAB (Marker Assisted Breeding) trials were conducted. Seed and soil samples collected from the High Fe trials were sent to ICRISAT. Thirty-three promising progenies were selected for use in breeding programme.

Seed multiplication: Sixty kg breeder seed of open-pollinated variety CZP 9802 was multiplied in isolation. Besides this seed of CZP 923, CZP 2K-3, CZP 2K-9 and CZP 9603 were also multiplied by hand sibbing.

Development of a new population: A new pearl millet open-pollinated variety, CZP 2K-11 was developed by intermating promising dual purpose progenies selected from promising breeding material and selection from germplasm.

GENETIC IMPROVEMENT OF CLUSTERBEAN, MOTH BEAN AND MUNG BEAN

Germplasm evaluation in moth bean: Evaluation of 112 accessions of moth bean showed wide variation for days to first flower (27 to 77), plant height (21.7 to 57.0 cm), main branches per plant (2.0 to 10.3), pods per plant (10.7 to 130.0), 100-seed weight (1.4 to 2.8 g) and seed yield per plant

(0.14 to 2.36 g). Twenty-one accessions had 37 to 165% more seed yield than CZM-1. Maximum seed yield was given by IC-39756 followed by IC-39728 and IC-39755.

Effect of gamma rays on moth bean: Seed of CAZRI Moth-2 and RMO-225 were irradiated with four doses of gamma rays. The higher doses progressively reduced the germination and increased seedling mortality compared to control (Table 2.3). On an average, maximum fall in germination (33.4%) over control was recorded at 44 kR dose. Maximum seed yield (1.85 g plant^{-1}) was recorded in CAZRI Moth-2 with 33kR.

Table 2.3. Effect of gamma rays on seed germination, seedlings mortality and seed yield in M_1 generation

Dose (kR)	Germination (%)		Seedling mortality (%)		Pods/plant		Seed yield/plant (g)	
	CAZRI MOTH-2	RMO-225	CAZRI MOTH-2	RMO-225	CAZRI MOTH-2	RMO-225	CAZRI MOTH-2	RMO-225
0	69.3	71.2	7.9	19.0	11.8	18.7	0.80	1.42
11	69.1	70.0	16.2	18.7	14.6	20.6	0.75	1.75
22	56.5	61.3	24.1	18.3	13.6	29.1	0.94	1.80
33	53.1	54.6	21.5	9.5	14.7	20.6	1.85	1.67
44	44.2	49.4	43.7	20.9	12.3	12.2	0.44	0.35

Mung Bean

Coordinated varietal trial: Among 23 entries received from IIPR, Kanpur, genotype KM11-573 was the maximum seed yielder (875 kg ha^{-1}), followed by KM11-560 (716 kg ha^{-1}), KM11-581 and KM11-575 (625-667 kg ha^{-1}). These genotypes took 32-34 days to flower and 58-62 days to mature.

Mutation breeding programme: Fifty early maturing mutants evolved through gamma irradiation were evaluated against the parent varieties S-8, K-851 and RMG-267. The mutants CZM-9, CZM-11, CZM-16, CZM-18, CZM-25, CZM-29 and CZM-34 (seed yield of 677-833 kg ha^{-1}) were better than all the checks (365-469 kg ha^{-1}) and matured in 57-66 days.

Clusterbean

Coordinated varietal trial: Eleven genotypes from different centres were evaluated at Jodhpur and Jaisalmer. At Jodhpur, GR-111 was the highest seed yielder (503 kg ha^{-1}) followed by GR-108 (460 kg ha^{-1}). These genotypes flowered in 30-31 days and matured in 89-91 days. At Jaisalmer, GR-101 was the highest yielder (1008 kg ha^{-1}) followed by GR-104 (966 kg ha^{-1}) and GR-108 (693 kg ha^{-1}).

Performance of clusterbean mutants: Fifty-one mutants developed from varieties RGC-936 and HGS-365 were evaluated, and the mutants CZGM-46, -32, -48, -39, -29, -26, -25, and -24 were better seed yielders (375-495 kg ha^{-1}), and matured in 90-98 days.

Performance of clusterbean selections: Selections No. 4, 18, 22, 24 and 25 performed better (234-260 kg ha^{-1}) than the other 30 selections.

Physiological Evaluation

Newly generated breeding lines of mung bean (23), and newly released varieties of moth bean (4) and clusterbean (10) were evaluated for seed yield and physiological parameters. In clusterbean, RGC-1002 was of medium-duration in flowering and had more leaf area, higher biomass and seed yield. In mung bean, genotypes with better leaf area had more biomass and economic yield. In case of moth bean there were no differences.

Maintenance Breeding

The basic seed stock of the following genotypes was maintained:

Mung bean	Clusterbean	Horse gram	Moth bean
CZM K-1 (4.0 kg) CZM S-1 (2.9 kg)	GDM-1 (1.25 kg) Maru Guar (3.00 kg) CAZG-11-1 (1.50 kg) CAZG-11-2 (4.0 kg) CAZG-11-3 (1.8 kg)	Maru Kulthi-1 (4.0 kg)	CZM-1 CZM-2 CZM-3

Resistance of Moth Bean, Clusterbean and Mung Bean Germplasm to Diseases

Moth bean: 112 lines were screened for their susceptibility/resistance to whitefly (*Bemisia tabaci*) and yellow mosaic virus (YMV). 17 lines viz. IC-311435, IC-323451, IC-39796, IC-39800, IC-370508, IC-329037, IC-329077, IC-333212, IC-39814, IC-39730, IC-39778, IC-39693, IC-39725, IC-311400, IC-39759, IC-311416 and IC-39811 were free while 44 lines were moderately susceptible.

Clusterbean: The incidence of *Myrothecium* leaf spot, bacterial blight and dry root rot ranged from 26-34%, 15-31% and 3-15%, respectively in 11 genotypes in IVT and AVT. None of the genotypes was free from all the three diseases.

Mung bean: The incidence of *Cercospora* leaf spot ranged between 11-33%.

Molecular Characterization of Coriander

Twenty two varieties of coriander (*Coriandrum sativum)* were molecularly characterized by nine RAPD primers, and showed intraspecific variation amounting to 66.2% polymorphism in banding patterns. The representative sequences of each subgroup have been submitted to NCBI database (Fig. 2.1).

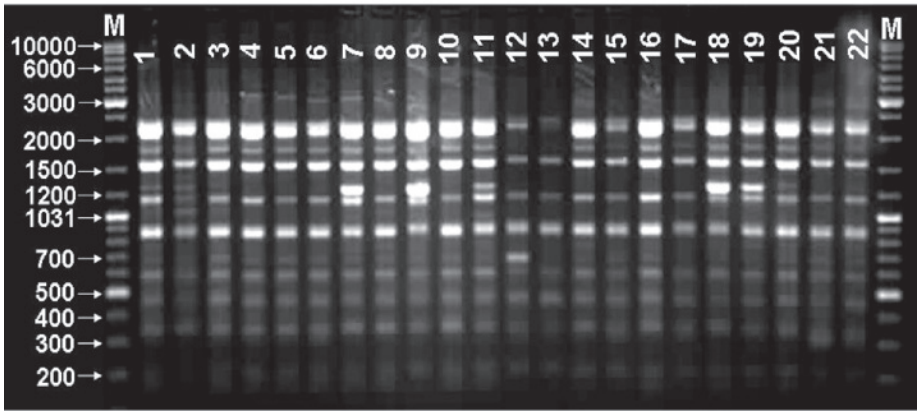


Fig. 2.1. RAPD profiles of 22 coriander varieties amplified by primer OPA 02.

TREES AND SHRUBS

Salvadora oleoides

Performance of germplasm: Eight-year-old 24 accessions were evaluated for survival, height, fruit formation and incidence of witch broom disease (WBD). The differences among the progenies were significant for survival and height. Mean survival of the progenies ranged from 33.3% (Acc 212) to 93.3% (Acc 214), height from 1.40 m (Acc 201) to 2.80 m (Acc 214). Population means were

74.4% for survival and 1.96 m for height. 6.72% of the shrubs showed signs of the disease. There was flowering in most of the collections but no fruit set.

Incidence of WBD and flowering: Eight accessions were screened and 75% of the shrubs of accession SO-5 and SO-3 were free from the disease. Among the diseased shrubs of these accessions, WBD bunches were less in SO-3 (16%) than SO-5 (25%). Maximum initiation of the disease (new) was in SO-1, SO-4 and SO-8 accessions. Disease-free germplasm exhibited initiation of inflorescence, whereas, in susceptible accessions initiation of innumerable diseased bunches was observed (Plate 10).

Guggal

Distribution: Survey of Guggal was completed in seven districts: Ajmer, Sikar, Jhunjhunu, Churu, Bikaner, Sri Ganganagar and Hanumangarh, and it was present in 5.46% of sampled sites having altitude of 488 to 753 m. The maximum number of sites of presence of guggal (11) occurred in Ajmer district out of 43 sites visited, and its density varied from 10-60 plants per ha in protected sites and 20-40 plants per ha in unprotected sites, preferring hills and piedmonts at 94% sites and plains at 6% sites. Though it was co-dominant at all the sites, but its dominance and vigor improved in protection while it declined in open conditions. Its habitat had sandy and sandy loamy soils. Most common associates included *Prosopis juliflora, Euphorbia caducifolia, Boswelia serrata, Wrightia tinctoria, Grawia tenax, Acacia senegal, Calotropis procera, Butea monosperma, Dichrostachys cinerea, Anogeissus pendula, Rhus mysorensis* and *Maytenus emarginata.*

Germplasm Collection

Twenty cuttings each from 13 individual shrubs from different sites were collected in Nov-Dec (Table 2.4). The cuttings with 2-8 days callusing of these genotypes were put for rooting using 5000 ppm IBA. There were 3 genotypes with 4 days callusing, 4 genotypes with 5 days callusing, 1 genotype with 6 days, 1 genotype with 7 days and 3 genotypes with 8 days callusing. Observations on sprouting were recorded every week, and after 18 weeks an average of 18% cuttings sprouted. The maximum sprouting was in 5 days callusing (31%) followed by 7 days callusing (25%), 4 days callusing (13%). There was no sprouting in 6 days callusing (Table 2.5).

Table 2.4. Germplasm collected in 2011

Germplasm (source)	Date of collection	Days of callusing	18th week % sprouting
Kukada (Bhim), Rajsamand	3 Nov	8	10
Bhagawar	3 Nov	8	0
Mahakaleshwar Mahadeo Temple, Rajgarh	7 Nov	4	20
Ramgarh	3 Nov	8	20
Shivpura	4 Nov	7	25
Mandavariya Firing Range, Kishangarh	5 Nov	6	0
Taragarh	6 Nov	5	50
Makupura Near Water Supply Tank	7 Nov	4	20
Tilora, Pushkar	6 Nov	5	30
Kharkhedi	6 Nov	5	45
Kot, Jhunjhunu	16 Nov	4	0
Khandela-II, Sikar	15 Nov	5	0
Sendara, Pali	4 Dec	2	0

Table 2.5. Sprouting behaviour of different days of callusing in guggal

Days of callusing	No of genotypes collected in Nov 2011	% of cuttings sprouted after 18 weeks
4	3	13
5	4	31
6	1	0
7	1	25
8	3	10
Total	12	18

Effect of genotypes and stem thickness on sprouting: Cuttings of different genotypes callused uniformly for four days treated with 5000 ppm IBA and put for rooting in fourth week of Sep. 2011 showed 8.6%, 27.6%, 34.8%, 34.1% and 34.1% sprouting after 4, 8, 12, 16 and 20 weeks. After 12 weeks some of the sprouted cuttings died. In two genotypes Belangri and Beriganga there was no sprouting. After 20 weeks, more than 50% of the cuttings in case of Dholavira-2 (84.6%), Moolsagar (52.6%) and SKN-2 (62.8%) sprouted (Table 2.6). Stem thickness of sprouted cuttings was more than the unsprouted cuttings.

Table 2.6. Sprouting behaviour of different genotypes

Genotype	% of cuttings sprouted	Stem thickness in sprouted cuttings (mm)				Stem thickness in non-sprouted cuttings (mm)			
		Mean	SD	Min	Max	Mean	SD	Min	Max
Bachau-2	29.4	9.94	3.18	6.65	13.86	6.71	3.28	3.37	14.11
Belangri	0.0	-	-	-	-	4.19	1.77	1.94	11.24
Beriganga-2	0.0	-	-	-	-	2.96	0.67	1.41	3.85
Dholavira-1	44.8	6.49	2.97	3.94	13.96	5.73	2.05	3.10	11.26
Dholavira-2	84.6	6.57	1.84	4.02	9.76	4.92	0.98	4.23	5.61
Jaisalmer-2	17.7	5.10	1.75	3.63	8.40	3.63	1.83	2.38	12.13
Kukma-3	47.2	8.35	2.40	4.37	12.83	6.09	2.53	3.28	13.54
Moolsagar	52.6	7.37	2.23	4.52	12.32	4.93	0.96	4.01	6.62
Ranitonk 2-2	57.1	8.79	3.55	4.39	20.51	6.91	2.55	3.93	12.01
RELD	26.3	6.61	0.60	5.85	7.29	5.12	2.97	3.08	6.10
SKN-1	33.3	8.52	3.30	4.25	15.09	7.36	2.99	3.22	12.19
SKN-2	62.8	8.34	2.38	2.41	14.22	6.56	3.11	3.22	14.95
Survey-3	25.0	7.62	2.03	4.93	10.10	7.01	2.11	4.89	12.75
Survey-5	31.2	7.77	2.17	5.25	12.63	6.73	2.52	3.48	13.85

Effect of seed size and colour on seed germination: Seed length, width and thickness were more in case of white seeds. The average values were 6.07 mm for seed length, 4.89 mm for seed width and 3.30 mm for seed thickness. Considering seed colour and size maximum values were for white large seed (length 7.44 mm, width 5.94 mm and thickness 3.62 mm). Maximum seed germination was in case of black large seeds (18%), and irrespective of seed size 11.7% of black seeds germinated. About three-fourths of the seeds decayed, one-third of the un-germinated medium size seeds had two embryos (Table 2.7).

Off-season Flowering and Fruiting in *Prosopis cineraria*

Normally flowering and fruiting in *P. cineraria* occurs in April-May, but this year it was in winter, which is not common. 25-year-old 65 plants raised from seeds and 28 plants raised from

air layering were evaluated for off-season flowering/fruiting, collar diameter, DBH and tree height. Flowering was in more trees raised vegetativly (42.8%) than from the seeds (6.2%), and fruiting was in two trees only and those were vegetativly propagated. Dry pods weight, seed yield and 100-seed weight were 1.15 g, 0.07 g and 1.81 g for one tree and 17.12 g, 1.08 g and 1.78 g for the other one. Tree height, collar diameter and DBH were more in flowering trees than the non-flowering ones in both the cases (Table 2.8). Flowering was mostly in the trees, which were facing the early morning sun.

Table 2.7. Seed parameters, germination and seeds with different number of embryos

Seed colour	Seed					Per cent of seeds			% of un-germinated seeds with embryos		
	Size	Length (mm)	Width (mm)	Thickness (mm)	Seed l/w	Germi nated	Un-germinated	Decayed	0	1	2
Black	Large	6.40	5.31	3.35	1.21	18.0	21.0	61.0	38.1	47.6	14.30
	Medium	5.53	4.54	3.26	1.23	9.0	12.0	79.0	8.3	25.0	66.60
	Small	5.07	3.92	3.05	1.32	8.0	4.0	88.0	75.0	25.0	0.00
white	Large	7.44	5.94	3.62	1.25	2.0	31.0	67.0	48.3	48.3	3.23
	Medium	6.65	5.32	3.28	1.25	0.0	25.0	75.0	68.0	28.0	4.00
	Small	5.30	4.31	3.27	1.24	1.0	4.0	95.0	75.0	25.0	0.00
Black		5.67	4.59	3.22	1.25	11.7	12.3	76.0	40.4	32.5	27.00
White		6.46	5.19	3.39	1.25	1.0	20.0	79.0	63.8	33.8	2.40
Large		6.92	5.63	3.48	1.23	10.0	26.0	64.0	43.2	48.0	8.76
Medium		6.09	4.93	3.27	1.24	4.5	18.5	77.0	38.2	26.5	35.30
Small		5.19	4.12	3.16	1.28	4.5	4.0	91.5	75.0	25.0	0.00

Table 2.8. Flowering in trees raised by different methods of propagation

Propagated by	Flowering/non-flowering	No. of trees	Tree height (m)	Collar diameter (cm)	DBH (cm)
Air layering	Flowering	12	6.47	19.2	16.6
	Non-flowering	16	5.46	16.0	13.5
Seed	Flowering	4	6.95	19.7	15.7
	Non-flowering	61	5.05	11.4	9.2

Kair [*Capparis decidua* (Forsk.) Edgew.]

Germplasm collection: Forty-five accessions were collected from Jaisalmer and Barmer districts. Wide range of variability was recorded for fruit diameter (11.4-22.6 mm), fruit weight (1.18-7.23 g), number of seeds per fruit (1-36) and test weight (13.91-26.92 g). Variation in colour of flowers and fruit size was also observed (Plate 11 and 12).

Variation in seed germination and seedling survival: The seeds of 45 accessions were sown in last week of August. The germination started on 10th day of sowing and continued up to 27th day, and took 19 days for 50% germination. Forty-three accessions showed more than 80% germination and others two no germination. After 5-months, seedlings survival ranged from 44.2 to 76.8%.

Evaluation of Efficient Rhizobia for Better Nodulation in *Acacia senegal*

Four Rhizobium cultures (As-4, As-7, Pc-4 and Pc-6) were inoculated into two genotypes (Nos. 35 and 113). Under different Rhizobium treatments germination in genotype 35 was 88% whereas, in genotype 113 it was 68%. Nodules were sparsely present on roots of both the genotypes, and number of nodules per seedling varied from 0 to 18 in genotype 35 and from 0 to 8

in genotype 113. Nodulation was maximum in genotype AS 35 with *Sinorhizobium saheli* (PC-6) from *P. cineraria*. Most of the rhizobial treatments enhanced the shoot length and shoot dry weight significantly over the control. Nodulation in the four-month-old seedlings significantly enhanced collar diameter and dry weights of root and shoot. Treating the seeds with rhizobia reduced the seed germination but enhanced the seedling biomass, and this effect was more with *Sinorhizobium kostiense* (PC-4).

Molecular identification of rhizobial cultures isolated from *A. senegal* and *P. cineraria*: Ten cultures each were isolated from one year-old seedlings of *A. senegal* (AS-1 to 10) and *P. cineraria* (PC-1 to 10) procured from local nurseries of Jodhpur and Pali districts. The genomic DNA, isolated from each culture, was used for amplification and sequencing of 16S rRNA gene. One isolate from *A. senegal* rhizosphere was identified as *Staphylococcus hominis* and from root nodules as *Sinorhizobium saheli* De Lajudie (8 nos.). Isolates from *P. cineraria* included *Lysinibacillus sphaericus* and *Bacillus subtilis* from rhizosphere and *Sinorhizobium kostiense* (1 no.) and *S. saheli* (5 nos.) from root nodules. *Sinorhizobium saheli*, *S. kostiense, L. sphaericus*, *B. subtilis* and S. *hominis* are identified as the major Plant Growth Promoting Rhizobacteria (PGPR) associated with the rhizospheres of *A. senegal* and *P. cineraria* in the arid region of western Rajasthan.

HORTICULTURE

Introduction, Collection and Evaluation of Cactus Pear (*Opuntia ficus-indica* L.)

Germplasm: Forty-three exotic cacti, introduced from Italy in collaboration with ICARDA, were evaluated for survival. Only 15 accessions could be saved, regenerated, and alongwith four earlier introduced clones were transplanted in October. After three months, survival was 44 to 100%. The varieties Seedless Santa Margherita Balice, Rossa Castel Sardo, RojaxRoja-4, Pianta 25, Trunzara Red san cono, A Giant and Militelo White showed 100% survival.

Vegetative propagation of cactus pear: Effect of healing-over-period (the period after detachment of cladodes from mother plant) on the success of multiplication was studied during first week of March. Survival increased with the healing-over-period and mortality of the plants was only due to the rotting at the base of the cladodes. The survival of plants further decreased after four months of planting in one and two weeks healing over period planted cladode whereas those planted after four weeks healing over period showed comparatively higher survival (53%). The plant height including the mother cladode was highest in those planted after two weeks of healing while it was almost same in one weeks and four weeks healing over period planted cladodes. The mean number of new leaves formed and weight of new leaves was almost at par in all the treatments. Thus it seems that cladodes planted after four weeks of healing-over-period had slightly better chances of survival (Table 2.9).

Table 2.9. Effect of healing-over-period on vegetative propagation of cactus pear

Healing-over-period (week)	Survival (%) after planting		After 4-months of transplanting		
	2-month	4-month	Plant height (cm)	No. of new leaves	Weight of new leaves (g)
One	71	37.5	36.9	2.17	225.0
Two	75	46.7	45.2	2.28	303.8
Four	80	53.3	37.5	2.58	269.9

Plate 9. Pearl millet hybrids contributed to All India Coordinated trials.

Plate 10. Initiation and development of WBD in susceptible accessions of *S. oleoides*.

Plate 11. Variation in flower colour in kair.

Plate 12. Variation in fruit size in kair.

High Yielding Gonda Genotypes Identified for Release

Twelve accessions collected from different parts of the country and evaluated for long time showed large variation in fruit size, shape, yield and pulp content. Two genotypes (CAZRI-G 2021 and CAZRI-G 2025) have been developed by selection from seedling population and further multiplied by budding, and identified for release as improved varieties for culinary purposes (Plate 13). These genotypes are early, high yielding, performed consistently well in respect of yield and yield attributing traits under supplementary irrigation. Morphometric characteristics and yield potential of both genotypes are given in Table 2.10 and Table 2.11.

Table 2.10. Morphometric characteristics and yield attributes of selected gonda genotypes

Characteristics	CAZRI-G 2021	CAZRI-G 2025
Growth habit	Semi spreading	Drooping
Plant height (m)	3.52	4.80
Collar diameter (cm)	9.23	10.34
Canopy area(m^2)	27.9	38.5
Leaf arrangement	Simple alternate	Simple alternate
Leaf shape	Orbicular	Orbicular
Leaf apex	Obtusely acuminate	Obtuse
Leaf base	Round to cordate	Round
Leaf margin	Toothed type	Entire toothed
Petiole length (cm)	3.0-4.5	4.0-6.2
Leaf surface (Dorsal)	Smooth waxy	Glabrous
Leaf surface (ventral)	Velvet hairy	Velvet hairy
Leaf venation	Reticulate	Reticulate
Number of fruits/bunch	14.8	14.0
Mean bunch weight (g)	70.4	61.5
Mean fruit weight (g)	9.0	10.5
Pulp: stone ratio	6.0	6.5

Table 2.11. Mean fruit yield of selected gonda genotypes over last five years

Accession no.	Fruit yield (kg per tree)				
	2007	2008	2009	2010	2011
CAZRI-G 2021	9.1	12.5	10.78	16.82	23.5
CAZRI-G 2025	7.6	14.2	22.95	27.55	26.0

Ber at Bhuj

Ten varieties (Seb, Gola, Illaichi, Aithli, Umran, Mahrwali, Tikadi, Banarsi Pebandi, Katha and Banarsi Kadaka) of ber are maintained. Gola was early to fruit and yielded more than Seb.

Performance of Date Palm Cultivars at Chandan (Jaisalmer)

Four cultivars were evaluated for phenological changes and fruit traits. Shamran, Khadravi and Umshok were the earliest for spathe emergence, spathe opening, doka and pind stage. Fruit size and pulp were minimum in case of Khadravi (Table 2.12).

Watermelon (*Citrullus lanatus*) at Jaisalmer

Germplasm evaluation for seed yield: Twenty-five selections were evaluated. Maximum mean values were 400.0 g for seed yield per plant (SKNK-138), 1070 for number of seeds per fruit (SKNK-679), 81.6 g for test weight (DRB-664) and 20.2 for number of fruits per plant (SKNK-665).

Seed yield per plant was minimum 105.7 g for DRB-661. The other selections which showed more than 300 g seed yield per plant were DRB-675, SKNK-665, SKNK-679 and GK-(C).

Table 2.12. Phenological stages and fruit characteristics of date palm

Character	Cultivar			
	Shamran	Khadravi	Migraf	Umshok
Spathe emergence	Feb 9-March 6	Feb 11- 28	Feb 25 -March 16	Feb 10-.March 14
Spathe opening	March 3-16	March 2 - 15	March 14- 28	March 3-25
Doka stage	June 23 -29	June 24 -29	July 8-14	June 24 –July 8
Pind stage	July 18 -Aug 26	July 18 -Aug 26	July 23 -Aug 26	July 18 -Aug 26
Fruit weight (g)	6.85	2.54	6.56	5.14
Fruit length (mm)	30.96	19.74	30.42	28.91
Fruit breadth (mm)	19.32	13.76	18.93	18.02
Pulp weight (g)	5.70	1.90	5.66	5.47

Performance of landraces: Twenty-one landraces were evaluated. CZJM-207 showed maximum number of seeds per fruit (787) and seed yield per plant (84.2 g), and CZJM-201 number of fruits per plant (5.9) and fruit yield per plant (11.3 kg). Wide range of variation in mean fruit weight (1.73-4.17 kg), fruit diameter (45.2-68.0 cm) and test weight (3.35-8.05 g) was observed among the landraces.

Coordinated varietal trial of *Kalingada* (Watermelon): Among 13 entries evaluated, seed yield ranged from 5.59 q ha^{-1} to 9.58 q ha^{-1} (SKNK-0903), fruit yield from 212.0 q ha^{-1} to 363.8 q ha^{-1} (MK-45-3), number of fruits per plant from 5.5 (MK-45-3) to 14.7 (SKNK-0903), test weight from 46.0 g (MK-81-1) to 69.9 g (SKNK-0903) and maturity of fruits from 99 days to 119 days.

Crossing programme: On the basis of *per se* performance 15 parents were selected for different traits, and 17 crosses were made successfully in summer, and further advanced to F_2 through selfing during kharif 2011.

Characterization of Soil Seed Bank of *Lasiurus sindicus* and its Effect on Species Dynamics in Arid Rangeland

These was considerable variation in the mean number of seeds among different categories of rangeland viz., fully protected, controlled and open grazing, and these were most abundant in uppermost part of the soils, particularly in the 0-3 cm of soil in the months of July, October and December. Under controlled grazing, the soil seed bank status of all species was significantly higher in May (31.2%) and July (58.4%) with respect to total seeds (Table 2.13).

A total of 14 plant species were identified in the collected samples irrespective of the type of rangelands, soil depth and the period of observation. Number of seeds of all plant species seeds was maximum in protected (9.8 m^{-2}) followed by controlled grazing (9.7 m^{-2}) and open grazing population (3.6 m^{-2}). The number of seeds varied widely across the species and maximum number of seeds was of *Lasiurus sindicus*. Number of seeds of *L. sindicus* was maximum (Fig. 2.2) in fully protected, controlled and open grazing rangelands in December (37.2%), July (25.0%) and December (48.2%), respectively.

Clitoria (*Clitoria ternatea*) at Bhuj

Twenty accessions collected from CAZRI, Jodhpur and IGFRI, Jhansi were evaluated for their growth and yield at Kukma, Bhuj. The accessions differed significantly for plant height, primary branches and yield attributes. The dry fodder yield ranged from 2861 to 4606 kg ha^{-1}. The

accessions CAZRI 752, JHC 94 and EC 1531-1 yielded more than 4000 kg ha^{-1}, whereas IFRI (2372 kg ha^{-1}) and CAZRI 1439 (2394 kg ha^{-1}) gave the least dry fodder yield.

Table 2.13. Distribution of seeds in soil seed bank in arid rangeland

Date	Soil layer (cm)	Number of seeds m^{-2}			Mean ± SE
		Fully protected rangeland	Controlled rangeland	Open rangeland	
08/03/2011	0-3	6.25	2.85	1.68	1.83 ± 0.29
	3-6	3.41	2.23	0.95	
	6-9	1.58	1.03	0.39	
	9-12	1.03	0.62	0.00	
12/05/2011	0-3	3.59	4.29	0.88	1.34 ± 0.25
	3-6	1.65	2.22	0.38	
	6-9	0.86	1.61	0.28	
	9-12	0.00	0.70	0.00	
19/07/2011	0-3	2.39	5.41	1.28	1.53 ± 0.26
	3-6	1.34	2.50	0.77	
	6-9	0.53	2.43	0.40	
	9-12	0.21	0.36	0.28	
15/10/2011	0-3	5.37	3.60	2.34	1.66 ± 0.26
	3-6	2.33	0.86	1.77	
	6-9	1.04	0.70	0.40	
	9-12	0.43	0.62	0.35	
03/12/2011	0-3	8.29	7.19	3.42	2.86 ± 0.38
	3-6	4.45	3.61	1.37	
	6-9	2.69	2.38	1.03	
	9-12	1.33	0.36	0.21	

Wild Groundnut at Bhuj

Four species of wild groundnut (*Arachis glabrata*, *A. prostrata*, *A. rigonii* and *A. pusilla*) collected from Junagadh (Gujarat) were evaluated for establishment, number of branches/plant, maximum length of branches and leaf area. *A. glabrata* had the maximum length of branches (95.5 cm) followed by *A. prostrata* (82.8 cm), and the minimum in *A. pusilla* (63.7 cm) (Plate 14).

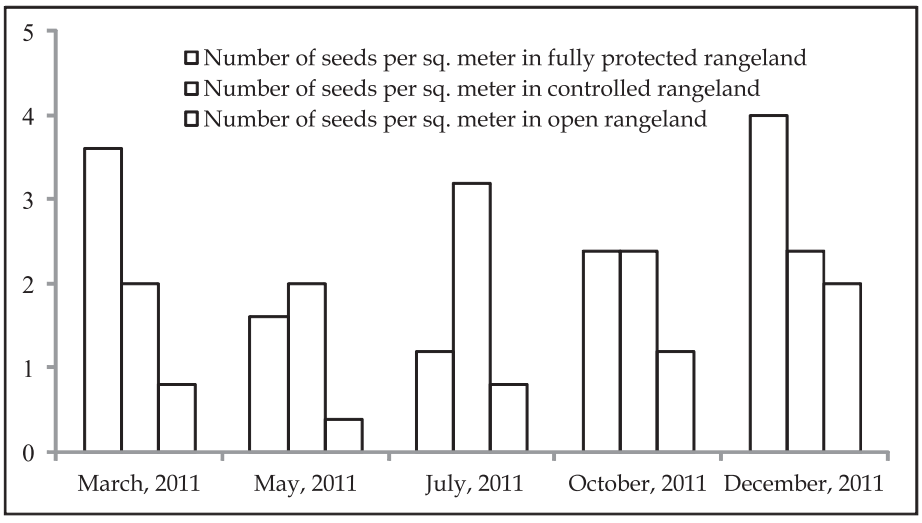


Fig. 2.2. Distribution of *Lasiurus sindicus* seeds in soil seed bank in three major categories of arid rangeland.

Advance Line Evaluation Trial of Sesame (*Sesamum indicum* L.) at Bhuj

Summer 2011: 51 selections (identified from 171 germplasm lines) and the standard check GT-2 were evaluated in summer 2011 for seed yield, earliness (days to maturity) and different phenological and yield contributing traits. Days to maturity in selections ranged from 96 to 114 days. Accession NIC 8683 S1 matured in 96 days, and NIC 8669 S1 and NIC 8677 S1 in 114 days. Maximum capsule filling rate was in NIC 8700 S2 (79.8%) followed by NIC 8676 S3 (65%) and NIC 8678 S1 (63%). NIC 8701 S2 had the maximum number of capsules per plant (111) followed by NIC 8656 S1 (103). However, standard check attained only 89 capsules per plant. The seed yield ranged from 32.8 to 113.1 g m^{-2}. NIC 8686 S2 was the highest yielder (113.1 g $m^{-2)}$ followed by NIC 8683 S2 (104.1 g m^{-2}) against the check, GT-2 (78.5 g m^{-2}). Selections namely, S2 NIC8686, S3 NIC 8683, S2 NIC17489, S1 NIC 8674, S2 NIC 8683, S1 NIC 8701 and S2 NIC 8678 were the high yielders (yield ≥ 106.6 g m^{-2}) (Plate 15).

Kharif 2011: Better performing 25 selections for yield and yield contributing traits under Advance Line Evaluation Trail *Summer* 2011 were again evaluated with three standard checks (GT-2, PB Til 1 and Murg 1). The selection NIC 17489 S2 was the highest yielder (278 kg ha^{-1}) followed by NIC 8683 S (271 kg ha^{-1}), while the standard checks produced only 245 to 253 kg ha^{-1} yield. Ten selections with the seed yield range of 256 to 278 kg ha^{-1} were better than the three checks. The yield levels were generally low due to erratic rains during the season, 374 mm in 35 and 36th standard weeks.

Seed Technology Research

Seed storage technology in cumin: The seed quality of variety RZ-209 after pre-storage treatment with two fungicides, carbendazim and captan (3 g per kg seed); one biocontrol agent, *Trichoderma harzianum* (4 g per kg seed) and irradiation @ 2.5, 5.0, 7.5, 10.0 kGy h^{-1} with storage in different containers i.e. earthen pot, gunny bag and tin was studied. The seed moisture remained below 6.7% throughout the storage period irrespective of storage containers and seed treatment. Seed germination was affected by seed treatments, storage period and packaging materials. The initial seed germination (90%) declined to 44% after storage of 21 months irrespective of seed treatments and containers. Seed treatment with bavistin and stored in tin containers was best for seed germination and seedling health. The incidence of storage insect pests was negligible in all the treatments. The presence of fungi like *Aspergillus flavus*, *A. niger*, *Fusarium* sp., *Penicillium* sp. and *Rhizopus* sp. was observed in control, and few in *T. harzianum* treated seeds. There was no fungus in case of irradiated seeds.

Seed Yield and its Quality in *Cenchrus ciliaris*

Foliage cutting had significant effect on quantity of seed but no effect on dry matter yield and seed purity in three genotypes CAZRI 75, CAZRI 2178 and CAZRI 2221 of *C. ciliaris*. Among the cutting treatments, uncut had maximum pure seed yield (66.1 kg ha^{-1}). Maximum green fodder (14585.9 kg ha^{-1}), dry matter (5836.2 kg ha^{-1}) and pure seed yield (67.6 kg ha^{-1}) were in CAZRI 2221. Among the combinations, CAZRI 2221 cut at 30 days gave maximum pure seed yield (97.8 kg ha^{-1}) followed by the uncut treatment of the same variety (90.7 kg ha^{-1}).

Seed Production

Sixty kg breeder seed of open-pollinated variety CZP 9802 of pearl millet, 625 kg breeder seed of moth bean var. CAZRI Moth 2, and 29.3 kg nucleus seed of moth bean var. CAZRI Moth 2

Plate 13. Improved gonda genotypes-CAZRI-G 2021 and CAZRI-G 2025.

Plate 14. Luxurious growth of *Arachis glabrata* at RRS, Kukma-Bhuj.

Plate 15. Sesame, NIC 8676 – a selection for more number of capsules/plant.

and CAZRI Moth 3 were produced. In addition to this, over 6000 kg truthfully labeled seed of various crops was also produced under ICAR Mega Seed Project and National Seed Project (Table 2.14).

Table 2.14. Crop wise seed production

Crop	Variety	Truthfully labelled seed (kg)
Grasses	*C. ciliaris*	237
Crops		
Mung bean	RMG- 62	503
	GM-4	120
	SML-668	620
Clusterbean (guar)	RGC-1031	5
	RGC-1003	75
	M-83	18
Moth bean	CZM- 3	90
	CZM- 2	670
Sesame	RT-346	100
Pearl millet	CZM-9802	1800
Mustard	Pusa Jaikisan	1297
	GM-2	115
Cumin	RZ-209	308
	GC-4	125

INTEGRATED ARID LAND FARMING SYSTEMS RESEARCH

CROP PRODUCTION AND CROPPING SYSTEMS

Long Term Effects of Fertilizer–N and Organic Manure on Pearl Millet

Effect of continuous cropping, rotations and fallowing: Continuous cropping (19th year) without fertilizer application produced 1571 kg grain ha^{-1}. Recommended dose of N gave 24.6% higher yield than control. Pearl millet grain and stover yield under pearl millet-clusterbean rotation (1876 and 2253 kg ha^{-1}) were significantly higher than the yield obtained under continuous cropping (1571 and 1820 kg ha^{-1}).

Effect of fertilizer-N application on yield: Application of 20 and 40 kg N ha^{-1} produced 1957 and 1991 kg grain ha^{-1}, which was significantly more than that obtained without fertilizer (1571 kg ha^{-1}). Application of 2.5 t and 5 t FYM alone produced 2382 and 2849 kg grain ha^{-1}, respectively, which was 21.7 and 43.1% higher than inorganic source. Similarly, combined application 2.5 t FYM + 20 kg N produced 37.1% more grain than that at 40 kg N as inorganic. The maximum grain yield (2904 kg ha^{-1}) was obtained with the application of 5 t FYM along with 40 kg N ha^{-1}. Continuous cropping of pearl millet without any fertilizer application resulted in 18.7% less stover yield as compared to recommended practice. Application of 20 and 40 kg N and similar quantity of N through organic source using 2.5 and 5 t FYM ha^{-1} significantly improved stover yield over without application of fertilizer.

Vertical distribution of organic carbon and nutrients: Soil organic carbon (SOC) and labile carbon (LC) increased slightly up to 15-30 cm depth; thereafter, as depth increases the value decreased. The SOC and LC ranged between 0.5 and 2.4 g kg^{-1} and 280-499 ppm, respectively. The similar trend was seen in respect of available phosphorous and potassium. Plots received only inorganic fertilizer also maintained the SOC at their initial level. Similarly, the level of SOC remained static even in plots which were kept fallow during alternate years and where legume-pearl millet cropping was followed. Application of organic manure (FYM) @ 2.5 and 5 t ha^{-1} increased the level of SOC and LC. Labile carbon was highest with 5 t FYM ha^{-1} and 40 kg N ha^{-1}. LC was relatively higher in the integrated nutrient management (INM) interventions (maximum in $M_{5.0}N_{40}$).

Effect of N Application Method on Clusterbean

Application of N in split doses had significant influence on the seed and straw yield of clusterbean. Maximum seed and straw yield was with the application of 10 kg N as basal dose along with spraying of 1% urea at vegetative stage and 1% at flowering stage. The increase in seed yield was 9.45 and 17.83% over 20 kg N as basal application and control respectively. Further urea applied through spray only either in single or double splits was unable to improve the seed and straw yield as compared to treatments supplemented with basal application of N. The net return (Rs. 7730) and benefit: cost ratio (1.59) were also observed maximum under the application of 10 kg N as basal dose along with spraying of 1% urea at vegetative stage and 1% at flowering

stage, whereas lowest net return (Rs. 4790) and benefit: Cost ratio (1.40) were recorded under control condition.

Effect of Clusterbean based Cropping Systems

Weed flora: The experimental field was mainly infested with broad leaved weeds which contributed 78% of total weed flora. The proportion of grassy weeds and sedges was 21 and 1% respectively. Among all the weeds *Amaranthus blitum* contributed 62% followed by *Celosia argentia* (21%), *Heliotropium sublatum* (6%), *Cenchrus setigerus* (5%), *Cyperus rotundus* (3%) *and others* (3%). Among all the cropping systems, sole clusterbean decreased maximum weed dry matter being 17.6, 8.01 and 3.82% lower as compared to sole pearl millet, clusterbean + pearl millet (2:1) and clusterbean + pearl millet (2:2), respectively. Two weedings given at 25 and 45 DAS significantly reduced maximum dry matter of weeds. However, integration of pendimethalin @ 1.0 kg ha^{-1} + one weeding at 25 DAS and pendimethalin @ 1.0 kg ha^{-1} + imazithypar @ 90 g ha^{-1} (post emergence) were recorded at par with of that two hand weedings. Among all the weed control treatments, two weedings recorded highest weed control efficiency (90.8%), followed by pendimethalin 1.0 kg ha^{-1} + one weeding at 25 DAS (90.8%).

Yield and net return: The highest pearl millet grain equivalent yield (2255 kg ha^{-1}) and net returns (Rs.10266) were recorded in clusterbean + pearl millet in 2:1 row ratio. The increase in seed yield was 21.6 and 15.8% higher over sole clusterbean and pearl millet, respectively. Among the weed control treatments, highest pearl millet grain equivalent yield (2276 kg ha^{-1}) was recorded in two weedings given at 25 DAS and 45 DAS, but net return was highest (Rs. 10356 ha^{-1}) in integrated application of pendimethalin + one weeding at 25 DAS. The net return was 2.7 and 46.9% higher over two weedings given at 25 DAS and 45 DAS and weedy check, respectively.

Compatible Crop and Suitable Row Spacing for Live Mulching in Rainfed Crops Grown with Colocynth

Yield and yield attributes of pearl millet reduced considerably with the introduction of colocynth in the pearl millet (Table 3.1). Among the five row ratio, sole pearl millet recorded 41% higher grain yield over highly dense ratio of 1:1 crop and colocynth live mulch. However, straw yield of pearl millet was affected to lesser extent (19.6-2.9%) with introduction of colocynth live mulch, though it was also recorded significantly higher with sole crop of pearl millet.

Table 3.1. Yield (kg ha^{-1}) of pearl millet, clusterbean and moth bean under different live mulch ratio with colocynth

Treatment (sole or live mulch ratio with colocynth)	Pearl millet		Clusterbean		Moth bean	
	Grain	Straw	Grain	Straw	Grain	Straw
Sole	821	1945	552	883	354	611
1:1	481	1564	455	895	306	542
2:1	498	1667	560	993	399	688
3:1	608	1783	647	1235	492	889
4:1	709	1887	599	1057	434	791
CD at 5%	105	212	80	106	45	71

Highest clusterbean yield was recorded with 3:1 crop: colocynth live mulch ratio (14.7%) among the different crop: colocynth ratio (Table 3.1). However, significantly higher straw yield showed in 3:1 (28.5%) along 4:1 (16.5%) crop: colocynth mulch.

Weed spectrum: In clusterbean and moth bean, crops without colocynth recorded higher weed density compared to introduction of colocynth in different proportions (Table 3.2). Significantly lower weed density and weed dry weight was observed in clusterbean and moth bean with 3:1 crop: colocynth ratio. Overall results revealed that, the pearl millet reduces the yield, whereas clusterbean and moth bean enhance the yield by the introduction of colocynth as *in situ* live mulch in 3:1 crop to colocynth ratio.

Table 3.2. Effect of different proportion of colocynth live mulch on weed indices under different crops

Treatments	Weed density (number/m^2)			Weed dry weight (g/m^2)		
	Pearl millet	Clusterbean	Moth bean	Pearl millet	Clusterbean	Moth bean
Crops sole	19.98	40.16	28.37	8.45	17.72	12.16
1:1 (crop: colocynth)	36.23	17.31	35.62	16.76	7.35	15.35
2:1 (crop: colocynth)	40.28	19.92	23.28	18.54	8.86	9.12
3:1(crop: colocynth)	23.65	17.28	14.49	10.87	7.21	5.51
4:1 (crop: colocynth)	27.86	20.22	18.83	12.64	9.45	8.34
CD at 5%	2.90	2.32	3.19	2.07	2.53	2.70

Drought Management in Arid Legumes

Skip row planting recorded 23.7% higher seed yield over normal planting in clusterbean. The straw yield, however, was not affected significantly with planting pattern, although it was higher with skip row planting. Under second factor it was observed that foliar spray of 1% urea at pre flowering and post flowering results into higher yield attributes and yield (Table 3.3). The increase in seed yield under this treatment was 56.9% higher over control.

Table 3.3. Yield and yield attributes of clusterbean var. RGC-936 grown with different planting patterns and urea treatments

Treatment	Pods/ plant	Pod weight (g pt^{-1})	Pod length (cm)	Seeds/ pod	100-seed wt. (g)	Seed yield (g pt^{-1})	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})
Planting pattern									
S_1	35.44	12.79	4.26	7.05	3.07	7.58	636	1019	1655
S_2	37.60	14.21	4.34	7.31	3.09	8.68	787	1070	1858
CD at 5%	1.49	0.97	NS	NS	NS	0.34	46	NS	71
Urea treatments									
F_1	36.75	14.11	4.33	7.31	3.10	8.20	745	1081	1825
F_2	42.00	15.55	4.53	7.48	3.14	8.62	893	1298	2191
F_3	34.13	12.54	4.24	7.05	3.08	8.10	641	944	1584
F_4	33.25	11.79	4.13	6.88	3.01	7.61	569	856	1424
CD at 5%	2.11	1.37	0.17	NS	NS	0.48	66	51	101

S_1- Planting at recommended row spacing; S_2- Skipping every three rows; F_1- 1% urea foliar spray at pre-flowering; F_2- 1% urea foliar spray at pre-flowering & post flowering; F_3- water spray and F_4- control.

Effect of Time of N Application in Clusterbean

The yield and yield attributes of clusterbean were affected by different time of N application. Yield attributes were highest under basal application of N + spray of 1% urea at vegetative and flowering stage followed by basal application of N + spray of 1% urea at flowering stage. Similarly, seed (782 kg ha^{-1}) and straw (1255 kg ha^{-1}) yield were also recorded significantly higher with above treatments. However, seeds/pod and 100-seed weight were not affected significantly by different time of N application in clusterbean under rainfed conditions.

Effect of Supplementary Irrigation and Mulching in Ber

Mulching and supplementary irrigation caused significant improvement in canopy area, fruit weight, fruit yield and TSS and reduction in weed population. The weed population was almost absent where ever black polythene mulch was applied and date palm leaves also reduced the weed intensity significantly as compared to control. The highest fruit yield of about 34 kg per plant was recorded with irrigation at 60 CPE and with polythene mulching, though same level of fruit yield could be obtained with same level of irrigation with date palm leaves mulching and irrigation at 90 CPE and date palm leaves mulch. Hence on the basis of the results obtained it could be concluded that supplementary irrigation at 60 CPE from September to November with mulching is beneficial in ber for obtaining higher fruit yield.

Performance of High Value Crops under Organic Farming

Effect of organic treatments on sesame yield: Manure application increased yield; effects being more up to 3 t ha^{-1} manure application (Table 3.4). Good rainfall distribution and temperature regime during the crop growth and reproductive stages also favored manure response. In protection treatments neem cake application enhanced crop yield partly due to nutrition and protection both, while spray of biopesticide purely increased yield by controlling pest. Combination of Neem cake + biopesticide + manure gave maximum yield.

Table 3.4. Effect of organic treatments on yield of sesame and clusterbean (kg ha^{-1})

Treatment	Sesame				Clusterbean			
	Manure application (t ha^{-1})							
Protection level	0.0	1.5	3.0	4.5	0.0	1.5	3.0	4.5
Control	196	397	452	624	236	268	307	345
Soil application of neem cake (400 kg ha^{-1})	238	433	694	848	258	303	385	404
Biopesticide spray (3% neem oil)	208	399	577	678	320	372	432	498
Soil application of neem cake (400 kg ha^{-1}) + biopesticide (3% neem oil) spray	324	555	896	1015	335	394	460	537

Clusterbean yield: Clusterbean, like sesame, also showed improvement in yield with manure application in combination with neem cake and biopesticide spray (Table 3.4), but these enhancements were not as high as in sesame. Yield enhanced due to biopesticide was more compared to neem cake application.

Contribution of diversity for controlling pest in organic system: The perennial components ber (*Ziziphus*), henna, *Calotropis* supported a good diversity and number of beneficial insects during the kharif season. On henna and ber plants honey bees, syrphid flies, houseflies and yellow jacket wasps, V*aspa* sp. were a major presence, the wasps being avid predators of many lepidopteran pests. Large number of bumble bees was observed on the *Calotropis* plant. Sesame

crop supported good diversity of big honey bees and bumble bees during peak flowering time in 1-2 week of September. Sulphur butterflies (*Catopsilia* sp.) were frequent on *Cassia* plants the eggs of these species attract trichogrammatid egg parasitoid to the field.

Effect of Sowing Dates on Pearl millet and Clusterbean Genotypes

Pearl millet varieties reflected delay in tillering, reduction in plant height, ear length, dry fodder yield and grain yield at second (6th August) compared to first (7th July) date of sowing. Downy mildew occurred only in second sowing. Among the pearl millet genotypes, CZP 2009 recorded maximum grain and dry fodder yield and water use efficiency in both the dates of sowing, while CZP 9802 showed least effect of date of sowing with respect to days to flag leaf, boot leaf and 50% flowering. Late sown clusterbean crop matured faster and yielded less than early sown crop due to terminal stress. Clusterbean genotype RGC 1031 reflected higher chlorophyll and membrane stability index as compared to RGC 1066 at vegetative stage, however, the latter variety yielded more.

Cropping System under Drip Irrigation for Improving Resource Efficiency

Influence of irrigation method on yield of summer lady finger: Summer lady finger under drip produced 15% higher yield and saved 30% water over check basin irrigation.

Influence of manure application on yield of kharif lady finger: Two manures viz., vermi compost and FYM were applied @ 2.5 t ha^{-1} to the kharif lady finger crop. Fruit yield (5.8 t ha^{-1}) was 68% higher with 2.5 t vermi compost compared with yield (3.5 t ha^{-1}) at 2.5 t FYM ha^{-1}. Plants were taller and more vigorous with 2.5 t vermi compost compared with 2.5 t FYM ha^{-1}. The moisture use by lady finger with vermi compost application was at par with FYM application.

***Muskmelon*:** Muskmelon cv. *kazri* was grown under drip irrigation produced 19% higher yield and saved 35% water over check-basin irrigation.

Effect of INM and Drip Irrigation Schedule on Chilli and Clusterbean

Green chilli fruit yield and quality: Green chilli fruit yield decreased with the decreasing in water supply from 1.0 to 0.6 ETc through drip irrigation system. There was no significant difference in yield at 1.0 ETc (20.6 t ha^{-1}) and 0.8 ETc (19.6 t ha^{-1}) irrigation level. Whereas, great yield reduction was observed at 0.6 ETc (16.9). Amongst nutrient treatments, the maximum fruit yield was recorded with 50% NPK as fertilizers + 50% N as VC (21.8 t ha^{-1}). The response of irrigation levels was lesser for TSS (°B), which ranged from 7.26 (0.6 ETc) to 7.58 (1.0 ETc). However, it was quite apparent for ascorbic acid and capsaicin content. The ascorbic acid content in green chilli fruits increased with the decrease in water supply through irrigation and recorded maximum in deficit water supply condition.

Soil properties: The mean per cent gravimetric moisture content (Mc) was recorded maximum for 0.8 ETc (11.74%) and minimum for 0.6 ETc (11.19%) irrigation level. 100% N as VC showed maximum moisture hold (12.12) followed by 50% NPK as fertilizers + 50% N as VC. Profile soil moisture was observed 64.9, 70.1 and 67.9 mm for 1.0, 0.8 and 0.6 ETc irrigation levels. Cone Index showed reverse trend with the irrigation levels i.e., less with higher amount of water supplied and vice versa.

Clusterbean fruit yield: Clusterbean fruit yield decreased with the decrease in water supply from 0.8 to 0.4 CPE through drip irrigation system. The maximum fruit yield was recorded at 0.8 CPE

(4.45 t ha^{-1}) followed by at 0.6 CPE (4.11 t ha^{-1}) and was minimum at 0.4 CPE (3.77 t ha^{-1}), irrespective of nutrient treatments. Amongst nutrient treatments, fruit yield was maximum for 100% N as VC (4.81 t ha^{-1}) followed by 50% NPK as fertilizers + 50% N as VC (4.64 t ha^{-1}) applied to the preceding crop, whereas minimum was in control (2.59 t ha^{-1}). It is obvious from results that fruit yield was stabilized with purely inorganic/chemical fertilizers applied plots; however, progressive increase was observed in yield with the sole application of organic manure (VC).

Evapotranspiration and Yield Relationships in Sesame

The evapotranspiration (ET) rates measured using gravimetric lysimeters for unstressed (100% ET rate irrigated) sesame crop (cv. RT-127) were 1.6-3.7 mm d^{-1} at initial stage, 2.1-9.2 mm d^{-1} at vegetative stage, 5.6-7.9 mm d^{-1} at flowering/fruiting stage and 0.6-4.1 mm d^{-1} during maturity (Fig. 3.1). Total amount of rainfall during crop growth period was 245.4 mm received in 28 rainy days. The seasonal ET of unstressed sesame crop was 315 mm with seed yield of 1041 kg ha^{-1} and water-use efficiency of 3.3 kg ha^{-1} mm^{-1}. The crop coefficients (ratio of actual ET to class A pan evaporation) for sesame were 0.20-0.92 at initial stage, 1.2-1.72 at vegetative stage, 0.96-1.33 at flowering/fruiting stage and 0.18-0.62 at maturity stage with a mean of 0.75 for the cropping season.

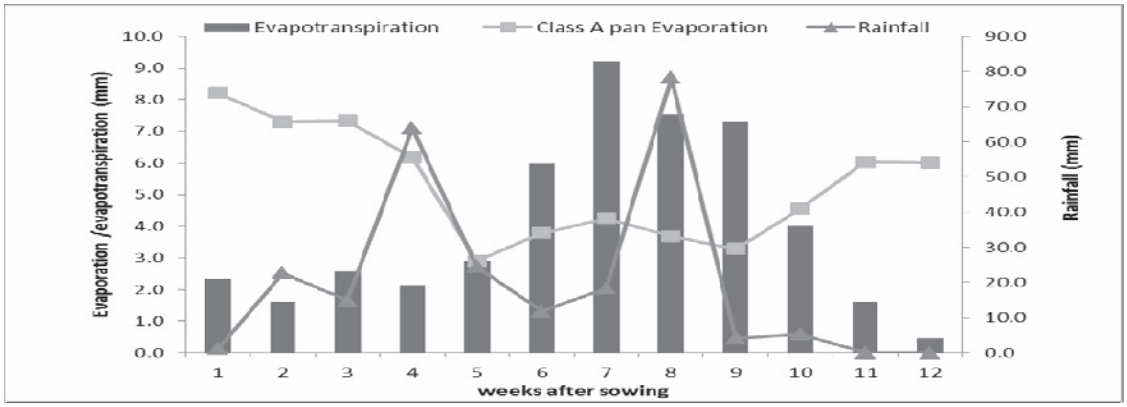


Fig. 3.1. Evapotranspiration rates of sesame crop, Class-A pan evaporation and rainfall.

Effect of Nutrient Management on Perennial Forage Legumes

Seed treatment with phosphorus solubilizing microbes (PSM) increased dry fodder yield of *Clitoria* by 20.2%, followed by seed treatment with PGPR (3.87%) over the control. Seed treatment with rhizobium did not influence the dry fodder yield significantly over the control. The maximum dry fodder yield of 4554 kg ha^{-1} was recorded in treatments receiving N and P at 50% of RDF along with application of rhizobium, PSM and PGPR. The lowest yield of 3122 kg ha^{-1} was recorded in control.

Response of *Clitoria* to micronutrients (Zn, Mn and B) was also assessed. Application of micronutrients significatntly influnced the fodder production of *Clitoria*. The response of *Clitoria* for dry fodder yield to Zn was linear where as it was quadratic to Mn and Boron application. Soil application of Zn @ 4.5 kg ha^{-1} increased fodder yield maximum (53.5%), followed by Mn (52.8%) @ 3 kg ha^{-1} and B (41.3%) @ 0.6 kg ha^{-1}. Combined application of Zn, Mn and B @ 3.0, 3.0 and 0.6 kg ha^{-1} at the time of sowing produced the maximum dry fodder yield of 4767 kg ha^{-1}.

Stylosanthes hamata was evaluated for growth and fodder yield at Kukma, Bhuj. The growth of stylo was luxurious and recorded height of 65 cm and branches of 4.8 plant^{-1} with a dry fodder yield of 3.8 t ha^{-1} at farm.

Intercropping of Grasses with Perennial Forage Legumes

Field experiment on intercropping of *Dicanthium* with perennial forage legumes, namely, *Clitoria* and stylo was conducted during kharif 2011 at RRS, Kukma, Bhuj. A strip consisting of 3 rows of *Dicanthium* was intercropped with 3 rows of forage legume. A treatment of sole crop of *Dicanthium*, *Clitoria* and stylo was also maintained for comparison. Data on Land Equivalent Ratio (LER) for dry fodder yield indicated that *Dicanthium* was a dominant species over legumes in intercropping system. Higher LER (0.77) was recorded for stylo than that of *Clitoria* (0.56 under intercropping system. Thus, intercropping of *Dicanthium* with stylo was more advantageous as it recorded higher LER of 1.35 as compared with LER of 1.16 for *Dicanthium* + *Clitoria* intercropping. A total dry fodder yield of 6687 kg ha^{-1} was recorded under intercropping of *Dicanthium* + stylo, followed by 6033 kg ha^{-1} under *Dicanthium* + *Clitoria* intercropping system. Considering the high protein content in the fodder of legume, the quality of fodder produced under intercropping system would be more nutritious than produce of grass alone.

Fodder Production with Limited Irrigation

Oat-pearl millet sequence produced maximum green fodder and oat-sorghum sequence produced maximum dry fodder yield (Table 3.5). WUE was maximum in oat-sorghum sequence. Green and dry fodder yield of all crops was maximum in 50 mm CPE irrigation level while WUE was maximum in 100 mm CPE level.

Table 3.5. Fodder yield and WUE under different cropping systems and irrigation levels

Cropping system	Fodder yield (t ha^{-1})				WUE (kg ha^{-1} mm^{-1})	
	Green		Dry			
	Rabi	Summer	Rabi	Summer	Rabi	Summer
Lucerne	30.6	18.5	4.7	4.7	10.9	11.6
Oat-pearl millet	41.4	27.8	6.9	5.1	17.6	12.5
Cenchrus + lucerne	24.4	20.3	4.2	5.6	10.6	14.5
Oat-sorghum	45.6	22.4	7.4	5.1	18.4	12.5
Irrigation level						
50 CPE	42.3	28.1	6.4	6.2	11.7	23.3
75 CPE	36.2	22.1	6.1	5.2	13.4	28.6
100 CPE	28.0	16.6	4.9	3.9	13.8	32.5

Fodder Production of Kharif Legumes under Different Sequences

Legume crops viz., cowpea, clusterbean, lablab and stylo were grown after summer fodder crops i.e. sorghum, pearl millet and lucerne under limited irrigation. Green and dry fodder yield of legumes were higher when grown after lucerne than after pearl millet and sorghum. Among legumes, clusterbean produced maximum green fodder yield (3030 kg ha^{-1}) followed by cowpea (2960 kg ha^{-1}) and lablab (1070 kg ha^{-1}). However, the growth performance of stylo was very poor.

CROP PHYSIOLOGY

Effect of Foliar Spray of Iron and Zinc on Wheat and Mustard

Foliar spray of iron and zinc as the aqueous solution of their sulphate salts at post flowering stage of both wheat and mustard reflected concentration and species dependent response. High concentrations (0.5 and 1.0%) of both zinc and iron sulphate resulted in deleterious effect on plant growth in the current season. There was a definite increase in total dry matter accumulation (Fig. 3.2) in wheat plants foliar sprayed with 0.25% Fe, 0.125% Zn and 0.25% Zn but there was poor partitioning towards grain resulting in lower harvest index compared to water sprayed control. In mustard, however, positive response of 0.125% Fe and 0.25% Zn with respect to dry matter accumulation was also associated with high harvest index. In these treatments the leaf metabolite contents (total soluble carbohydrates, starch free amino acids and protein) at reproductive stage did not corroborate with the trends in yield. Relative water content of leaves was, however, higher in foliar sprayed plants compared to water sprayed control.

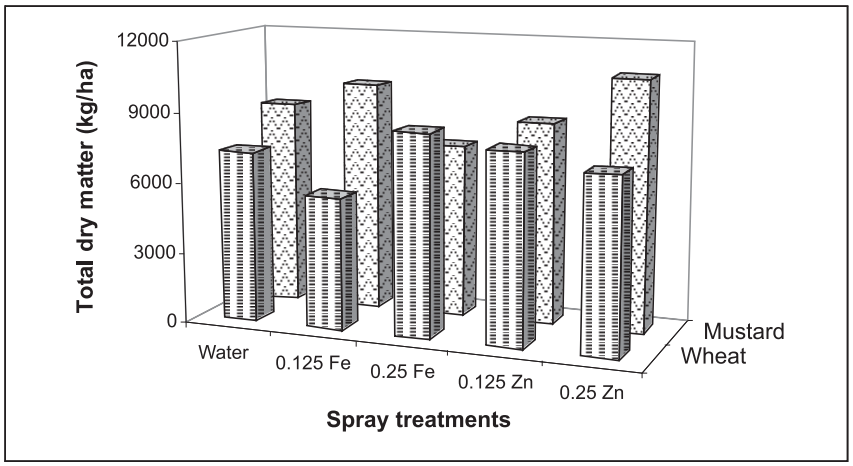


Fig. 3.2. Effect of iron and zinc foliar sprays on dry matter accumulation of wheat and mustard.

Effect of High Temperature on Wheat and Mustard

Wheat (var. Raj 3077) and mustard (var. Pusa Jai Kisan) were subjected to high temperature at two growth stages i.e. 5-6°C increase in ambient temperature at flowering stage and 8-10°C increase at maturation stage. Such an exposure at flowering stage resulted in plant water deficit. Consequently treated plant recorded 6-8 bars lower plant water potential than corresponding control maintained at normal temperature (N). This was associated with drop in relative water content (RWC), reduction in the activity of nitrate reductase (NR) and content of total soluble carbohydrate and starch in leaves. The deleterious effect of high temperature (H) was more pronounced in mustard compared to that in wheat.

Exposure at maturation stage resulted in further reduction in plant water potential in both the crops which was associated with reduced total soluble carbohydrate and starch in wheat leaves. In contrast mustard reflected an opposite trend probably due to non-utilization of carbohydrate-C skeleton for lipid synthesis at this stage. Approximately 56-58% reduction in total dry matter and 70-72% reduction in yield was recorded in mustard exposed to high temperature at either stage. Corresponding values for wheat were 38-40% and 53-59%, respectively.

Effect of High Temperature on Pearl Millet and Clusterbean

In a pot experiment, one set of both pearl millet and clusterbean plants were exposed to high ambient temperature while other was kept under normal condition. Sampling was done thereafter to analyze the effect of high temperature on different metabolites. At a later stage both these sets were sub-divided into two groups each wherein one sub-set was subjected to water stress by withholding irrigation while another was given normal irrigation. Exposure to high temperature at vegetative stage imparted tolerance with respect to metabolite/process against water stress imposed at later stage. Similar trend was observed with respect to total dry matter accumulation and yield in pearl millet. Clusterbean yields, however, did not reflect such an imparted tolerance (against water stress due to pre-exposure to high temperature at an early stage). Further, clusterbean was more sensitive to either stress than pearl millet with respect to plant water potential, RWC, leaf soluble carbohydrate. Nitrate reductase activity was, however, more drastically reduced in pearl millet than clusterbean under either stress.

Effect of Pre-sowing Seed Treatments on Performance of Cumin Crop

Irrigation at 7 DAS gave significantly higher emergence index (EI), total biomass and seed yield of cumin compared to irrigation given at 14 DAS. In 7 DAS irrigation treatment, EI was 42 and 46% more than control when seed treatment was given with GA100 and GA250, respectively. Seed priming in water and soil gave 22 and 18% higher EI than control. Seed treatment with GA100, GA250, Thio250 and Thio500 ppm increased seed yield by 47, 32, 28 and 18% over control when irrigation was given at 7 DAS, while seed priming in soil and water gave 5 and 9% more yield than control. Seed treatment with GA100, GA250, Thio250 and Thio500 ppm resulted in 48, 31, 27 and 19% more biomass production compared to the biomass obtained without seed treatment in 7 DAS irrigation treatment. The B:C ratio was negative in all the treatments when irrigation was given at 14 DAS. In 7 DAS irrigation treatment, seed treatment with GA100 and GA250 ppm gave B:C ratio of 0.23 and 0.07, while seed treatment with Thio250 and Thio500 ppm gave B:C ratio of 0.10 and 0.01, respectively.

Effect of Temperature and Salinity on *Acacia jacquemontii*

Germination percentage (G_F): Temperature, salinity and their interaction had significant influence on the final germination percentage (G_F). Among the tested temperatures, highest G_F was recorded at 20-25°C. Maximum germination was observed under non-saline control and salinity had significant inhibition ≥10 dS m^{-1}, and at given level of salinity the inhibition is more pronounced at higher temperature.

Seedling growth: Seedling growth of *A. jacquemontii* showed significant response to temperature and salinity. The maximum seedling growth was recorded at 25°C and decreased significantly with increase in temperature. Across the salinity levels, the reduction in seedling growth at 20 and 30°C was 10.1 and 28.3% compared to 25°C. The reduction in seedling growth was more at higher temperature (30°C) than at low temperature (20°C). Salinity inhibited the seedling growth compared to non-saline control. Temperature modified the influence of salinity on seedling growth and salinity induced inhibition was more pronounced at higher temperature (30°C) at any given level of salinity.

Seedling vigour index: Temperature, salinity and their interaction had significant influence on seedling vigour index. The maximum vigour was recorded at 25°C and decreased at low and high

temperature. The reduction in vigour was more at 30°C than at 20°C. Salinity decreased the seedling vigour index. The inhibitory effect of salinity on vigour changed with shift in temperature, the inhibition of vigour was higher at high temperature at any given salinity level.

Growth of *A. jacquemontii* in field: The growth attributes showed response to planting density, and there were decrease in growth with an increase in planting density. The difference in canopy area between 1000 and 2000 plant ha^{-1} was not pronounced, however the canopy area with 3000 and 4000 plant ha^{-1} was 31.4 and 35.5% less compared to 1000 plant ha^{-1}. Canopy volume showed remarkable decrease with an increase in planting density, and its value at 2000, 3000 and 4000 plant ha^{-1} were 7.9, 37.7 and 42.8% less compared to 1000 plant ha^{-1}.

Role of Sulphydryl Compounds for Improving Crop Productivity of Arid Legumes in Water Deficit Conditions

Water relation and biochemical parameters: Application of sulphydryl compounds showed significant influence on relative water content (RWC), water potential (Ψw), membrane stability (MSI), lipid peroxidation (LPO) and total chlorophyll (Total Chl) content in leaves of clusterbean at 50 DAS (Table 3.6). The highest increase in RWC, Ψw, and MSI was found with the application of 400 ppm TGA followed by 1000 ppm TU. The highest improvement in water potential was observed with application of 400 ppm. The maximum increase in MSI was found with 400 ppm TGA (16.5%), 1000 ppm TU (14.3%), 300 ppm TGA (13.3%), 750 ppm (12.2%), 200 ppm TGA (10.1%) and 500 ppm (9.4%).The total Chl content and lipid peroxidation were varied from 1.93 to 2.41 mg g^{-1} and 7.70-9.33 μ mol g^{-1} FW, respectively.

Table 3.6. Effect of sulphydryl compounds on relative water content (RWC), water potential (Ψw), membrane stability index (MSI), chlorophyll (Chl) content and lipid peroxidation (LPO) in leaves of clusterbean

Treatments	RWC (%)	Ψw (-MPa)	MSI (%)	Total Chl (mg g^{-1} FW)	LPO (μmol $MDAg^{-1}$ FW)
Control	66.20 ± 1.07	2.93 ± 0.08	60.15 ± 1.03	1.93 ± 0.08	9.33 ± 0.21
TGA 200 ppm	74.11 ± 1.48	2.58 ± 0.06	66.22 ± 1.56	2.26 ± 0.09	8.08 ± 0.29
TGA 300 ppm	74.43 ± 1.58	2.47 ± 0.09	68.17 ± 1.47	2.36 ± 0.09	7.87 ± 0.26
TGA 400 ppm	75.99 ± 1.06	2.39 ± 0.05	70.06 ± 1.01	2.39 ± 0.06	7.57 ± 0.29
TU 500 ppm	73.02 ± 1.41	2.61 ± 0.08	65.80 ± 1.78	2.28 ± 0.06	8.26 ± 0.25
TU 750 ppm	74.58 ± 1.39	2.53 ± 0.08	67.48 ± 1.86	2.32 ± 0.07	7.96 ± 0.20
TU 1000 ppm	74.97 ± 2.00	2.44 ± 0.10	68.76 ± 1.01	2.41 ± 0.06	7.70 ± 0.31

Antioxidant enzymes activity: The application of –SH compounds significantly influenced the activity of antioxidant enzymes viz. catalase (CAT), ascorbate peroxidase (APOX), guiaicol peroxidase (GPOX), superoxide dismutase (SOD) and glutathione reductase (GR) in leaves as compared to water spray control at 50 DAS. The highest increase in activities of CAT, APOX and GPOX with the application of 400 ppm TGA and maximum increase in activities of SOD and GR was resulted with 1000 ppm TU. The respective increase in CAT activity was 57.6, 50.7, 49.9, 40.2, 35.9 and 23.5% over control. The application of 1000 ppm TU showed highest increase in SOD and GR activities followed by 400 ppm TGA, 1000 ppm TU, 300 ppm TGA, 750 ppm TU, 200 ppm TGA and 500 ppm TU (Table 3.7).

Gas exchange parameters: The application of –SH compounds showed significant ($P<0.05$) influence on gas exchange parameters i.e. net photosynthetic rate (Pn) and stomatal conductance (gs) at flowering stage. The Pn had range: 11.14-15.10 μ moles m^{-2} s^{-1}, being highest with application of 400 ppm TGA (38.1%), followed by 1000 ppm TU (35.5%), 300 ppm TGA (31.0%), 750 ppm TU (28.6%), 500 ppm TU (26.5%) and 200 ppm TGA (22.9%). Application of sulphydryl compounds brought 16.47 to 39.97% improvement in stomatal conductance over water spray control. The highest increase in gs was recorded with 1000 ppm TU (40.0%) followed by 400 ppm TGA (35.2%), 300 ppm TGA (29.6%), 750 ppm TU (24.5%), 500 ppm TU (17.6%) and 200 ppm TGA (16.5%) over control.

Table 3.7. Effect of sulphydryl compounds on catalase (CAT), ascorbate peroxidase (APOX), guiaicol peroxidase (GPOX), superoxide dismutase (SOD and glutathione reductase (GR) in leaves of clusterbean

Treatment	CAT (μ mol min^{-1} mg^{-1} protein)	APOX (μ mol min^{-1} mg^{-1} protein)	GPOX (μ mol min^{-1} mg^{-1} protein)	SOD (U mg^{-1} protein)	GR (μ mol min^{-1} mg^{-1} protein)
Control	8.56 ± 0.72	1552.0 ± 118.8	983.9 ± 77.1	15.17 ± 0.80	16.42 ± 1.66
TGA 200 ppm	10.57 ± 0.99	1891.1 ± 92.1	1263.2 ± 85.5	19.08 ± 0.91	22.91 ± 1.48
TGA 300 ppm	12.83 ± 0.66	2139.2 ± 114.3	1381.3 ± 75.3	19.68 ± 0.99	24.03 ± 1.24
TGA 400 ppm	13.49 ± 0.83	2374.3 ± 104.1	1501.3 ± 71.7	20.48 ± 0.46	25.23 ± 1.00
TU 500 ppm	11.63 ± 0.86	1971.1 ± 130.0	1204.5 ± 50.3	18.86 ± 1.07	21.91 ± 1.38
TU 750 ppm	12.00 ± 0.71	2094.7 ± 110.8	1409.7 ± 82.3	19.29 ± 0.76	23.20 ± 1.26
TU 1000 ppm	12.90 ± 0.67	2203.0 ± 132.4	1444.0 ± 90.4	21.56 ± 1.20	26.47 ± 0.92

Energy and Mass Exchange in Arid Grassland System

Seasonal energy balance studies: Decadal (10-days) analysis of half-an-hourly micro-meteorological data recorded from February to November 2011, showed that daytime average net radiation (*Rn*) varied from 196 to 369 Wm^{-2} with the highest coincident to the start of the withdrawal of south-west monsoon and lowest in the month of November. Bowen ratio was very high (1.5 to 3.0) during most of study period with dips (0.15-0.46) during the wet spells. Similarly, the decadal albedo shows a higher magnitude (0.23 to 0.35), highest (0.39) in the month of April and lowest (0.15) in the month of September when green grass growth was at peak. This might have led to a significant complementary exponential relation ($Y=0.045e^{12.13X}$, $R^2 = 0.65$) between decadal albedo and Bowen ratio. The soil heat flux (G) varied between 35 and 60 Wm^{-2} with significant lowering during peak grass growth period in September. The daytime average decadal latent flux for evapotranspiration showed significantly lower magnitude between 90-210 Wm^{-2} with prominent peak coincident to peak growth stage. A cross calibration was made between Potential Evapotranspiration (PET) estimates from less data intensive Priestly-Taylor (P-T) and data intensive Penman-Monteith (P-M) approaches. This yielded a linear predictive model ($Y = 0.730X + 20.18$, $R^2 = 0.93$). The relative ET (AET/PET), an indicator of soil moisture availability, showed prominent peak at 0.85 coincident to south-west monsoon spells (Aug. 3rd to Sept.1st). On the contrary, a notable second peak at 0.7 during November 1st decade but preceded and succeeded by low RET in the dry-down phase could be due to low Bowen ratio caused by advection during seasonal transition leading to temporary reversal of low trend of latent heat fluxes. It showed a low range (0.25 to 0.4) during rest of the period representing prevailing soil dryness.

Physiological responses of perennial grasses to diurnal micrometeorological conditions: Three perennial grass species viz., *Lasiurus sindicus*, *Panicum antidotale* and *Cenchrus ciliaris* showed bimodal distribution in their diurnal photosynthetic rates with first peak in morning hours (13.88 and 13.67 µmol CO_2 m^{-2} s^{-1}) and second but bigger peak during afternoon hours (18.86 and 17.28 µmol CO_2 m^{-2} s^{-1}). The *L. sindicus* showed maximum water use efficiency (WUE) during morning and evening hours but *P. antidotale* and *C. ciliaris* had maximum WUE only during morning hours. Consequently, radiation use efficiency (RUE) of all the three species showed similar trend viz., minimum (0.43, 1.03, 1.09 g MJ^{-1}) during afternoon hours and peaks (2.96, 5.39 g MJ^{-1}; 3.53, 2.03 g MJ^{-1}; 3.04, 2.12 g MJ^{-1}) at morning and afternoon hours. The diffuse fraction was also found to have sharp bimodal trend (15-51%) with peaks in the morning and late afternoon. Combination of higher diffuse fraction and lower ambient temperatures in the morning and afternoon hours in contrast to noon hours might have resulted into generalized bimodal trend in the RUE of *L. sindicus* and *C. ciliaris*. However, *P. antidotale* showed somewhat different physiological response as it showed only one peak (24.3 µmol CO_2 m^{-2} s^{-1}) during diurnal cycle but at the same time it showed higher daytime average leaf-scale net photosynthetic rate (10.75 µmol CO_2 m^{-2} s^{-1}) than *L. sindicus* (7.66 µmol CO_2 m^{-2} s^{-1}) and *C. ciliaris* (8.04 µmol CO_2 m^{-2} s^{-1}). The study showed that the magnitude of physiological responses of grass species differed largely to the given microclimatic regime.

FARMING SYSTEM

Performance of Dry Land Crops in Agroforestry Systems

Highest grain and fodder yields of pearl millet (var. ICPT-8203) were recorded in *Prosopis cineraria* based production system (Table 3.8). However, the mung bean (var. SML-668) showed highest productivity in *Z. mauritiana* (cv. Gola) based production system. In general, the long duration varieties of dry land crops showed better performance than the short duration varieties, mainly because of adequate moisture availability and better utilization during anthesis and pod development. Amongst various farming system components the crop performance in general was lower in arable farming system than the other two components (Table 3.8).

Table 3.8. Grain and fodder yield (kg ha^{-1}) of annual crops in agroforestry system

Crop	Variety	Arable		Khejri		Ber	
		Grain	Fodder	Grain	Fodder	Grain	Fodder
Pearl millet	HHB-67	2050	5150	2100	5200	2000	5000
	ICPT-8203	2450	5350	2500	6000	2300	5000
Mung bean	SML-668	375	3150	400	3300	418	3650
	K-851	175	3050	183	3100	200	3175
Moth bean	RMO-435	195	3050	280	3100	293	3450
	CAZRI-3	170	3050	180	3350	195	3500
Clusterbean	RGC-936	210	2250	200	2150	190	2050
	RGM-112	200	2200	195	2100	180	2000
Cowpea	V-585	390	2260	418	2430	460	2650

Accordingly, the net returns (Rs. ha^{-1}) and B:C ratio were also higher in *P. cineraria* + pearl millet var. ICPT-8203 (Rs. 32290, 2.42) and *Z. mauritiana* + mung bean var. SML-668 (Rs. 17555,

2.01) systems. However, the economic gains were lower in moth bean and cowpea as compared to all other crops under study (Table 3.9). In contrast to other crops the yield and economic gains in clusterbean were higher in arable farming system, ascribed mainly to better soil moisture and solar radiation utilization.

Table 3.9. Net returns (Rs. ha^{-1}) and B:C ratio of crops in agroforestry systems

Crop	Variety	Sole cropping		*P. cineraria* + crops		*Z. mauritiana* + crops	
		Net returns	B:C	Net returns	B:C	Net returns	B:C
Pearl millet	HHB-67	25175	2.19	25565	2.19	24105	2.15
	ICPT-8203	28900	2.29	32290	2.42	25830	2.17
Mung bean	SML-668	14025	1.84	15320	1.89	17555	2.01
	K-851	6430	1.41	6820	1.43	7685	1.47
Moth bean	RMO-435	4215	1.25	6480	1.37	8440	1.48
	CAZRI-3	3645	1.22	5265	1.31	6285	1.37
Clusterbean	RGC-936	13085	2.31	12215	2.24	11530	2.22
	RGM-112	12385	2.24	11870	2.23	11020	2.19
Cowpea	V-585	5220	1.29	6500	1.36	8375	1.45

Albedo in arable farming system varied from 15.6 to 21.9%. The maximum albedo was observed at a canopy surface of moth bean (21.9%) and the lowest was for pearl millet (15.6%). The net radiation under arable crops varied from 24.7 to 36.9 W m^{-2}. The soil moisture content was higher in cowpea than other crops. It was due to higher ground coverage by cowpea leaves than other crops. In general throughout the crop growth period moisture content was on an average 30% higher in sub surface layer (15-30 cm) than the surface layer.

Productivity of *Z. rotundifolia* and *C. mopane* based Silvi-pasture Systems

During 2011, the grass component in *Z. rotundifolia* based silvi-pasture system showed very high forage yield (6 t ha^{-1}). After assessment of carrying capacity of the silvi-pasture the grazing of 16 growing *Tharparkar* cattle (8 females + 8 males) has been introduced on 1.5 ha area having tree density (90 plants ha^{-1}). The grazing helped enhance the body weight of test animals' upto 40 days, thereafter it showed declining trend. Hence it was concluded that the pasture could sustain 520 adult cattle units. Further during the grazing period as per norms they were supplemented with concentrate mixture (1.0 kg^{-1} day^{-1} animal^{-1}) having 19.4% crude protein and 70% total digestible nutrients.

Silvi-pasture system with *C. mopane* (1.0 ha) was kept for seed production. Besides 250 kg seed the pasture could yield 9.0 t ha^{-1} of forage, thereby revealing no adverse effect of tree component on the grass productivity. Further from pruning of trees 1392 kg of leave and 2726 kg of fuel wood also could be realized (60 trees ha^{-1}). Soil chemical analysis in the silvi-pasture system revealed that the pH increased from 8.34 to 8.64 in 0-15 cm and 8.54 to 8.70 in 15-30 cm soil depth between initial growth stages to maturity. However the trend was not perceptible in pure pasture of *C. ciliaris*.

Forage Production under Silvipastoral System

The height and canopy area of *C. mopane* were higher when grown in association with cowpea and grasses in strip cropping however, the growth of *H. binata was* variable with cropping

system (Table 3.10). Maximum green and dry fodder yields were recorded with *C. ciliaris*, which were significantly higher than grass-legume strip cropping. The low yield in strip cropping was due to low productivity of cowpea as compared to *C. ciliaris* and *L. sindicus*. The dry matter production of *C. ciliaris*, *L. sindicus* and cowpea decreased up to two rows from trees and thereafter it was less affected in silvipastoral system with 10-year-old trees of *H. binata* and *C. mopane*.

Table 3.10. Effect of cropping system on tree growth and fodder yield under silvipastoral systems

Cropping system	*C. mopane*			*H. binata*		
	Plant height (cm)	Canopy area (sq. m/tree)	Dry fodder yield (q ha^{-1})	Plant height (cm)	Canopy area (sq. m/tree)	Dry fodder yield (q ha^{-1})
C. ciliaris (Cc)	309	6.9	18.7	333	3.9	26.4
L. sindicus (Ls)	294	8.7	20.0	303	1.9	18.6
Cc + cowpea	315	8.8	10.9	326	5.4	16.9
Ls + cowpea	334	9.8	16.8	340	3.8	15.8

Economics of Agroforestry Models Developed with Organic Inputs in Arid Zone

In silvipasture system, except drought year of 2009 there was profit of Rs. 1300 and 1700 ha^{-1} with the application of 2.5 t ha^{-1} and 5.0 t ha^{-1} manure, respectively. In agrisilviculture system of *Z. rotundifolia* and pearl millet, B:C ratio was 1.16, 1.29 and 1.5 with application of manure @ 0.0 t ha^{-1}, 2.5 t ha^{-1} and 5.0 t ha^{-1}. However, highest profit of Rs. 10902 ha^{-1} was obtained with the application of 5 t ha^{-1} manure in crop and 10 kg $plant^{-1}$ in *Z. rotundifolia*.

In *Z. rotundifolia* and clusterbean system B:C ratios were 1.79, 3.06 and 2.74 with the application of manure @ 0.0, 2.5 and 5.0 t ha^{-1}. However, highest profit of Rs. 27996 ha^{-1} was obtained with the application of 5.0 t ha^{-1} manure. This shows that if there is limitation of manure, application of 2.5 t ha^{-1} manure is recommended. Although profitability will increase upto 5.0 t ha^{-1} manure application, if available.

System Productivity of *P. cineraria* based Agroforestry System with Organic Inputs

The weed biomass increased (at initial stage) with the increasing dose of manure mainly due to better moisture and nutrient availability. However, after first weeding at 25-30 days this trend reversed due to better crop growth that suppressed the weeds. The weed biomass available from first weeding was used as mulch which also suppressed growth of weed but promoted crops.

Crop growth and yield of pearl millet and clusterbean increased with the increase in dose of manure and highest yield of pearl millet 1031.6 kg ha^{-1} and clusterbean 643.8 kg ha^{-1} were recorded with the manure application @ 5.0 t ha^{-1}. *P. cineraria* showed favorable effect on the growth and yield of pearl millet and increased yield by 12.8% while in case of clusterbean no such difference was observed, as compared to sole crop.

Response of Different Ber Cultivars to Top-working on Senile Trees

Thirty-three-year-old unproductive, damaged trees of ten different cultivars, which were giving negligible yield, were headed back from ground level leaving rootstock portion in the month of May-June. Numerous shoots emerged 12-15 days after heading back but only three healthy shoots were selected and rest were thinned out whenever appeared. Buds were taken from healthy and productive trees of same ten cultivars and were budded on selected shoots during July-August. Bud take success ranged from 78% in Kaithali to 100% in Gola, Seb, Umran, Thornless

and Aliganj. However, duration of bud take ranged from 10 days in Jogia and Thornless to 15 days in Chhuhara and Aliganj (Plate 16). Growth performance of top worked trees revealed that cv. Thornless attained maximum height (1.39 m) and secondary branches (6.5) followed by Gola (1.16 m and 6.2), whereas diameter of main shoot was maximum in Seb (1.42) followed by Thornless (1.4) and Gola (1.35). Except Chhuhara, all the cultivars started flowering even in first year of rejuvenation.

Soil Moisture Conservation Studies in *Pongamia pinnata* and Henna based Agroforestry in Pali Region

During seventh year of *P. pinnata* plantation (8 x 4 m and 5 x 4 m spacing) mean annual increment of 72 cm in plant height and 0.6 cm in collar diameter were recorded. In casualty replacement plantation overall 93.8% establishment after five months of rainy season was observed. *Cenchrus setigerus* (CAZRI-76) intercropped with *Pongamia* gave forage yield of 13697.5 kg ha^{-1} with dry matter production of 2150.5 kg ha^{-1}. Continuous trench (0.4 m wide and 0.75 m depth) to harvest the runoff slightly improved the collar diameter (1.9 cm) of *P. pinnata* over no trench (1.6 cm). Higher density plantation recorded more plant height (120.0 cm) and collar diameter (1.9 cm) as compared to low density plantation (plant height 104.4 cm and collar diameter 1.7 cm).

Eight-year-old henna plant height varied from 107.5 cm to 143.5 cm and branches $plant^{-1}$ varied from 7.7 to 11.9 (Table 3.11). The maximum henna dry leaf weight was recorded in 3 m wide henna alley followed by 6 m wide henna alley; whereas, the maximum dry leaf yield of 1741.0 kg ha^{-1} was recorded under sole henna followed by strip cropping (1419.62 kg ha^{-1}). Intercropped clusterbean recorded highest yield (139.6 kg ha^{-1}) as sole followed by strip cropping (126.3 kg ha^{-1}) and clusterbean: henna (1:5) treatment (120.7 kg ha^{-1}).

Table 3.11. Yield attributes, dry leaf yield of Henna and clusterbean seed yield under henna-clusterbean intercrop

Treatment	Plant height (cm)	Branches per plant	Dry leaf yield		Clusterbean seed yield (kg ha-1)
			(g m^{-1})	(kg ha^{-1})	
Clusterbean: henna (1:1)	124.6	9.3	306.7	1271.3	48.7
Clusterbean: henna (1:2)	115.9	7.8	218.7	1067.6	37.7
Clusterbean: henna (1:3)	107.5	7.7	201.3	1004.9	15.3
Clusterbean: henna (1:5)	143.5	11.9	236.7	781.6	120.7
3 m wide alley	130.0	9.6	422.7	833.3	94.9
6 m wide alley	131.2	10.4	343.3	735.1	112.4
2.4 m strip cropping	129.4	8.4	310.9	1419.6	126.3
Sole henna	129.3	9.0	329.8	1741.0	-
Sole clusterbean	-	-	-	-	139.6
CD (P=0.05)	11.4	0.88	32.2	113.0	12.2

Agri-horti-silvi System with Sprinkler Irrigation

Highest plant height of citrus and mopane was recorded with intercropping of clusterbean where as in shisham it was highest with intercropping of mung bean. All the trees showed significantly higher plant height over no intercropping which was 15.38, 9.5 and 11.67% higher over their sole planting. Highest stem girth and canopy of citrus and mopane was observed with

Plate 16. Response of different ber cultivars to (a) Top-working on senile trees, (b) Heading back from ground level in May end, (c) Thinning of newly emerged shoots and select only 2-3, (d) Budding in July with selected varieties and (e) Fruiting in first year.

the intercropping of mung bean which was 45.24,18.18% higher of stem girth and 39.48,19.54% higher in canopy, respectively over no intercropping.

Mung bean and clusterbean were intercropped in between the interspaces of trees showed that the plant height, number of branches per plant and number of pods per plant was highest under the intercropping with citrus followed by shisham and lowest was with mopane. Highest total biological yield of mung bean (1412 kg ha^{-1}) and clusterbean (1352 kg ha^{-1}) was recorded under intercropping with citrus which was higher over intercropping with shisham (mung bean 1158 and clusterbean 1114 kg ha^{-1}) and mopane (mung bean 775 and clusterbean 517 kg ha^{-1}), respectively.

The highest chlorophyll content in clusterbean (2.44 mg g^{-1}) and mung bean (2.62 mg g^{-1}) and chlorophyll a/b ratio was recorded in intercropping with citrus and lowest was observed in intercropping with mopane. Among different trees the total chlorophyll content was highest in mopane (2.69 mg g^{-1}) followed by shisham (2.31 mg g^{-1}) and lowest was in citrus (1.58 mg g^{-1}). The highest Leaf area per plant of mung bean (558.5 cm^2 $plant^{-1}$) was recorded under its intercropping with citrus which was 150.9% higher over intercropping with mopane but was found to be at par with shisham.

Highest leaf water potential was in clusterbean (-3.18 MPa) and mung bean (-3.28 MPa) in intercropping with mopane which was 18.7, 24.2 and 41.4, 62.9% higher over their intercropping with shisham and citrus, respectively. Among different trees (in November) highest leaf water potential was observed with mopane (-6.99 MPa) followed by citrus (-5.51 MPa) and shisham (-3.58 MPa). The highest leaf water potential of mopane was due to more water requirement resulting absorption of more soil water and providing more stress for water to the intercrops.

Agri-horti System under Drip Irrigation System

The highest plant height of citrus and bael was recorded with intercropping of moth bean whereas in gonda it was with clusterbean. The plant height of citrus, bael and gonda were significantly higher by 9.5, 34.0 and 54.4% higher over their sole cropping. Highest stem girth of all the fruit trees was recorded with intercropping of moth bean, which was 117.5, 27.0 and 105% higher over their sole cropping. The canopy was highest with intercropping of clusterbean which was significantly higher over the intercropping of moth bean and also without intercrop planting.

Growth and yield attributing characters of mung bean and clusterbean were lowest in intercropping with mopane whereas these were highest with intercropping in citrus followed by shisham. Highest total biological yield of moth bean (1563.7 kg ha^{-1}) and clusterbean (1262.5 kg ha^{-1}) was recorded with the intercropping with bael which was 42.97, 5.74 and 13.91, 6.31% higher over intercropping with citrus and bael, respectively. In moth bean the effect of fruit trees were found to be non-significant effect on seed yield but in clusterbean the significantly lower seed yield (15.02%) was in intercropping with citrus than bael.

Ber based Oleri-horti Models in Arid Region

The growth and yield attributes of pea were significantly higher with drip irrigation compared to furrow method. Averaged across all mulching treatments, the leaf area per plant and pods per plant with drip irrigation were 14.9 and 20.9% more than furrow irrigation. Drip irrigated pea gave significantly higher pod yield than furrow irrigation and averaged across all mulching treatments the pod yield under drip irrigation were 17.9% more than furrow irrigation.

Growth, yield attributes and yield of pea showed significant response to mulching. Plant height under various mulch materials varied from 53.1-67.4 cm, and plant height with plastic, hessian cloth and indigenous material were 29.6, 19.3 and 10.6% higher compared to no-mulch. Mulching improves the leaf area by 14.6-37.7% and pod per plant by 15.5-40.7%; being highest with plastic mulch and lowest with indigenous plant material. The pod yield with plastic, hessian cloth and indigenous plant materials were 36.4, 24.3 and 15.6% higher than no-mulch.

Interaction of irrigation method and mulching had significant influence on growth, yield attributes and yield of pea. The pod yield varied from 4.92-8.62 t ha^{-1}, being highest under drip irrigation with plastic mulch. The effectiveness of mulch varied with method of irrigation i.e. the plastic and hessian cloth mulch improved pod yield by 28.1 and 19.5% compared to no-mulch with furrow irrigation, whereas the improvement under respective mulch under drip irrigation were 21.6 and 12.9% respectively. The lowest pod yield is recorded with furrow irrigation without mulch.

Effect of Supplementary Irrigation and Mulching in Ber

An observation trial was conducted on the effect of supplementary irrigation and mulching on fruit yield and physic-chemical characteristics of ber var. Gola. Mulching and supplementary irrigation caused significant improvement in canopy area, mean fruit weight, fruit yield and TSS and reduction in weed population (Table 3.12).

Table 3.12. Effect of mulching and supplementary irrigation on plant growth, fruit yield and physico-chemical characteristic of ber var. Gola

Treatments	Plant height (m)	Canopy area (m^2)	Weed population	Fruit weight (g)	Fruit length (mm)	Fruit breadth (mm)	Pulp: Stone ratio	TSS (°Brix)	Fruit yield (kg $plant^{-1}$)
T_1	1.38	7.56	164.3	16.39	31.7	31.5	8.50	18.9	23.6
T_2	1.70	9.30	23.7	19.23	61.7	30.4	8.60	19.2	23.8
T_3	1.36	9.86	1.3	19.40	34.0	32.8	9.60	19.4	26.8
T_4	1.48	9.75	154.7	18.26	33.8	32.7	10.53	18.3	23.2
T_5	1.15	10.35	52.0	15.20	31.3	31.0	8.70	15.2	32.3
T_6	1.23	12.78	2.7	18.43	33.2	32.3	10.00	18.4	33.9
T_7	1.43	11.34	141.7	19.43	32.9	31.6	9.56	19.4	28.7
T_8	1.20	11.23	22.7	19.90	33.9	32.2	9.46	19.9	33.7
T_9	1.43	11.97	2.0	18.00	32.3	32.0	9.13	18.0	27.3
T_{10}	1.08	10.24	89.3	19.86	32.5	33.7	8.96	19.9	26.8
T_{11}	1.43	10.92	47.3	18.00	32.0	31.5	8.97	18.0	27.3
T_{12}	1.23	10.92	3.0	17.43	31.6	31.0	9.13	17.4	29.8
CD(p=0.05)	NS	13.35	42.9	1.75	NS	NS	1.66	1.8	3.4

T_1- Control (No irrigation, no mulch), T_2- Mulching (date palm leaves), T_3- Black polythene mulch, T_4- Irrigation at 60 CPE, T_5- Irrigation at 60 CPE + datepalm leaves mulch, T_6- Irrigation at 60 CPE + polythene mulch, T_7- Irrigation at 90 CPE, T_8- Irrigation at 90 CPE + date palm leaves mulch, T_9- Irrigation at 90 CPE + polythene mulch, T_{10}- Irrigation at 120 CPE, T_{11}- Irrigation at 120 CPE + date palm leaves mulch, T_{12}- Irrigation at 120 CPE + polythene mulch.

The weed population was negligible where ever black polythene mulch was applied and date palm leaves also reduced the weed intensity. The highest fruit yield of about 34 kg per plant was with irrigation at 60 CPE and with polythene mulching, though same level of fruit yield could be obtained with same level of irrigation with date palm leaves mulching (T5) and irrigation at 90 CPE and date palm leaves mulch (T8). Hence on the basis of the results obtained it could be

concluded that supplementary irrigation at 60 CPE from September to November with mulching is beneficial in ber for obtaining higher fruit yield.

Effect of Pruning Time on Ber Productivity

Pruning of ber var. Gola at 10 days interval from May to July exhibited significant effect on vegetative growth, fruit set, fruit yield and quality. The canopy area differed significantly owing to pruning date. Pruning on 13th June resulted in significant increase in fruit set and decreased fruit drop which ultimately resulted in high fruit yield (75.4 kg plant^{-1}).

Ber Pollinators

Twenty six species of insects (10 Lepidoptrans, 2 Dipterans, 6 Hymenopterans, 3 coleopterans, 1 Orthoptera, 1 Odonata, 1 Dictyoptera, and 2 Hemipterans) were observed visiting flowers during the peak flowering season. The Dipterans (*Musca domestica*, *Stomoxys calcitrans*, *Chrysomyia* sp., *Sarcophaga* sp., *Eristalinus punctulatus*) were the most active pollinators followed by Hymenopterans (*Polistes hebraeus, Apis cerana, Apis dorsata*). Maximum activity of major pollinators was recorded during 8.00-14.00hrs. Highest number of visits was recorded in *Musca domestica* (18.67 per flower) followed by *Stomoxys calcitrans* (13.55 per flower), *Polistes hebraeus*, *Chrysomyia* sp., *Sarcophaga* sp. (13.33 per flower) and *Apis cerana* (13.00 per flower).

Ailanthus excels based Silvi-Agri-Pastoral System

Across all the spacing the survival percentage of trees was 80% at 5½ year age. Trees attained average height of 396.0, 399.0 and 428.0 cm tree-1 in 6 x 6, 8 x 8 and 10 x 10 m spacing, respectively (Table 3.13). Collar diameter (CD) growth also followed similar trend with maximum being in 10 x 10 m spacing and minimum for 6 x 6 m spacing. Mean annual increment (MAI) in height was also maximum in 10 x 10 m spacing, which was 8.0% and 7.2% higher than the values obtained in 6 x 6 and 8 x 8 m spacing, respectively. Collar diameter increment exhibited more sharp variation among different spacing as far as MAI is concerned. MAI in collar diameter of the trees in 10 x 10 m spacing was 41.6% higher than in case of trees in 6 x 6 m spacing and 20.2% higher than the trees in 8 x 8 m spacing. These data clearly indicated that 10 x 10 m spacing is most suitable for developing diversified system like present one for the overall performance of *A. excelsa* in 300 mm annual total rainfall condition in arid region. The mean canopy cover of A. excelsa at this stage was 4.5, 4.6 and 6.6 m2 tree-1 in 6 x 6, 8 x 8 and 10 x 10 m spacing, respectively.

Table 3.13. Growth patterns of *A. excelsa* under different spacing in silvi-agri-pastoral systems

Spacing (m x m)	Height (cm)		Collar diameter (cm)		Mean basal area	
	Current (cm tree^{-1})	MAI (cm y^{-1})	Current (cm tree^{-1})	MAI (cm y^{-1})	Current (m^2 tree^{-1})	MAI (m^2 tree^{-1} y^{-1})
6 x 6	396.0	77.2	10.10	2.02	80.8	16.2
8 x 8	399.0	79.8	11.90	2.38	110.6	22.1
10 x 10	428.0	85.6	14.30	2.86	160.5	32.1

Performance of goats fed on *A. excelsa* leaves: The initial body weight of T_1 (control) and T_2 (treatment) was 18.4 ± 0.92 and 17.96±1.48, respectively, while final body weight was 20.72±0.88, and 23.66 ± 1.42 kg, respectively. The dry matter intake/100 kg body weight for T_2 was 4.03 kg. The average daily gain (ADG) of T_1 and T_2 was 37.0 and 92.0 g, respectively. It was observed that the glucose level of the group maintained on free grazing and *A. excelsa* was more or less same after a period of 45 days onwards. The other blood parameters like haemoglobin, total protein,

BUN, cholesterol and albumin and the macro minerals calcium and phosphorus were comparable and showed non-significant differences. Thus the feeding of *A. excelsa* top feeds to goat showed high acceptability and palatability, with no adverse effect on health. Moreover, dry matter intake and average daily gain (ADG) were more in animals fed on *A. excelsa* leaves.

Effect of Management Practices and Gum Inducer on Gum Production of *Acacia senegal* in Rocky Land

The conventional practice making blazes on tree trunk (control) in *A. senegal* results in negligible gum production. However, two fortnightly irrigations before treatment resulted in production of gum to the tune of 20 g tree^{-1} in case of half concentration of the normal dose treatment and 46 g tree^{-1} in case of normal dose treatment. Only manuring of the trees resulted in production of 29 and 34 g gum tree^{-1} in half concentration of normal dose treatment and normal dose treatment, respectively. Gum production was 60 g tree^{-1} when half concentration of normal dose was applied with manuring and irrigation which was higher than even normal dose treatment. With little tree management in the form of manuring and watering the concentration of gum inducer can be reduced to the half of normal strength. Moreover, when simple blazes were made on tree trunk (control), the plants produced some gum. This indicated that in rocky and semi-rocky areas where *A. senegal* grows in abundance, tree management practices coupled with gum inducer application can be effective for gum arabic exudation. In case of 100 trees ha^{-1}, such unproductive land form can produce 6 kg gum ha^{-1} which can provide an income of Rs. 3000 to the farmer.

Effect of weather parameters on gum production: An attempt was made to analyze the trend of gum production in *Acacia senegal* with respect to weather conditions after treating the trees with CAZRI gum inducer. The gum production details were obtained from the farmers of 28 households precisely. We worked out on the basis of this study that average gum production per tree was only 338 g as compared to 500 g last year. The major climatic parameters during March and April (main season for gum arabic production) of current year and last year were analyzed, which indicated that maximum and minimum temperature during this year were about 3°C lower than the last year. Perhaps lower temperature did not favor the optimum gum production and this slight decrease in temperature resulted in about 30% reduction in gum arabic production.

Growth Performance and Adaptability of *Acacias* and *Prosopis* in Rajasthan

After 15 years of transplanting the maximum survival was 28.6% in accession no. 1126 of *P. pallida*, 16.6% in case of local collection of *A. senegal*, and 2% of *A. albida.* The logarithmic equations developed by using annual height and collar diameter data shows more resemblance for collar diameter, while its accuracy is less for height.

SOIL FERTILITY AND SOIL MICROBIOLOGY

Decomposability of Mustard Residue

Mustard residues with high ligno-cellulosic materials decompose very slowly in soil under arid conditions. These residues were treated with actinomycetes and mild orthophosphoric acid to break the lingo-cellulosic bonds so as to enhance their decomposition. Four species of actinomycetes, isolated from the farm soil and multiplied in a broth, were added to the mustard residues and the contents were incubated. Mustard residues were also treated with 0.1 N H_3PO_4 and contents were incubated at room temperature. All species of actinomycetes reduced the lignin content of mustard residues. Maximum reduction in lignin content (11.4% over control) was

recorded after inoculation with Species 1 (Fig. 3.3). Phosphoric acid treatment had no effect on lignin content of the residues but decreased cellulose content by 5%.

Pretreatment of mustard residues with either actinomycetes (except spp. 2) or orthophosphoric acid increased their decomposition. Mustard residues treated with orthophosphoric acid had the same lignin content as in control; residues pretreated with orthophosphoric acid decomposed faster than the untreated residues (control) or those treated with any species of actinomycetes (Fig. 3.4). Conversion of cellulose into its monomers after hydrolysis with orthophosphoric acid and its positive effect on decomposers could be a possible reason.

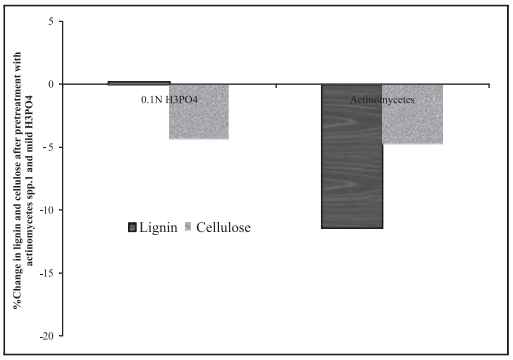


Fig. 3.3. Effect of actinimycetes sp.1 and dilute H_3PO_4 pretreatment on lignin and cellulose content of mustard residue

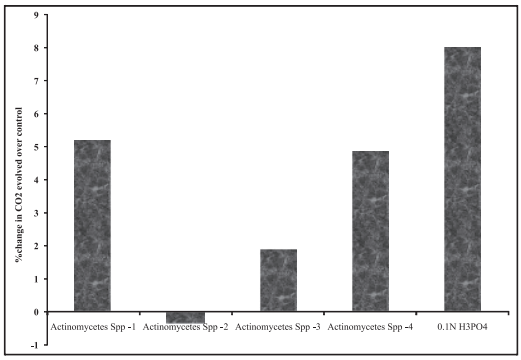


Fig. 3.4. Effect of actinomycetes and mild H_3PO_4 pretreatment on decomposition of mustard residue in soil

Nutrient Dynamics of Leaf Litter and Roots of Predominant Tree Species and their Effect on Crop Production in Agri-Silvi-Horti Systems of Arid Zone

Lignin Content of leaf litters and roots of trees species: Lignin plays important role in litter decomposition. Lignin content in leaf litters of tree species ranged from 12.6 to 34.1%, with highest value in Mopane, from 15.4 to 45.5% in leaf litters of fruit tree species with highest value in Gonda. The corresponding values of lignin in roots ranged from 11.6 to 34.1%, in tree species being highest in shisham and 11.8 to 14.4% in fruit tree species with highest value in citrus.

Effect of leaf litters on crop growth and yield: Application of leaf litters @ 2.5 t ha^{-1} has a significant effect on increase in plant height, number of pods per plant and yield of clusterbean as compared to control. Maximum yield of clusterbean was obtained with the application of leaf litters of citrus and *Aegle marmelos*. Grain yield varied non-significantly with the application of leaf litters of *Cordia myxa* and *Acacia senegal*.

Growth and biomass of tree species: Among the species, there was significant variation in height, collar diameter and biomass. The biomass of 25-year-old tree species ranged from 22.2 to 108.6 kg $plant^{-1}$ on dry weight basis. The highest biomass was observed in *A. tortilis* followed by *A. senegal*. Considering the weight loss during drying, maximum weight loss of 40.5% was observed in the above ground biomass of *C. mopane* and lowest 42.7% in *A. senegal*.

Development of Bacterial P Biofertilizers

A new bacteria *Bacillus coagulans* having excellent phosphatases and phytase activity was isolated from arid soils and tested under greenhouse conditions and in the field in a loamy sand soil (sterilized and non-sterilized soil conditions). Exploitation of plant unavailable (poorly soluble) P was higher in sterilized soil, mainly due to an increased bacterial population. Seed inoculation in

clusterbean influenced acid phosphatase and phytase activity. The depletion of organic P was much higher than the depletion of mineral and phytin P. The microbial contribution to the hydrolysis of the different P fractions was significantly higher than the plant contribution. The maximum effect of inoculation on different enzyme activities (acid phosphatase, alkaline phosphatase, phytase and dehydrogenase) was observed in plants between 5 and 8 weeks of age. A significant improvement in plant biomass (25%), root length (28%), plant P concentration (22%), seed (19%) and straw yield (28%) resulted from inoculation. The results suggested that *B. coagulans* produces phosphatases and phytase, which mobilized P from unavailable native P sources and enhanced the production of clusterbean and may be used as P biofertilizer under loamy sand soil.

Mycorrhizal Induced Saponin Accumulation in Safed Musli Tubers

The amount of saponin accumulated in the tuber of safed musli (*Chlorophytum borivilianum*) was evaluated with or without mycorrhizal inoculation in a greenhouse experiment conducted over 270 day period. Differences in the saponin concentration and the total amount in tuber between the treatment and between the developmental stages were examined. The mycorrizal treatment included three species viz. *Glomus fasciculatum*, *G. intraradices* and *G. mosseae*. The amount of saponin accumulated in tuber increased with growth and it was more under *G. mosseae* infected plants. Mycorrhizae inoculated plants resulted up to 25-fold improvement in saponin content at critical growth stage (45 days) and up to 4-fold improvement at crop harvest compared to non-inoculated plants. *G. mosseae* was found to be most efficient mycorrhizal species. The present results suggest the possibility to stimulate the saponin content by treating the tubers with mycorrhizal inoculation, which improved the therapeutic value of safed musli tubers.

AMFungi Encourage the Drought Tolerance of *C. borivilianum* by Enhancing Antioxidant Enzyme System

The influence of three mycorrhizal inoculums viz., *G. fasciculatum*, *G. intraradices* and *G. mosseae* on superoxide dismutase (SOD), catalase (CAT), glutathione reductase (GR), glutathione-s-transferase (GST), polyphenol oxidase (PPO) and peroxidase (PRO) enzyme activities were evaluated in well-watered and drought stressed conditions. Mycorrhizal plant materials showed higher drought tolerance effect than non-mycorrhizal ones by enhancing antioxidant enzyme activities. Antioxidant activities were more at 180 days of crop harvest. Therefore, it is recommended to harvest *C. borivilianum* roots at 180 days crop age. Moreover, mycorrhizal drought stressed roots showed significantly higher antioxidant activities than the well-watered conditions. Thus, it can be assumed that higher antioxidant activities in roots of mycorrhizal plants might have contributed to alleviate oxidative damage to biomolecules and also, cultivation of *C. borivilianum* with arbuscular mycorrhizae in arid-zone can be a value addition against drought stress.

Nano Technology

Myco synthesis of Zn and Fe nanoparticles: A new technique (fungal protein) was developed for production of nanoparticles from respective salt solution after preparation of fungal ball. Identification of fungi was made as the basis of morphological parameters including spore formation, hyphal colonization and colour after staining with cotton blue dye, and molecular characterization of fungal isolate was performed by partial sequencing of 18S and 28SrRNA and complete sequencing of Internal Transcribed Sequencing 1 (ITS-1).

INTEGRATED LAND AND WATER RESOURCES MANAGEMENT

Influence of Organic Inputs Given to *Azadirachta indica* and *Ziziphus rotundifolia* on Soil Properties

Compost @ 5 kg and 2 kg neem cake were applied every year to *Z. rotundifolia* and *A. indica* trees for six years. There was significant improvement in soil physical condition with manure application (Table 4.1). Microbial property also improved. Infiltration rate (IR) was less with manuring probably due to increase in bulk density (BD) under the pressure exerted by roots. Field Capacity (FC) was statistically same under both the trees, other parameters differed significantly. Hydraulic conductivity (HC) and BD improved more under *A. indica* but IR was less, may be due to better root growth.

Table 4.1. Influence of manuring on soil properties under two tree species

Treatment	FC moisture (0-10 cm) (% by weight)	CI (kg cm^{-2})	HC (cm h^{-1})	BD (g cm^{-3})	IR (cm h^{-1})	Dehydrogenase (P cat g^{-1})	
						0-15 cm	15-30 cm
Z. rotundifolia							
Manured	7.92	6.02	5.28	1.66	14.4	5.70	2.78
Control	7.50	7.32	3.68	1.72	19.2	4.16	3.23
SEd	0.33	0.88	0.46	0.01	1.8	1.05	0.41
A. indica							
Manured	7.82	2.87	9.03	1.57	9.6	3.88	3.35
Control	6.79	3.95	4.88	1.63	15.6	4.57	3.68
SEd	0.43	0.48	0.78	0.02	1.1	0.52	0.29

Both the tree species showed better growth and productivity under manured condition (Table 4.2). *A. indica* exhibited better growth, while *Z. rotundifolia* gave higher production and produced 116.2 kg fruits ha^{-1}.

Table 4.2. Effect of manuring on production of *Z. rotundifolia* and *A. indica* (100 plants ha^{-1})

Tree species	Manured		Unmanured	
	Fuel wood (kg ha^{-1})	Leaves (kg ha^{-1})	Fuel wood (kg ha^{-1})	Leaves (kg ha^{-1})
Z. rotundifolia	1667.2	524.5	1243.6	433.7
A. indica	1170.3	179.5	937.4	106.2

Performance of Range Grasses on Degraded Grazing Land

Pastures of *C. ciliaris* and *C. setigerus* grasses were established at grazing land of Beriganga area. Both the grasses performed well under shallow soil and produced 20-25 q dry matter and 40-50 kg seed per hectare. The productivity of sown pasture was higher than the natural pasture having *Aristida* and *Dactyloctenium* species of annual grasses.

Management of Rocky Stony Site of Bhopalgarh

Grass yield from different blocks of reseeded and natural pastures, on the basis of FEQ, ranged from 323-1656 kg ha^{-1} (Table 4.3).

Table 4.3. Yield of *C. ciliaris* (FEQ basis) in different silvi-pasture systems

Tree species	Grass yield (kg ha^{-1})
A. indica	1334.6
T. undulata	1386.5
A. senegal	1467.2
C. wightii	1622.8
C. ciliaris sole	1656.3
Natural pasture	322.6

Comparative performance of grass species: Out of the four grass species planted in 2008 at rocky site, maximum fodder yield was given by *C. Ciliaris* followed by *D. annulatum* (Table 4.4).

Table 4.4. Comparative performance of grasses at rocky stony site

Name of the grass species	Survival percentage	Seed yield (kg ha^{-1})	Dry fodder yield (kg ha^{-1})
Cymbopogon jwarancusa	95.2	21.6	436.8
Dichanthium annulatum	96.4	36.7	1034.9
Cenchrus ciliaris-358	99.1	44.4	1342.8
Cenchrus setigerus	96.9	53.6	520.3

Guggal plantation: Plantation of guggal (*C. wightii)* done in 1996, 2007 and 2008 showed 82-100% survival (Table 4.5).

Table 4.5. Survival and growth of *C. wightii* at rocky stony site

Year of plantation	Survival percentage	Plant height (cm)	Collar diameter (cm)
1996	100.0	140.3	6.21
2007	96.3	85.6	2.49
2008	82.6	92.2	2.08

Hydrological Monitoring and Development of Beriganga Research Farm

Block boundary, streams/drains, hillocks and pond were marked on the map for 1.02 km^2 area of Beriganga block-II which has a total catchment area of 128.4 ha with 28.6 ha area outside the boundary. Two Sand Filled Check-dams (SFCDs) were constructed on the main drain (B2a4) and three on two tributaries of main drain. The selected drain (B2a4) is 540 m long with catchment area of 18 ha and average slope of 2.78% (Fig. 4.1). The average length, width, height and earthwork of SFCDs were 4.0 m, 0.8 m, 1.2 m and 16.2 m^3, respectively. About 200 half-moon terraces (dia 2.5 m) were constructed on the sloppy land at the foothill of hillocks near the drain covering an area of 0.5 ha. Seven rainfall events (>15 mm) effectively contributed to runoff generation. Runoff varied from 6.8 to 18.2% with an average of 13%. A total of 23282 m^3 runoff was generated by the Block-I of which 17.33% was retained by check-dams.

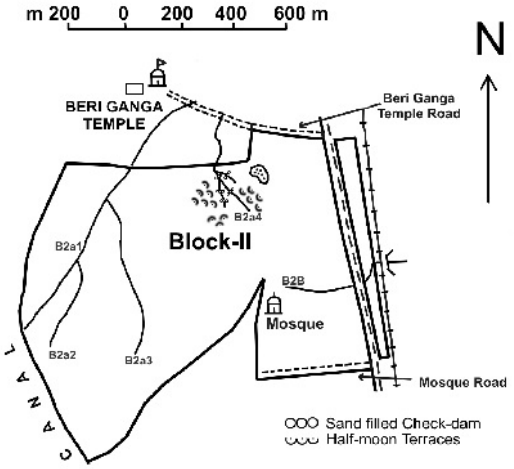


Fig. 4.1. Drainage details of Beriganga- Block-II research farm.

Water Productivity of Field Crops under Medium Textured Saline Soils

At Pali, deep tillage significantly increased seed yield of mustard (17.3%) over control. Residual effect of 10 t FYM ha^{-1} caused significant improvement in seed yield of mustard (20.8%) over control. Increasing distance from the line source sprinkler by every 2 m created water levels of 86.6, 78.9, 70.7 and 64.0% of ET_{max} and gave 97, 79, 52 and 43% seed yield of mustard compared to yield at ET_{max} (Table 4.6). The interaction effect of residual FYM and deficit irrigation was significant. Maximum seed yield of 2167 kg ha^{-1} was obtained from the residual FYM with ET_{max} irrigation, followed by residual effect of FYM with ETd_1 irrigation (2110 kg ha^{-1}) as against only 771 kg ha^{-1} obtained under no residual FYM with highest water deficit (ETd_4).

Table 4.6. Effect of tillage, residual FYM and deficit irrigation on mustard

Treatment	Plant height (cm)	Siliquae $plant^{-1}$	Seed weight (g $plant^{-1}$)	Biological yield (kg ha^{-1})	Seed yield (kg ha^{-1})	WP (kg m^{-3})
Tillage						
Conservation tillage	136	164	7.8	4768	1338	0.679
Deep tillage	160	184	8.5	5673	1569	0.798
CD (P=0.05)	7	14	0.6	343	122	0.061
FYM (Residual)						
Control	138	164	7.6	4741	1316	0.670
10 t ha^{-1}	157	185	8.6	5699	1590	0.806
CD (P=0.05)	7	14	0.6	343	122	0.061
Irrigation level						
ET_{max}	162	198	9.2	6986	1956	0.814
ETd_1	157	192	8.8	6707	1905	0.916
ETd_2	148	180	8.3	5481	1540	0.812
ETd_3	136	159	7.3	3762	1025	0.604
ETd_4	133	143	7.0	3164	841	0.546
CD (P=0.05)	8	17	0.6	400	123	0.062

Cropping Systems and Newer Tillage Option for Improving Land and Water Productivity in Typic Calcorthid Soils

Two planting patterns (conventional and bed planting) and 5 cropping systems viz., sole sorghum, intercropping of sorghum with dhaincha (green manuring), dhaincha (brown manuring), cowpea and mung bean during kharif season in rotation with wheat were studied. Beds of 40 cm width and 15 cm height with 30 cm wide furrows were prepared. The crops were sown in two rows on the shoulders of each bed. During rabi season, bed planting gave wheat yield at par with conventional sowing (Table 4.7).

Table 4.7. Effect of planting pattern, intercropping and nitrogen economy in fallow – wheat system

Treatments	Rabi (2010-11)		Kharif (2011)					
	Wheat		Sorghum		Intercrop yield (kg ha^{-1})			
					Mung bean		Cowpea	
	Grain (kg ha^{-1})	WUE (kg ha^{-1} mm)	Dry fodder (kg ha^{-1})	Grain (kg ha^{-1})	Grain	Stover	Grain	Stover
Planting system								
Bed	3867	14. 3	11421	783	453	810	260	980
Conventional	4113	9.5	12698	831	305	776	190	850
CD (P=0.05)	NS	0.8	NS	NS				
Cropping system (kharif)								
Sorghum + dhaincha (GM)	4295	12.7	8173	630				
Sorghum + dhaincha (BM)	4185	12.3	9803	661				
Sorghum + mung bean	3938	11.9	11353	812	379	793		
Sorghum+ cowpea	3894	11.6	11698	824			225	915
Sole sorghum	3639	11.1	19268	1108				
CD (P=0.05)	458	1.2	2354	091				
Nitrogen (rabi)								
100% N	4152	12.3						
75% N	3828	11.5						
CD (P=0.05)	131	0.4						
Sole-wheat v/s treatments								
Fallow-wheat	4128	10						
Kharif crops-wheat	3987	12						
'F' Test	NS	Sig.						

In the succeeding kharif season, yields of intercrops i.e. mung bean and cowpea were higher under bed planting. Residual effect of intercropped dhaincha, mung bean and cowpea significantly improved yield of succeeding wheat crop compared to sole sorghum. Reduction in dose of nitrogen by 25% significantly reduced the yield of wheat crop. Overall, yield of wheat grown after different treatments was at par with yield in fallow – wheat system. In third consecutive kharif season (2011), intercropping of dhaincha provided 10500-13300 kg ha^{-1} of green biomass for incorporation. Additionally, this system provided 42.4% and 56.8% sorghum dry fodder and grain yield compared to sole sorghum.

In another experiment, harvesting of fodder sorghum in kharif season at 60 DAS significantly reduced rabi taramira yield compared to harvesting at 50 DAS. However, yield reduction was minimum under sorghum + dhaincha (green manured at 40 DAS) compared to sole cropping of sorghum for 60 days. Application of gypsum to taramira significantly improved seed yield by 23.6%. During the succeeding kharif season, enhancing the crop duration from 50 to 60

days significantly increased the green fodder yield by 24.8%. Bed planting was at par with conventional planting.

Evaluation of Rabi Crops for Higher Water Productivity in Arid Gujarat

Wheat (GW 496), barley (RD 2552), chick pea (RG 896), mustard (GM 2), cumin (GC 4), coriander (GC-2) and fenugreek (Gujarat fenugreek-1) were evaluated for water productivity under deficit irrigation regime, created through line source sprinkler irrigation. Water gradients were applied after establishment of the crops. The irrigation was given at 50% depletion of available soil moisture from the 0-50 cm soil profile. Grain yield of all the crops reduced significantly under deficit irrigation. The relationship between relative grain yield and water deficit was linear and significant (Fig. 4.2). The least reduction in grain yield under deficit water supply of less than 40% of field capacity was recorded in cumin (6.5%) followed by barley (24%) and fenugreek (33%). The wheat and chickpea were more sensitive to moisture deficit.

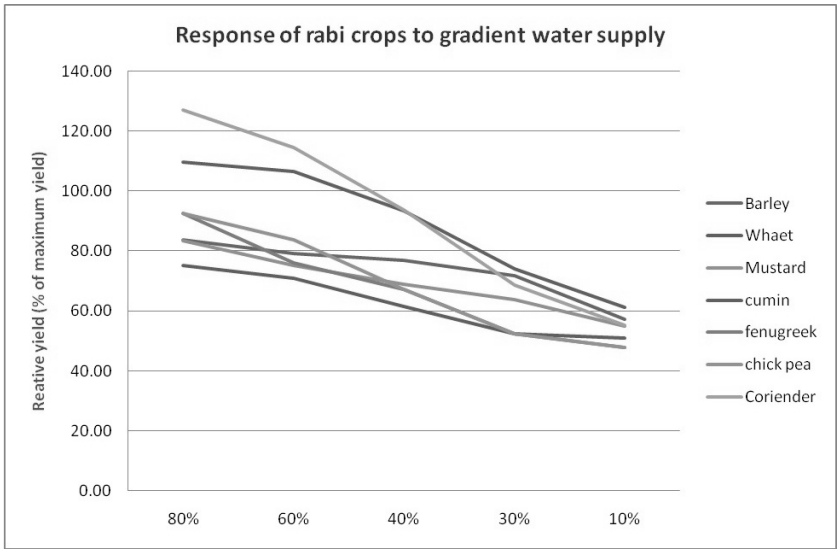


Fig. 4.2. Per cent reduction in grain yield of rabi crops under water deficit gradients.

Impact Assessment of Global Warming on Reference Evapotranspiration

There was wide variation in annual normal evapotranspiration (1502-2177 mm ET) computed through Penman-Monteith model (Plate 17). More than 50% area of the western Rajasthan comes in the ET range of 1900-2100 mm whereas about 30% area comes in ET range of 1700-1900 mm.

The increase in ET with 1°C increase in temperature was highest in Jaisalmer (96 mm) and least in Ganganagar (35.1 mm) district. More than 68% areas of western Rajasthan showed 40-60 mm increase in ET. The increase in temperature by 1°C will cause an additional annual water demand of 1570.9 mcm for the western Rajasthan based on net irrigated area of 3164512 ha (Table 4.8). Thus, global warming is likely to increase annul ET by nearly 2% for increase in temperature by 1°C (Plate 18).

Table 4.8. Area (,000 ha) and additional water requirement for irrigation with 1°C rise in temperature

District	Total area	Cropped area	Irrigated area	Net annual groundwater available (mcm)	Additional water requirement for irrigation (mcm)
Barmer	2817.3	1650.4	150.5	249.8	71.8
Bikaner	3035.6	1465.3	228.4	197.6	103.4
Churu	1385.9	1140.8	58.1	197.7	20.5
Ganganagar	1093.0	906.8	786.9	198.8	276.2
Hanumangarh	970.3	882.7	549.9	194.6	246.3
Jaisalmer	3839.2	467.4	90.7	52.6	87.1
Jalor	1056.6	740.9	202.2	423.6	131.4
Jhunjhunu	591.7	609.7	242.6	243.0	155.3
Jodhpur	2256.4	1227.8	176.6	393.1	77.3
Nagaur	1764.4	1365.4	294.8	628.2	238.8
Pali	1233.1	582.9	112.1	413.4	51.3
Sikar	774.2	671.6	271.9	324.5	111.5
Total	20817.6	11711.6	3164.5	3517.0	1570.9

IMPROVEMENT OF ANIMAL PRODUCTION AND MANAGEMENT

Assessment of Climate Stress

Weekly climate data of maximum and minimum for both dry and wet bulb temperatures were used for calculating the Temperature Humidity Index (THI). Longer heat stress period was observed in the year, which was from 2nd week of March to 2nd week of November (Fig. 5.1). THI values ranged from 78.7 to 90.2. Most critical THI values were observed between 4th week of April and 1st week of August, where it remained above 85. The night hours were also found stressful from 3rd week of May to 4th week of August with THI values ranging from 78.6 to 81.7. The cold stress period was from 2nd week of December to 4th week of February. The maximum diurnal difference was during winter season especially from 3rd week of October to 3rd week of January.

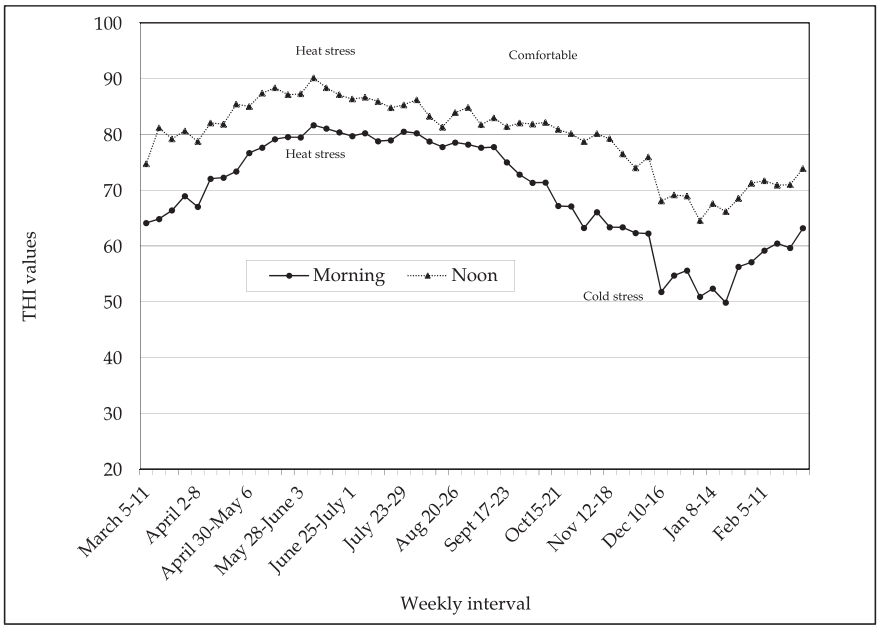


Fig. 5.1. THI values.

Effect of Steaming-up on the Performance of Goats

Steaming-up of Marwari and Parbatsari goats was done under different shelter systems during September-October. The animals of steaming-up group were supplemented with extra concentrate mixture (CP-20%) @ 300 g d^{-1} $goat^{-1}$ for a period of four weeks prior to kidding. Steamed-up goats yielded highest milk (1.4 kg) per day in improved animal shelter, and had highest level of blood glucose (57.3 mg dl^{-1}) just after parturition. All the animals were found negative for ketosis around kidding. Average birth weight of kids from steamed-up goat (2.5 and 2.8 kg under improved and conventional shelter, respectively) was higher than kids from non-steamed-up group (2.3 and 1.9 kg under improved and conventional shelter, respectively). The preliminary study showed positive effect of steaming-up on body weight gain of goats during advanced period of gestation.

Effect of Management of Environmental Stress on Growth Performance of Kids

Effect of feeding and shelter manipulation on the growth performance of growing kids was studied. Kids were distributed into four groups viz. conventional shelter with grazing in warmer part of day (T1), conventional shelter with extra concentrate ration (200 g d^{-1} $animal^{-1}$) and grazing in warmer part of day (T2), improved shelter with grazing in cooler part of day (T3), improved shelter with extra concentrate ration (200 g d^{-1} $animal^{-1}$) and grazing in cooler part of day (T4). The THI values ranged from 71.3 in the morning to 81.6 in the afternoon. Kids of T2 and T4 groups had higher body weight gain than kids of T1 and T3 groups. The growth rate was lowest in T1 which might be due to comparatively more stress on kids. Kids of T4 group had least pulse rate (85.5 beats min^{-1}) and body temperature (102.3°F). Higher body temperature (103.2°F) and respiration rate (24.8 breaths min^{-1}) were in kids of T2. Kids of T1 group felt maximum stress while kids of other groups tried to adjust against stress.

Roof Insulation in Animal Shelter with Thatched Panels

An animal shelter with east-west orientation (10 m long, 5 m wide, 3 m height from centre and 2.5 m from sides) was designed for small ruminants. The thatched panels of bamboo mats were fixed 15 cm below to the asbestos sheet ceiling. After completing the bamboo structure, the bamboo mats with dry grasses were placed below the ceiling. The microclimate of the shelter improved due to insulation by reduction of the inside temperature up to 4°C in comparison to the outside environment.

Performance of Tharparkar Cows Maintained on *Cenchrus* spp. Dominated Pasture

A group of Tharparkar cows was maintained on *Cenchrus* spp. dominated pasture along with supplementation of concentrate. Average age at first calving and lactational milk yield was 46.9 months and 2105.9 litres (305-day basis), whereas daily milk yield was 7.2 litres with peak yield of 10.3 litres. The average dry period and calving interval was 98.4 and 390.4 days.

Performance of Goats Fed on Ardu and Neem Leaves

Animals of control group (T0) were let out for grazing on *Cenchrus* dominated protected pasture having *Prosopis cineraria* (khejri) trees and *Ziziphus* spp. (bordi) bushes for six and half hours daily without supplementation of concentrates. Whereas, animals of T1 and T2 were offered *ad libitum* masoor straw and wheat bran (1.2 kg) daily. In addition, animals of T1 were offered ardu leaves (*Ailanthus excelsa*), while of T2 with neem leaves (*Azadirachta indica*). Water was available *ad libitum* to animals of each group. Blood samples were collected at fortnightly interval to study haemato-biochemical parameters.

Average body weight gains of animals in T0, T1 and T2 were 2.3, 5.7 and 5.1 kg, respectively (Fig. 5.2). The dry matter intake/100 kg body weight for T1 and T2 groups were 4.03 and 3.97 kg, respectively (Table 5.1). There was non-significant difference in water intake between T1 and T2 and it ranged from 1.6 to 2.6 litres per head day^{-1}. Blood glucose level of T0 and T1 was significantly higher than that of T2 animals. However, average creatinine value of T2 animals was at higher level. The other blood parameters: haemoglobin, total protein, BUN, cholesterol, calcium and phosphorus showed non-significant differences. Thus feeding of ardu and neem leaves to goat showed high acceptability and palatability, however, dry matter intake and average daily gain were more in animals fed on ardu leaves.

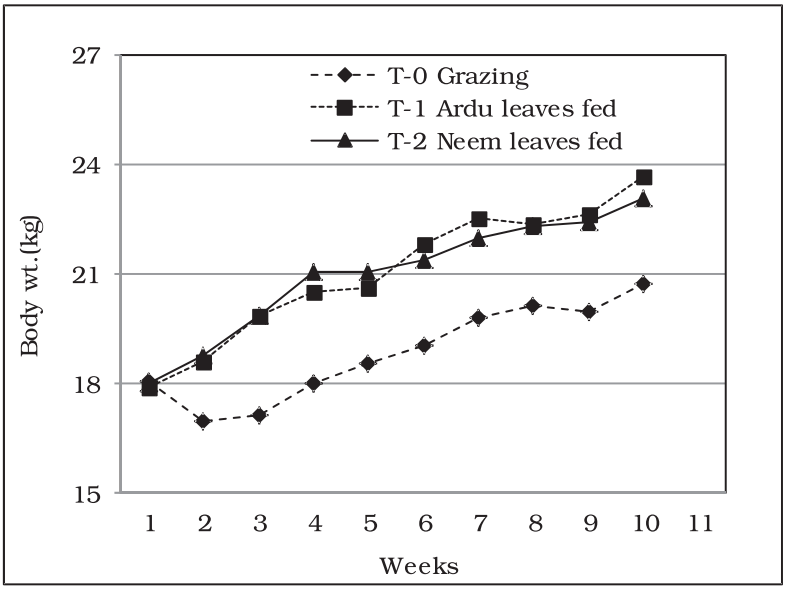


Fig. 5.2. Body weight changes in goats fed on Ardu (*Ailanthus excelsa*) and Neem (*Azadirachta indica*) leaves.

Table 5.1. Average DM (kg) and water (litre) intake day^{-1} animal^{-1} by goat at fortnightly interval

Treatment	Attribute	Fortnight				
		1st	2nd	3rd	4th	5th
Ardu fed group -T1	Ardu leaves (g)	314	392	504	436	425
	Masoor straw (g)	278	310	299	290	312
	Wheat bran (g)	216	216	216	216	216
	Water (l)	2.3	2.2	2.2	1.8	2.6
Neem fed group -T2	Neem leaves (g)	384	407	390	373	390
	Masoor straw (g)	271	307	306	288	312
	Wheat bran (g)	216	216	216	216	216
	Water (l)	2.2	2.0	2.1	1.6	2.6

Performance of Sheep and Goat Maintained on Improved Silvi-pasture

The study was conducted to compare nutrient availability in sheep and goats maintained on the natural and improved silvipasture. Growing rams and bucks of 13-14 months of age were equally allocated into two groups. Animals were grazed on protected natural pasture (T1) and improved silvipasture having *C. ciliaris* and *Ziziphus* spp. (Bordi) shrubs (T2). In T1, availability of dry matter was 18.6 kg with 5.0% CP, and in case of T2 the values were 37.3 kg with 7.5% CP. Sheep were found to be close grazer and preferred green sprouting portion of grasses, whereas goat preferred weeds and Bordi over the grass. The increase in average daily body weight gain (ADG) was 34.7% in sheep and 21.7% in goat on improved pasture. Improved silvipasture enhanced ADG in both sheep and goat.

Performance of Growing Calves Fed on Economic Concentrate Mixture Containing *Prosopis juliflora* Pods

Effect of balanced concentrate mixture prepared using *P. juliflora* pods (PJPP), mustard seed cake, guar korma, cotton seed cake, wheat bran, maize grain, common salt and mineral mixture was studied in growing calves. The concentrate had 18% crude protein and 70% total

digestible nutrients. Twenty calves (10 males and 10 females) were divided into two groups. Animals of control (T1) group were fed ration without PJPP whereas, animals of treatment (T2) group were fed PJPP incorporated feed. The growth performance of animals is given in Table 5.2.

Table 5.2. Per cent gain in body weight of growing calves

Period	T1		T2	
	Male	Female	Male	Female
October to December	20.8	22.8	19.0	21.7
January to March	24.2	11.4	18.5	11.8
April to June	11.3	8.4	10.0	8.2

There was an increase in the live weight of animals in both the groups. However, initially the average gain in body weight was higher in male calves of T1. Heifers in both the groups were pregnant and carried normal pregnancy. Feeding of *P. juliflora* pod based concentrate did not adversely affect the health, growth and reproduction of the animals.

Case Study of Livestock Mobility in the Rajasthan State (CAZRI-ICARDA Project)

Preliminary survey of four districts viz. Pali, Jodhpur, Barmer and Jaisalmer was conducted to study the migration pattern of livestock. The main communities rearing sheep in Rajasthan are Raika (Dewasi/Rebari), Sindhi Muslim, Jat and Rajputs. The scheduled castes and tribes particularly Meghwals also keep sheep but flock size is generally less than 100. People with small flock size mainly migrate within the native district, but farmers with large flock size migrate out of district or state. The migration routes were different in different locations. The people from Barmer district generally follow the routes leading to Gujarat state and from Jodhpur and Pali migration is towards Punjab, Haryana, Madhya Pradesh and Uttar Pradesh. In general, three kinds of livestock migration are prevalent in the western Rajasthan:

- Within district, mainly from November to June
- Semi-migration, mainly from November to July/August. It may be out of district/state.
- Permanent migration: In this kind of migration, animals are permanently moved from the home tract to other districts or states. The members of families go on rotation basis and stay for few months at those locations but animals are not brought back to the native villages. The reason behind permanent migration is lack of pasture lands for grazing of larger flock size round the year in western Rajasthan and better forest and water resources availability in MP, UP. Further and they get better prices for their animals in these regions.

PLANT AND ANIMAL PRODUCTS, AND VALUE ADDITION

Development of Aloe Products for Different Applications

Shaving products: Aloe shaving cream and aloe shaving gel in good looking semi-transparent form were developed. The final formulations of shaving cream and shaving gel contained 20 and 24% aloe gel, respectively. Both products have comparable lather quality, moisturizing effect and emollient properties, but the shaving cream has longer shelf life (> 10 months) than shaving gel (<3 months).

Bioethanol from aloe leaf waste: Neutral cellulose fraction (>40%) from aloe leaf waste was processed for bioethanol conversion. After pretreatment at 121°C for 15 min under pressure in distilled water, the material was treated with yeast *Saccharomyces cerevisiae* (105 cell/100 ml flask) at 35 ± 2°C for 5 days. 1, 2, 5% of substrate produced 0.339, 0.672 and 1.133% ethanol, respectively. Alcohol conversion did not increase proportionately while substrate concentration increased from 2 to 5%, indicating that the substance contains some inhibitors, which are to be identified and removed for better ethanol yield.

Oleo-gum Resin from *Commiphora wightii*

Development and standardization of techniques for gum extraction: Ethephon solution was administered into 2.5 cm deep slanting hole made with carpenter's gimlet (a hand tool for drilling small holes). Plastic syringe was convenient to dispense specific volume of the solution into the hole. A spout was made from 'U' shape aluminium channel to channelize the flow of exuded oleo-gum resin into the collecting container. Plastic mugs fastened to the plant stem with plastic tape were used as oleo-gum resin container. Small chisel was used to make channels in the plant stem to guide the flow of oleo-gum resin into the container.

Products from Fruits of *Salvadora oleoides*

There was less fruiting and about 10 kg good quality fruits were procured from Araba area in Barmer district. The fat content of the seeds was 48.84%.

Increased Pod Production from Managed Stands of *Prosopis juliflora*

Pods production from unmanaged and managed stands of Prosopis juliflora was 15 kg and 25 kg per tree respectively (Plate19), showing 40% increase in pod production with management in target villages, however increase in pod production in CAZRI experimental plot was 20%.

Commercial Product CAZRI Pashu Aahar

The technology of processing Prosopis juliflora pod flour based cheaper concentrate feed has been transferred to industrial partners (National Food Products, India, Jodhpur and Amrit Agro Industry, Jodhpur) of NAIP, who are processing and marketing it with brand name CAZRI Pashu Aahar (Plate 20). The trial of this feed in villages showed increase in the milk yield of cattle to the tune of 15-25%.

Concentrate Animal Feed Mixture for Growing Calves

The feed ingredients in this mixture prepared for growing calves were *Prosopis juliflora* pods powder, mustard seed cake, guar (*Cyamopsis tetragonoloba*) korma, cotton seed cake, wheat bran, maize grain, common salt and mineral mixture. Feeding trial of this mixture on growing Tharparkar cattle at KVK, CAZRI showed no negative effect on the health of the animals due to P. juliflora pod flour in the feed.

Prosopis juliflora based Complete Feed Block

A process for making complete feed block based on *P. juliflora* was standardized. These blocks comprise of 90% *P. juliflora* pods milling product and 10% molasses, which on dry matter basis contained 1.6% ether extractives, 11.7% crude protein and 78.6% total carbohydrates. Gross energy value of this complete feed block was 406 kcal per 100 g. This is a very simple technology and farmers in target villages are being trained to process it on their own. Efforts are being made for developing a small industry for manufacture of such complete feed block in rural areas.

Extraction and Isolation of Mesquitol from Sap/Heart Wood

Powdered *Prosopis juliflora* heartwood and sapwood extracted with ethanol and dried under vacuum yielded 6-8% and 1-2% mesquitol, respectively with a new process which has fewer steps than the prevailing processes.

Impact of Project Implementation

In target villages, 60 households, which were involved in activities under the project "Value chain on value added products derived from *Prosopis juliflora*", got additional income of Rs. 1388 per month (average). Farmers have established a pod collection centre themselves in village Lalpura of Sanchore Tehsil (Jalor District). The villagers of target villages also gained employment for 750 man-days per month in *P. juliflora* plantation and wood collection activities of NAIP project partners Transtech Green Power Pvt. Ltd.

Pearl Millet Bran for Animal Feed

Feed blocks were prepared from the bran, which generally goes unutilized. The pearl millet bran is comparable to wheat bran in all nutritional parameters (Table 6.1). The quality of blocks prepared from wheat bran only and those from wheat and pearl millet bran combination was comparable. Therefore, the pearl millet bran can also be used for production of feed blocks for supplementation of critical nutrients to the livestock in arid areas.

Table 6.1. Nutritional parameters of pearl millet and wheat bran

	Wheat bran	Pearl millet bran
Fresh weight basis		
Water (%)	7.58	6.92
Dry weight basis		
Minerals (%)	11.41	6.65
Organic matter (%)	88.59	95.73
Ether extractives (%)	4.34	9.48
Crude protein (%)	14.36	18.01
Total carbohydrates (%)	69.89	65.86
Gross energy (kcal/100 g)	412 .00	464.00

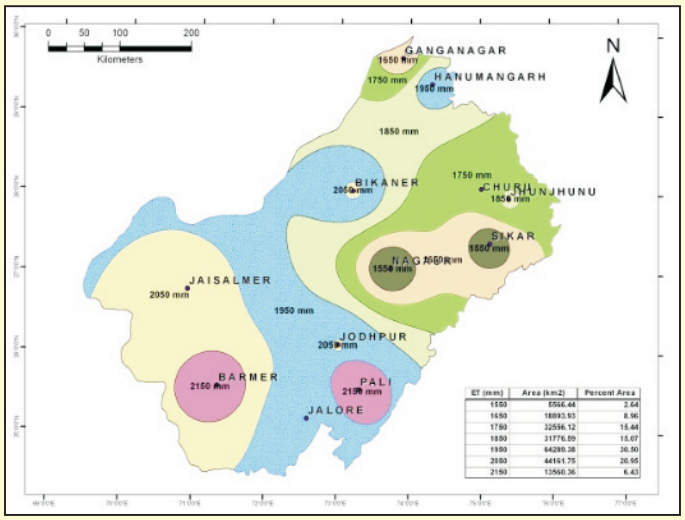


Plate 17. Spatial distribution of normal evapotranspiration (Penman-Monteith model).

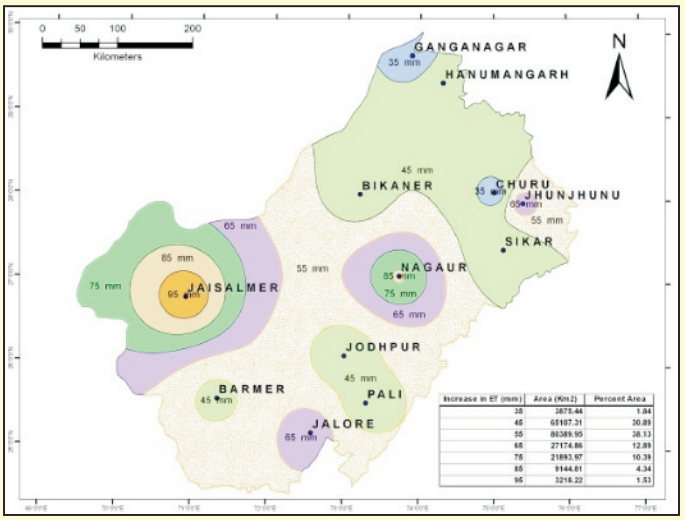


Plate 18. Spatial distribution of increased ET demand for 1°C rise in temperature.

Weedy

Managed

Plate 19. Unmanaged and managed stands of *Prosopis juliflora.*

Plate 20. CAZRI Pashu Aahar.

Lucerne leaf meal block: To supplement critical nutrients including provitamin-A, calcium and phosphorus to the desert livestock during summer season, harvested lucerne was chopped, loosely spread over wire mash and dried in the sun, milled in hammer mill and compressed in fodder block making machine to produce 1 kg blocks. Lucerne blocks contained 91.8% dry matter, 84.4% organic matter (23.5% crude protein, 57.7% total carbohydrates, 15.6% minerals, 3.2% ether extract) and 402 kcal gross energy.

Mineral-block: A simple technology for production of 25-30 kg mineral block has been developed to supplement macro- and micro-minerals, vitamins along with non-protein nitrogen and fermentable sugars for range foraging community livestock. The technology involves mixing of common salt (52.1%), vitamin-mineral mixture (13.0%), dolomite (13.0%), feed grade jaggery (11.7%), urea (1.6%), guar korma (5.2%), lime (2.6%) and guar gum powder (0.8%), and then pressing in the cylindrical iron mould with hammer. The compressed salt-mixture blocks are then dried in the sun.

INTEGRATED PEST MANAGEMENT

Developing a Consortium of *Bacillus firmus* and *Trichoderma harzianum* for the Control of Soil Borne Plant Pathogens

Development of a bio-formulated product: A new bio-formulated product of two native biocontrol agents viz., *B. firmus* and *T. harzianum* by using cheap and readily available food substrate and carrier has been developed in which both the bioagents can survive for 120 days.

Effect of Different Moisture Gradients, Temperature and Electrical Conductivity on Survival of Biocontrol Agents

Higher level of moisture holding capacity (100 and 70%) of the food substrate significantly enhanced the survival of *B. firmus*, while, the population of *T. harzianum* survived better at lower (30 and 50%) moisture gradients (Fig. 7.1). Survival was not affected by temperature gradients (30, 35 and 40°C) (Fig. 7.2) and both the biocontrol agents were able to survive electrical conductivity up to 6.6 dS m^{-1}.

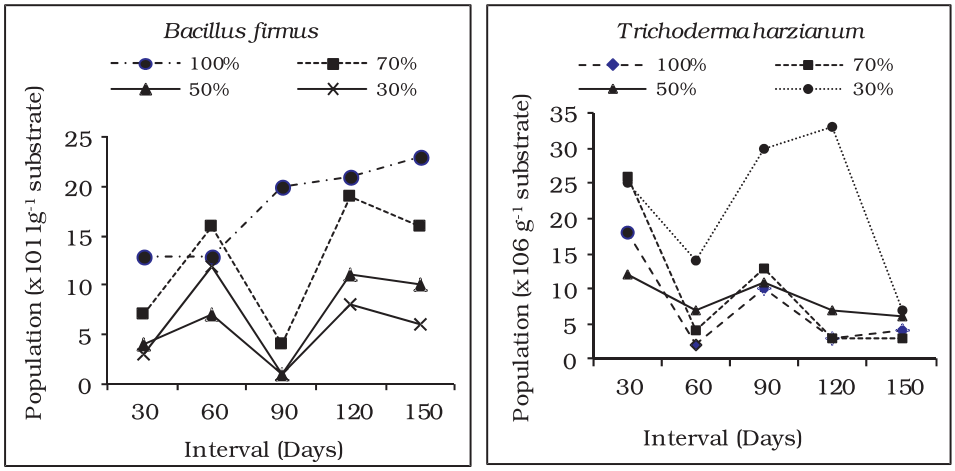
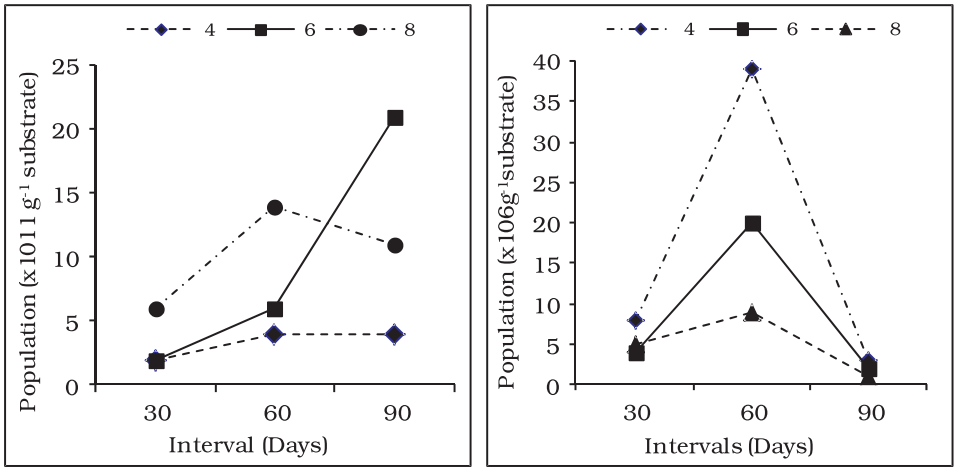


Fig. 7.1. Effect of different moisture gradient on survival of *B. firmus* ($x10^{11}$) and *T. harzianum* ($x10^{6}$ g^{-1}amendment) in promising substrate. Initial population 54.3 $x10^{8}$ (*B. firmus*) and $7x10^{5}$ g^{-1} substrate (*T. harzianum*)

Developing Biocontrol Agent Enriched Composts for Suppression of Soil Borne Plant Diseases

Efficacy of biocontrol fortified compost on plant mortality due to dry root rot on clusterbean: Under field conditions, incidence of dry root rot on clusterbean was least (plant mortality 3.68%) with application of *P. juliflora* compost combined with weed compost than the other composts (Neem, Indian mustard) and non-amended control (15.2%). Maximum population of *T. harzianum* (2.8×10^{2} g^{-1} soil) was in *P. juliflora* and weed compost combination followed by sole application of *P. juliflora* compost (1.1×10^{2} g^{-1} soil).



Bacillus firmus *Trichoderma harzianum*

Fig. 7.2. Effect of different temperature on population of *B. firmus* and *T. harzianum*.

Disease Tolerance in Pearl Millet

Thirty-nine inbred and hybrids were evaluated against downy mildew (DM) disease in pots under net house conditions. DM was observed in only three inbreds ranging from 20 to 66.6% twenty-eight days after sowing, and others were free from the disease.

Fifty-two pearl millet entries comprising of AHT and inbred lines were screened against DM and smut diseases under DM sick plot conditions using infector row technique. The incidence was recorded 30 and 60 DAS at soft dough stage. Five entries had DM ranging between 22.2 and 40%. Average DM pressure of 36% was recorded on infector rows of cv. *Nokha local* 60 DAS. Only one entry (42) showed 30% smut incidence.

Sixteen maintainer and ms (male-sterile) lines were screened, and only one line (CZMS 4B) was free from DM. CZMS 2A, 3A, 6A and 8A had DM below 5% and others had incidence of above 10% varying from 12.2 to 66.6%. In these lines 20% incidence of smut was recorded in two lines (CZMS 15B and 16A). There was 99% incidence of blast disease caused by *Pyricularia penniseti* in all the lines.

Five cultivars of pearl millet viz. CZP 9802, CZP 9603, CZP 2003, CZP 2009 and CZIC 923, growing under National Initiative on Climate Resilient Agriculture (NICRA) Project, were screened against DM under field conditions at two dates of sowing. Incidence of DM was more in August sown crop than the crop sown in July. CZIC 923 had the lowest mean incidence (4.4%) of DM followed by CZP 2003 (5%) and CZP 2009 (10.4%). The highest incidence of DM was recorded in CZP 9802 (21.7%).

Effect of Skimmed Milk and *Gliocladium virens* on Germination, Seedling Vigour and Downy Mildew in Pearl Millet

Treatments of cv. *Nokha local* consisted of seed treatment with skimmed milk (SM- 2, 3 and 10% dilutions) and *G. virens* (0.6%) and *G. virens* in soil (6 g pot^{-1}). Neutral and metalaxyl (0.2%) treated positive controls were among the other treatments. All the treatments reduced incidence of DM compared to neutral control. A combination of seed treatment of SM 2% + *G. virens* provided highest protection (39.3%) of DM followed by seed treatment of *G. virens* with its application in soil, seed treatment of SM 10% + *G. virens* and seed treatment of SM 3% + *G. virens*.

In comparison with neutral control, combination of SM 3% + *G. virens* and *G. virens* seed treatment in soil enhanced the plant height (155.4 cm), root length (27.9 cm) and ear head length (18.3 cm). However, the maximum number of leaves was observed in the combination of seed treatment of *G. virens* and its application in soil. Positive control consisting of metalaxyl seed treatment (0.6%) showed 144.0 cm plant height, 25.2 cm root length, 9.3 number of leaves and 14.6 cm ear head length with 4.5 cm ear head girth.

Seed Germination and Seedling Vigour

Under laboratory conditions SM (10%) + *G. virens* (0.6%) treated seeds showed maximum germination (62.5%) and vigour index (VI) followed by SM 2% + *G. virens*. Maximum elongation of root and shoot was recorded in the treatments SM (5%) + *G. virens* and SM (3%) + *G. virens*, respectively. However, in control highest germination was observed (79.1%) with VI of 1408.

Isolation, Characterization and Multiplication of Native Microbial Entomopathogens for the Management of Insect Pests of Arid Region

Antibiotic resistance and high temperature tolerance studies of isolated *Bacillus* cultures (Az-2 and Az-7): *Bacillus* cultures Az-2 and Az-7 which were identified to be carrying *cry1 Ac* gene effective against lepidopteron insects were exposed to higher concentrations of novobiocin (30 µg/ml) and kanamycin (20 µg/ml). After six days of growth in antibiotic supplemented Luria Agar medium plates, resistant colonies were obtained at a frequency of 0.001%. These cultures were also found to tolerate temperature up to 42°C in agar medium plates as well as liquid medium

Bioactivity of Azadirachtin on Insects in Mung bean Crop

Two sprays of 0.25, 0.5 and 1.0% azadirachtin, at 15-day interval, significantly reduced the population of jassids and whiteflies in mung bean crop. Reduction in population of jassids varied considerably from 17.3 to 59% after 5 days, and 15 to 50.4% after 12 days of 1st spray and 41 to 72% after 19 days and 35.5 to 61.3 days after 26 days of 1st spray, while the reduction in population of whitefly varied between 4.6 to 58.7%, 4.2 to 46.9%, 14.6 to 68.5% and 15.5 to 63.3% after 5, 12, 19 and 26 days respectively of 1st spray.

BIO-EFFICACY OF NEEM FORMULATIONS

Under laboratory conditions, bio-efficacy of neem formulations viz. Nimbicide @ 0.03%, Amritguard @ 0.03%, Gronim @ 0.15, Achook @ 0.15%, Econeem @ 0.3%, Neem drop (neem kernel oil cold pressed) and ethanolic neem extract were tested against aphid *Myzus persicae* by leaf disc choice method. Effective concentration to produce 50% feeding deterrence was 0.65 and 0.95 for 2nd instar nymphs. The disruption of *M. persicae* feeding was related to the azadirachtin content (0.15, 0.3 and 0.6%). The toxicity of topical application was 5 times more effective than leaf surface contact. LC_{50} of these formulations varied between 0.86 to 1.78%.

Insects in Organic Farming System for High Value Crops

The perennial components, jujube, henna and *Calotropis* supported a good diversity and number of beneficial insects during the kharif season. Honey bees, syrphid flies, houseflies and yellow jacket wasps on henna and jujube plants; bumble bees on the *Calotropis* plant, and big honey bees and bumble bees on sesame crop during peak flowering were the major beneficial insect fauna. The soil was free from termites and ants before the rainy season. Termites (1-10),

ants (1-6) and red velvet mites (1-3) appeared after the first showers. Off-season sesame plants and weed (*Heliotropium* sp.) supported large population of red cotton bug (50-60).

Sesame: Stray pockets of damage by til hawk moth and head binding (2-3% plants) were observed in the crop, and were naturally controlled with time.

Clusterbean: High incidence of whiteflies (10-25 nymphs per leaf), moderate of jassids (*Empoasca* sp.) (2-5 per leaf) on the lower surface of the leaves and flea beetles causing holes (5-15 per leaf) were observed on the leaves during flowering and pod formation. Spittlebugs were seen on some plants only.

NEMATODES

Effect of Application of *G. fasciculatum* on Root-Knot Nematode Infected Seedlings

In 45-day old *Meloidogyne incognita* infected seedlings of chilli, there was significant improvement in fresh and dry weight of shoot and fresh weight of root over nematode check for two levels (500 and 1000 spore/500 cc of soil) of *Glomus fasciculatum* inoculum. Difference was not significant between the two levels of *G. fasciculatum* inoculum. Colonization and density of infection into roots in 1000 spores/500 g soil were significantly higher than that of 500 spores/500 g soil inoculum of the fungus. AM fungus had significant suppressing effect on gall numbers (Table 7.1) over nematode check treatment. Both the levels of *G. fasciculatum* drastically reduced the total population and fecundity of *M. incognita* with maximum reduction in 1000 spores/500 g soil inoculum.

Table 7.1. Effect of application of *G. fasciculatum* on root-knot nematode infected seedlings on plant growth parameters and multiplication of *M. incognita*

Treatment	Dry weight (g)		% Colonization of roots	No. of galls/plant	No. of egg masses/ plant	Final nematode population
	Shoot	Root				
Gf_1 + N	3.81	2.40	52.3	117	129	29683
Gf_2 + N	4.19	2.85	56.8	102	102	23610
Nematode check	2.72	1.55	0.0	166	223	62380
LSD (P = 0.05)	0.71	1.31	1.1	18	21	14

Gf: *G. fasciculatum;* Gf_1:@ 500 spores/500 g soil; Gf_2: @ 1000 spores/500 g soil; N: *M. incognita.*

Pathogenicity of *Meloidogyne incognita* on chilli: In a pot trial, six inoculum levels of *M. incognita* (10, 100, 1000, 2000, 5000 and 10000 larvae/500 g soil) were tested for pathogenic potential on RCH-1 variety of chilli. Increasing the inoculum level of nematode resulted in progressive decrease in fresh and dry weights of shoot and root. Maximum reduction in the weights was at 10,000 larvae/500 g of soil. The significant reductions were discernable at 1000 inoculum level and above. The per cent reduction in dry weights of shoot and root over absolute check at 1000 inoculum level was 43.6% and 36.4% which increased to 56.6% and 53.2% at 10,000 inoculum level. The multiplication of the nematode was also observed to increase with the increase in the nematode inoculum. Maximum increase in the rate of multiplication of the nematode over 10 larvae/500 g soil of *M. incognita* was at 1000 larvae/500 g of soil. Two larvae/g of soil was the damaging threshold level of *M. incognita* on RCH-1 variety of chilli.

RODENTS

Mitigation of Bait Shyness

Various interventions for mitigation of shyness (i.e. exposure of different additives in pearl millet grains for three days) considerably reduced the persistence of shyness period from 10- 53 days in different species (Table 7.2)

Table 7.2. Effect of additives on bait shyness in *T. indica* and *F. pennanti* at two different temperature levels

Species	Temperature *	Periodicity of mitigation of bait shyness (days)			
		Control	Groundnut oil 2% + Salt 1%	Coconut oil 2% + salt 1%	Conspecific odour treated bait
T. indica	Low	50	40	25	15
	High	75	60	35	22
F. pennanti	Low	20	18	9	8
	High	25	23	15	13

*Low, (average 21°C), High, (average 31°C).

Funambulus pennanti

Conspecific odour scented baits: Bait shyness period in squirrels was reduced from 20 days to 8 days by exposure of conspecific odour treated pearl millet bait for three days at lower temperature (18 to 25°C). However at higher temperature (28 to 35°C), similar treatment with conspecific odour treated bait, mitigation of bait shyness took longer duration of 13 days.

Impact of Canal Irrigation on Rodent Faunal Diversity in IGNP Command Areas

Species composition of rodents has not altered in IGNP areas of Jaisalmer district (Ramgarh and Mohangarh), which is relatively recent in irrigation status, whereas, mesic rodents have established well in IGNP command areas of Sri Ganganagar district by replacing xeric rodents (Table 7.3). Rodent damage to pods/fruits of pea, gram, and cucurbit vegetables ranged between 6-8.5%. In case of wheat, 8.53% tillers were damaged in periphery of fields.

Rodent Surveys in Kachchh Region (Gujarat)

In cotton and sugarcane fields in Kukma village, three rodent species: Indian bush rat (*Golunda ellioti*, 54.5%), Indian gerbil (*Tatera indica*, 36.4%) and house rat (*Rattus rattus*, 9.1%) were predominant. 13.1% canes and 3.4% bolls of cotton were damaged especially in the blocks near bunds.

Rodent Management in Date Palm Plantations

Serious rodent damage caused death of 2-10% plants in young plantations of date palm cultivar Barhee at farmers' fields. *Tatera indica* (60%) and *Meriones hurrianae* (40%) were the main pest species. Pearl millet based baits of zinc phosphide and bromadiolone resulted in 60-75% reduction in rodent population. Application of castor based 'ecodon', a herbal repellent, around the plants also checked the visit of rodents (25-45%) to the treated plantations.

Effect of Land Use Pattern on Rodent Species

At the C R Farm *T. indica* population increased from 60% in 2005 to 84% in 2011, but in case of *F. pennanti* the population reduced from 16-17 to 12%. Xeric species like *Meriones hurrianae*, *Gerbillus gleadowi* and *G. nanus* have been completely replaced during the last four decades.

Table 7.3. Occurrence of rodent species at different sites in IGNP Command areas

Study sites	Crop fields/location	Rodent species	Trap index
Bikaner	Agri-horti system under drip irrigation	*M. hurrianae* >*T. indica* >*M. booduga*	14.62
	Pasture system - *C. ciliaris*	*M. hurrianae*	9.95
Lunkaransar	Wheat, barley, mustard, gram and pea	*T. indica* > *M. hurrianae*	11.24
	Mustard and gram	*T. indica* > *M. meltada* > *M. booduga*	
	Near bank of canal areas	*N. indica, B. bengalensis*	
Sri Ganganagar	Cotton and sugarcane	*T. indica* >*M. meltada* >*B. bengalensis, N. indica* >*M. booduga*	7.22
	Rice	*B. bengalensis*> *T. indica* >*M. booduga*	
	Clusterbean, fodder sorghum	*T. indica* >*M. booduga*	
	Cotton and fodder stores	*T. indica* and *R. rattus*	
	Tree plantations – Neem, *Hardwickia binata* and teak	*F. pennanti*	
Mohangarh	*Tinda* and Cucumber	*T. indica, M. hurrianae* and *M. booduga*	
	Stores and houses in fields	*R. rattus* >*M. musculus* > *T. indica*	8.00
Ramgarh	Harvested field of wheat	*T. indica* >*M. hurrianae* >*G. gleadowi* and *M. booduga*	-
	Cucurbit vegetables	*G. gleadowi* > *M. booduga* and *T. indica*	
	Range land	*G. gleadowi* > *G. nanus* > *M. hurrianae*	

Trap index: Annual mean trap index (rodents/100 traps/day) was lower (4.28) than the previous years (5.3-5.5). Higher trap index during winters (November-January) (5.05-5.56) was mainly due to higher catches of squirrels and Indian gerbil, coinciding with fruiting season of pomegranate and jujube.

Habitat preference: In different cropping systems, rodent population was maximum in silva fields (42.16%) followed by horticultural orchards (36.76%) and crop fields/grasslands (21.08%). *F. pennanti* was mainly trapped from fruit orchards, whereas *T. indica* was from all the three habitats almost uniformly.

Breeding status of *T. indica*: Sexually mature males (with scrotal testes) were trapped round the year in monthly trappings. Similarly, pregnant females were trapped round the year with higher rates (33-50%) during January, April, September and November.

NON-CONVENTIONAL ENERGY SOURCES, FARM MACHINERY AND POWER

Solar Devices

Solar desalination device of basin type: The device with absorber area of 4.2 m^2 was constructed by using cement concrete hollow blocks. It has double sloped clear window glass roof (3.5 mm thick) having 20° tilt from horizontal and two distillate channels for collection of distilled water (Plate 21). It has advantage of embedded air, which acts as thermal insulation and is not prone to corrosion. The device was found to provide 8.22 litres distilled water per day.

Further, four more solar still were constructed by using a) stone slab, b) brick masonry, c) cement concrete, and d) vermiculite cement.

Solar heating unit for bio-diesel production: A solar energy based thermal unit was designed, developed and tested to heat 25 L tumba oil to more than 60°C in 3-4 hours for subsequent use in bio-diesel production through trans-esterification. The prepared biodiesel was tested for running a 35 hp tractor in the field with a blend of 20% and performance was satisfactory.

Green structure for controlled environment: A photovoltaic (PV) mister was designed and fabricated with a fast moving disc for creating mist from circulating water and a fan assembly run with a PV system for incorporation in a Quonset type green structure, erected for developing controlled environment enclosure (Plate 22). The structure was 5.3 m long and 4.0 m wide with a volume of 33 m^3. Thermal modelling of the green structure was also carried out to predict the temperature and validated in winter.

Improved passive cool chamber: Improved passive cool chamber (surface area 5 m^2 and volume 6 m^3) with additional holes drilled in side walls for larger evaporating area was tested. Maximum depression in temperature was attained within one hour compared to 2-3 hours in old chamber. A mathematical model was developed to predict the temperature inside the cool chamber which was found to give correct prediction during winter season.

PV–thermal integrated device: The device was improved with alternative glazing to air heating tunnel and incorporation of a PV system for operating AC and DC loads (Plate 23). The composite device was found useful for illumination in addition to ensured functioning for winnowing and drying of agricultural produce during cloudy days.

Performance of solar thermal devices: The devices such as solar water purifier, animal feed solar cooker, solar dryer, cooker, water heater, three in one integrated device and photovoltaic devices viz., PV duster, PV generator and PV mobile unit were continued to evaluate long term effects and to identify degradation and maintenance problems. The payback period for the PV–thermal integrated device was about 2 years. The PV mobile unit can provide about 210 unit electricity in a year. The improved three in one integrated device save about 340 kWh equivalent electricity per year. PV generator provides about 1700 units of electricity in a year.

Farm Implements and Tools

The three furrows (six rows) seed drill: The drill was evaluated for its field performance and demonstrated to the farmers of KVK adopted village Newra Road (Osian). Moth bean (CAZRI-2) and

mung bean (GM-4) crops sown with this drill produced about 17-18% higher seed yield compared to the yield obtained with traditional sowing method.

Improved traditional sowing device: In the mechanized metering system the bit and bush assembly was set to regulate the openings for uniform metering of different shape and size of seeds and the press wheel assembly was also adjusted to provide uniform pressure in each furrow throughout its field operation. Pearl millet, mung bean, moth bean and clusterbean crops sown by using the improved seed drill gave 12-15% higher yield compared to conventional method of sowing.

Field performance of improved weeder: Fifteen improved weeders were field tested in the SUMAMAD adopted villages Bhujawad and Rohilla Kala during kharif Season. The field capacity of this single slot weeder was 193.4 m^2 h^{-1} with 94.5% weeding index while for traditional kassi the field capacity was only 160.5 m^2 h^{-1} with 91.8% weeding index. Feedback revealed that the farmers liked single slot *kassi* more compared to traditional *kassi* due to convenience in its use and larger coverage of crop area with little fatigue.

Process Engineering

Shelf life enhancement of pearl millet flour: The pearled pearl millet flour deteriorated much less compared to flour prepared from unpearled grain under ambient conditions (41°C and 60% RH) in 20 days (Table 8.1). However, there was practically no change in the quality of flour kept under refrigerated conditions in both cases.

The pearling of grains (6-8% moisture content) was carried out by the developed pearler and pearled grains, partially pearled grains, grit and fine-bran were separated. These fractions were analyzed for chemical constituent. The data indicated that grit fraction of pearl millet kernel obtained by the milling has 4.3% ash content (minerals), 18.9% crude protein and 17.0% ether extract (lipid).

Table 8.1. Effect of temperature on changes in lipids of pearled pearl millet flour during storage

Days	Storage condition	Fat acidity or Acid value (mg KOH kg^{-1})		FFA (%)		Peroxide values (meq kg^{-1})	
		T1*	T2*	T1	T2	T1	T2
0	Ambient	4.62	11.09	2.32	5.57	16.39	16.66
10	Ambient	7.25	20.93	3.64	10.52	27.52	16.24
10	Refrigerated	4.61	9.78	2.36	5.91	33.06	25.33
20	Ambient	13.87	40.7	6.44	20.4	20.95	11.06
20	Refrigerated	4.66	10.26	2.39	6.15	33.44	21.06

*T1: Flour from pearled grain; T2: Flour from unpearled grain (control).

Status of Wind Farms and Solar Power Plants in Western Rajasthan: The installed capacity of wind power projects commissioned in Jaisalmer, Jodhpur and Barmer districts of western Rajasthan is 1208.12, 288.75 and 9.6 MW, respectively. The maximum projects were installed by individual power producers (1447.37 MW) followed by Rajasthan Renewable Energy Corporation and least by Rajasthan State Mines and Mineral Limited (19.80 MW). In case of solar power plants, 42 MW is from solar PV plants and 2.5 MW from solar thermal power plants at various places in Jodhpur, Jaisalmer, Bikaner and Nagaur districts.

SOCIO-ECONOMIC INVESTIGATION AND EVALUATION

Economics of Commercial Camel Breeding Enterprise in Southern Rajasthan

Primary survey in Udaipur, Banswara, Chittorgarh and Dungarpur districts of Rajasthan revealed, for 98.63% of sample households, camel breeding was the main occupation with average herd size of 21.06 units. Camels were taken away to Gujarat and Madhya Pradesh for about 8 months during winter and summer season. During migration, camel breeders stay in farmer's field who offer them money, free food and tobacco. Human labour is the major item of total maintenance cost (59%). About 80% animals are sold to traders who used to sell them further in fairs at Pushkar and Jhalrapatan. The commonly occurring diseases in camel are trypanosomiasis (surra), pox (mata), pneumonia, mange, enteritis (diarrhea) and abortion. The camel calves suffer from enteritis, pica and pox.

Average fixed investment per household was found to be Rs. 4,22,284 of which animals alone accounted for 97.4%. The average cost of maintaining a camel unit (21.06 animals) was Rs. 1,02,935. The proportion of fixed cost and variable cost in total cost of maintaining a camel are 51%, 49%, respectively. Average net return worked out per camel household per year was Rs 1, 01,464; with B:C ratio of 1.99 (Fig. 9.1). The financial viability of camel herders indicated a payback period of 03 years. Camel production was financially viable at 12% discount rate in terms of both NPV and BCR criteria.

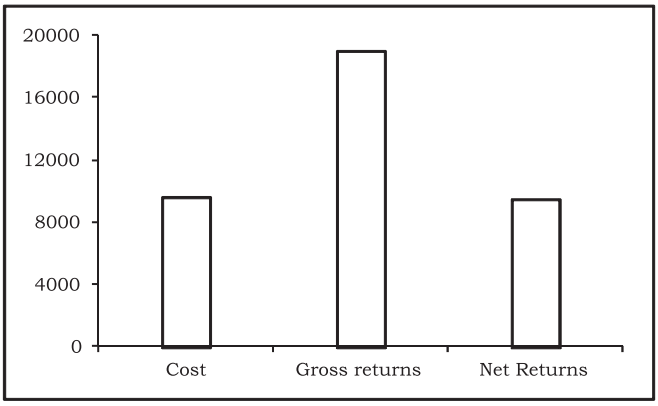


Fig. 9.1. Cost and returns per adult camel, Rs. annum^{-1}.

Impact of MGNREGA on Livelihood Security

The study in village Bhacharna, Luni tehsil of Jodhpur district revealed that more than 80% were female workers. Agriculture was mainly rainfed. The village was inhabited by multi-castes. Major works carried out under MGNREGA were; deepening, digging and bunding of ponds, making cemented slopes, plantation of trees and construction of gravel roads. Almost 74.0% of budget money was spent on wages for labour activities and 26.0% on procurement of materials. Further, 65% income of disadvantaged group of population was derived from MGNREGA. There was shortage of labour for timely agricultural operations, primarily due to increased labour rate. Farmers coped up with the situation through family labour, mutual exchange of labour and partly

hiring from outside. The movement of day labourer to urban centres was declined by 18%. Farmers with small land holding size were found to be more dependent on MGNREGA work (Table 9.1).

Table 9.1. Sources of income under different land size category (Rs./household)

Particulars	Agriculture	Livestock	MGNREGA	Others	Total
Landless	17000 (12.77)	16000 (12.02)	37600 (28.25)	62500 (46.96)	133100 (100)
Marginal	2000 (40.82)	-	29000 (59.18)	-	49000 (100)
Small	60000 (22.67)	33000 (12.47)	987000 (37.29)	73000 (27.57)	264700 (100)
Semi-medium	446500 (43.90)	120000 (11.80)	95100 (9.35)	355500 (34.95)	1011700 (100)
Medium	178000 (24.86)	96000 (1341)	29100 (4.10)	413000 (57.63)	716100 (100)
Large	280000 (57.10)	175000 (35.67)	35600 (7.23)	-	490600 (100)

Note: Figures in parenthesis indicates per cent of total income in each category.

Economics of Sand Dune Cultivation under Irrigated Conditions

Cropping pattern: A sample of 30 farmers having tube-well and canal systems facility was selected randomly in Bikaner and Jaisalmer district. Use of sprinkler irrigation system was found prominent. One murba, equivalent to 5 ha land was allotted to every farmer. The cropping pattern followed by the selected farmers under plain area as well as in dune area has been shown in the Table 9.2.

Table 9.2. Cropping pattern under plain and dune area

Bikaner				Jaisalmer							
Tube-well				Tube well				Canal			
Plain		Dune		Plain		Dune		Plain		Dune	
K	R	K	R	K	R	K	R	K	R	K	R
Gr PM	G W M	Gr PM	G W M	Gr PM	C A	CB PM	Is W M	CB PM	G C	CB	Is

where, K= Kharif, R= Rabi, Gr= Groundnut, CB= Clusterbean, G= Gram, PM= Pearl millet, W=Wheat, M= Mustard, A= Ajwain and Is= Isabgol.

Cost and returns from crops: The cost and returns per hectare basis for cultivation of wheat, groundnut was economically viable on both sand dunes and sandy plains. However, the net returns per ha were higher in the plains as compared to dunes in Bikaner. Similarly in Jaisalmer, productivity of groundnut, cumin, azwain and clusterbean was higher in the plain areas as compared to dunes.

Major constraints perceived by farmers: Inadequate and irregular supply of power, lack of Government support, lack of proper training, technical service and non-availability of labour in time are the major constraints. In Jaisalmer, constraints perceived by farmers include lack of Government support (81.66% farmers), lack of proper training (73.33%), non-availability of labour (66.66%) and non-availability of tractor in time (55%).

Assessment of Food Security in Jodhpur District of Western Rajasthan

This study was conducted from farm households representing different land holdings and caste category in Sar village of Luni tehsil in Jodhpur district. Households were categorized either as food secure or food insecure based on the value of food security index 'z' calculated for calorie and protein availability. The mean household size was 4.84. The study showed that 80% of households were having sufficient aggregate daily per capita calorie availability (z=1.22) and 20% were having lower availability (z=0.60) according to z calculated for calorie. 70% of total households found food secure (z=1.74) and 30% were having lower supply (z=0.71) for protein.

Impact of Depleting Groundwater on Agriculture and Livelihood of Farmers in Pali District

Demography: Average age of farmers in Jaitran tehsil was 49.0 years, majority of them (70.8%) were literate/educated, having joint family (54.2%), with average family size of 9.2 members. Agriculture was the primary occupation with semi-medium to medium size (above 2 ha - upto 10 ha) land holding (79.2%). 58.5% had open well for groundwater irrigation.

Status of groundwater: The average depth of open wells was 31.5 m and 106.3 m for tube wells. 43.2% wells/tube wells had electric motor pumps, 24.3% had engine operated pumps. 65.2% of open wells were renovated in last 10 years.

Change in cropping pattern at farm level: The rabi, zaid and irrigated crops, viz. cotton, chilli, wheat, mustard, vegetables have vanished from the cropping pattern. Pearl millet (18%), sorghum (22%), clusterbean, mung bean (425%) are the major kharif crops and cumin (36%), wheat (22%), mustard (16%), isabgol (12%) are the major rabi and zaid crops cultivated now.

Change in cropping pattern at district level: Analysis of secondary data using the coefficient of concordance (W) test on change in cropping pattern from 1982-83 to 2006-07 showed significant high degree of monocity in the cropping pattern with W value between 0.84 and 0.95). Temporal analysis indicated decline in irrigated crops. Cumin and isabgol showed continuous increasing trend, except during 2002-03 to 2006-07. Area under clusterbean and green gram showed continuous increasing trend. Taramira, grown mostly on conserve moisture also increased. 8.3% farmers adopted drip irrigation, 25.0% adopted sprinkler irrigation and 70.8% invested in PVC/cement/iron pipes to minimize the conveyance loss of irrigation water. The knowledge index of farmers on efficient use of groundwater varied from 24.5% to 87.8%. One third possessed high level of knowledge, 50% medium level and 16.7% were having low level knowledge. Farmers required include efficient methods of irrigation with Mean Per cent Score (MPS) values varying from the highest 79.0 to lowest 61.0. Majority of farmers (87.5%) opined for 1-3 days duration training before sowing of crops and half of them preferred for on-campus as well off-campus training.

TECHNOLOGY ASSESSMENT AND TRANSFER

Rehabilitation of degraded rangelands and stabilization of production in arable arid land of Thar Desert

Demonstrations of various improved technologies for rehabilitation of degraded rangelands were done at villages Bhujawar and Rohilla Kalan of Jodhpur district and Bharmasar of Jaisalmer district.

In both the villages of Jodhpur district, improved varieties of pearl millet, mung bean, moth bean and clusterbean gave significantly higher grain and fodder yields than farmers' own seed. In these villages soil and water conservation activities were performed, vitamin-mineral mixture powder formulated in CAZRI was supplemented to 200 animals, off-campus trainings on enrichment of poor quality dry fodder through urea treatment were organized for skill development of farmers at ten sites and four animal health camps were organized in which more than 1500 animals were treated for various diseases. Feedback analysis on use of weeding implements revealed that the farmers preferred single slot *kassi* to traditional *kassi* due to convenience in its use and larger coverage of crop area with little fatigue.

Apart from these, a rainfed farming-system-model with budded ber (*Ziziphus mauritiana*), karonda (*Cordia myxa*) and seedlings of sisham (*Dalbergia sisso*), karanj (*Pongamia pinnata*), ardu (*Ailanthus excesla*) and kumat (*Acacia senegal*) was developed at farmer's field in Bhujawar. Use of improved varieties and integrated nutrient management in wheat, mustard and cumin on conserved moisture gave higher yields than farmers' practices. Gum induction from *A. senegal* by injecting CAZRI gum inducer was done on 238 trees at Bhujawar, which produced 25 kg gum.

In Rohilla Kalan *in-situ* budding of 143 shoots of wild ber (*Ziziphus rotundifolia*) with the buds of *Z. mauritiana* was done, with more than 85% of the budding union success. One animal feed solar cooker was also installed at this village.

Farmers of Bharmasar village were given nine demonstrations on clusterbean and use of improved varieties and integrated nutrient management of wheat, mustard and cumin on conserved moisture. Seeds of watermelon, popularly known as *mateera* were distributed among ten farmers for seed production as these seeds have a high market value. Farmers were trained on seed collection techniques and pasture development particularly for development of pastures of Sewan (*Lasiurus sindicus*).

Extension and Adoption of Gum Inducing Technology

The technology for exudation of gum arabic with CAZRI gum inducer has become popular in western Rajasthan and stakeholders are earning money by selling gum arabic in local market. Number of trees treated with gum inducer reached to 22600 during 2010 in Barmer, Jodhpur, Nagaur and Pali districts resulting in production of 6.7 t of gum arabic, and with average rate of Rs. 500 per kg generated a revenue of Rs. 38,000,00. Besides *A. senegal* other gum yielding trees like *A. tortilis, A. nilotica, A. leucophloea, P. cineraria, P. juliflora, Anogeissus rotundifolia*, etc. can also be treated by this technique effectively for gum production.

Dissemination of Improved Farm Technologies and Constraints Analysis

Demonstrations were conducted at Bheenjwadia village of Osian tehsil of Jodhpur district on various improved technologies viz., seed varieties, improved agricultural practices including recommended seed rate, seed treatment, time and method of sowing, weed, nutrient and water management (Plate 24).

Moth bean and clusterbean: In 24 demonstrations on moth bean (CZM-3) and clusterbean (RGM-112 and RGC-936) seed yield of CZM-3 was 210% higher compared to 145 kg ha^{-1} in local variety. In case of clusterbean, the average seed yields of RGM-112 and RGC-936 were 67.4 and 60.5% higher respectively than 215 kg ha^{-1} in local check. Net returns per ha in moth bean (CZM-3) were Rs. 11140 more and in clusterbean (RGM-112 and RGC-936), Rs.3600 and Rs. 4050 more respectively than the local variety.

Pearl millet: The mean seed yield of improved varieties of dual purpose pearl millet (CZP-9802) was 55% higher as compared to 930 kg ha^{-1} under farmers' practices. Fodder yield was also 28% higher than local variety.

Groundnut: In two demonstrations, groundnut variety Girnar-2, along with improved package of practices gave 35% higher seed yield and Rs.12050 more net returns as compared with farmers' practices.

BIO-PESTICIDES

Neem Cake

The seed yield of improved variety of cumin RZ-209 was 26.1% higher as compared to 518 kg ha^{-1} of local variety. Application of Neem cake @ 400 kg ha^{-1} increased seed yield by 22% over control in local variety, and 24.4% in variety RZ-209 resulting in additional net returns of Rs.10900.

Marusena (*Aspergillus versicolor*)

Seed treatment of cumin RZ-209 with marusena, a biocontrol agent against wilt, was done at 6 farmers' fields. The mean seed yield in treated plots was 605 kg ha^{-1} with 4.13% increase in yield over untreated plots. However, the effect of bio-agent was more discernible on local cultivar, where the yield in treated plots was 5.31% higher compared to untreated plots. Higher net returns of Rs. 2376 and Rs. 2650 per ha were obtained due to seed treatment with *marusena* in RZ-209 and local variety respectively.

RODENT CONTROL

Four demonstrations were conducted on rodent management technologies in kharif crops and three on rabi crops. Before undertaking demonstrations, on-farm training on rodent management, extent of problem, the rodent species, techniques for preparation and application of poison baits and precautions in their use was organized.

In cumin and wheat, rodent control success (on the basis of burrow count) with zinc phosphide was 64.3 and 53.9% respectively whereas single baiting with bromadiolone reduced burrow count by 22.7 and 27.6% in cumin and wheat, on 4^{th} day after treatment. After two weeks,

control success in zinc phosphide was reduced to 55.4% in cumin and 50.8% in wheat. However, with bromadiolone the success increased to 72% and 68.52% in respective crops. The double baiting with both acute and chronic rodenticides gave highest rodent control success of 78.9% in cumin and 82.0% in wheat on 15th DAT resulting in 10.9 and 7.14% increase in seed yield.

Rodent control success with zinc phosphide was 50 to 67.27% in pearl millet, mung bean, moth bean, clusterbean and groundnut on 4th day after treatment. Control success in groundnut was the least (50%) and required repeat applications. Increase in grain yield due to rodenticidal treatment ranged between 8-16% in different crops.

FARMERS PARTICIPATORY ACTION RESEARCH PROGRAMME (FPARP)

Field Demonstration on Rabi Crops

For popularization of improved varieties, field demonstrations of wheat, mustard and cumin were carried out in three villages namely Birai, Rajaband and Benan. Use of improved varieties of wheat (Raj 3765), mustard (Pusa Jai Kisan) and cumin (RZ 209) gave 18.8, 22.0 and 37.8%, respectively more seed yield than the local variety (Plate 25).

Effect of Improved Practices on the System Productivity

The total productivity of cropping systems increased by 16 to 38% with the use of improved varieties (wheat Raj-3765, mustard Pusa Jai Kisan, cumin RZ 209, pearl millet HHB 67, mung bean RMG 268 and clusterbean RGM 112) and integrated nutrient management (50% N through FYM + 50% N through fertilizer) as compared to farmers practices. Among all the cropping systems, mung bean-cumin gave highest additional net return (Rs. 24507 ha^{-1}) followed by clusterbean-mustard (Rs. 13638 ha^{-1}) and pearl millet-wheat cropping system (Rs. 5157 ha^{-1}) as compared to farmers' practices.

Impact Assessment

Technologies of kharif crops namely, bajra, mung, moth and clusterbean, and rabi crops i.e. mustard, wheat and cumin were popularized through demonstrations, trainings and field days in the villages Birai, Khudiala, Bisalpur, Chodha and Benan of Jodhpur district adopted by CAZRI under FPARP. Levels of knowledge, adoption and constraints of 40 beneficiary and 40 non-beneficiary farmers were assessed.

Knowledge Level

The knowledge level and practice wise knowledge of most of beneficiary farmers were high for both kharif and rabi crops whereas knowledge of non-beneficiary farmers was low to medium.

Adoption Level

Adoption level of most of beneficiary farmers was medium to high and of non-beneficiary farmers low to medium. The mean adoption of beneficiary farmers of kharif crops ranged from 40 to 43% and of rabi crops 45 to 48%. In case of non-beneficiary farmers it ranged between 31 to 35% in kharif and 33-37% in rabi crops.

Constraints in adoption of improved technologies: The main constraints as perceived by majority of the farmers were the non–availability of improved seeds in time, high cost of seed and

low market price of the produce. Majority of the farmers lacked skill in treating seeds in kharif and rabi crops. Other problems faced by the farmers were the problem of high cost of fertilizers, lack of soil moisture, poor soil health, and lack of knowledge of plant protection measures. Weed control with weedicides was perceived as technically complicated and high cost of weedicides was the main constraint in adoption of weed control in mustard, wheat and cumin. Lack of operational skill in plant protection measures, non-availability and high cost of pesticides were perceived as major constraints by both beneficiary farmers and non-beneficiary farmers

Effect of High Yielding Variety and Nutrient Management on the Performance of Rabi Crops

Seed yield of all the crops significantly increased with the use of high yielding varieties and 100% application of recommended dose of fertilizer (RDF) as compared to farmers practice. Use of wheat-Raj 3077, mustard-Pusa Jai Kisan and cumin variety RZ 209 with the application of 100% RDF resulted in 27.7, 24.4 and 26.4%; increase in seed yield as compared to local variety grown with farmers' practices.

Production Potential of High Yielding Varieties of Kharif Crops

The yield of all the crops was significantly improved due to use of high yielding varieties. The increase was recorded 14.8 to 28.12% with the use of high yielding varieties of different crops during kharif season as compared to local checks (Table 10.1).

Table 10.1. Seed yield of improved varieties and local checks of kharif crops

Crop	Variety	Seed yield (kg ha^{-1})
Pearl millet	HHB 67	1280
	MP 171	1160
	Local check	920
Green gram	RMG 268	720
	SML 668	680
	RMG 62	610
	Local check	520
Clusterbean	RGM 112	860
	RGC 936	750
	Local check	620
Moth bean	RMO 435	520
	CAZRI Moth 3	500
	Local check	380

Integrated Nutrient Management in Pearl Millet

Integrated application of 50% RDF + 50% FYM gave maximum grain yield of pearl millet, which was 38.6% higher than farmers practice. Application of 100% RDF (40 kg N + 40 kg P_2O_5) and 100% FYM (10 t ha^{-1}) increased seed yield by 29.6 and 27.7%, respectively over farmers practice (Plate 26).

Validation of Indigenous Technical Knowledge of Grain Storage

Traditional methods of grain storage in the arid region were: mixing/covering seeds with sand, ash, neem seed cake and mixing castor oil with the grains. Among different methods, sieved

Plate 21. Solar desalination device made of cement concrete hollow block.

Plate 22. Green structure with PV mister.

Plate 23. PV-Thermal integrated system for winnowing, drying and illumination.

Plate 24. Moth bean crop with improved technology.

Plate 25. Mustard crop with improved technology.

Plate 26. Pearl millet crop with nutrients management.

ash mixed at 10% rate with clean and dried wheat grains showed least weight loss and gave maximum protection (up to 97%) from insect pests.

Agricultural Technology Information Centre (ATIC)

Agricultural Technology Information Centre of CAZRI, Jodhpur effectively provided products, services, technologies and information to different stakeholders through a single window delivery system. Besides the farm advisory services and technological inputs provided at the ATIC, the farmers were given farm advice through helpline, exhibitions, farm literature and technical correspondence. During the year, a total of 5128 farmers/entrepreneurs, development departments' officials, students, NGO's representatives from 11 states of country visited the ATIC and Institute. Among the visitors, 2704 visitors approached ATIC to purchase technological inputs or value added products and 2424 visitors were mainly benefitted through farm advisory service provided by the center. Center earned sizeable revenue through sale of different technological inputs/products including seeds of improved varieties of pearl millet: CZP 923, CZP 9802, green gram: SML 668, RMG 268, RMG 62, moth bean: CZM 3, CZM 2, sesame: RT 346, clusterbean: RGC 1031, RGC 1003, RGJ 136, cumin: GC 4, RZ 209, mustard: Pusa bold, Jai kisan, grasses: *Cenchrus ciliaris*, *Lasiurus sindicus*, *Cenchrus setigerus*, planting material of ber and pomegranate, neem, khejri (*Prosopis cineraria*), rohida (*Tecomella undulata*), *Aloe vera*, etc., value added products- Aloe crack cream, Aloe moisturizer, bio-fertilizers, bio-control agents (*Marusena*), and value added fruit products. The facility of soil and water testing was also provided to the farmers at the centre.

EMPOWERMENT OF WOMEN AND MAINSTREAMING OF GENDER ISSUES

Capacity Building of Farm Women through Selected Agro-based Technologies in Jodhpur District

Farm women were given demonstrations on improved technologies of crops and vegetable production for enhancing their knowledge and skills.

Crop demonstration: During kharif season, 22 demonstrations on different crops viz. pearl millet (CZP-9802), mung bean (SML-668, RMG-268) and clusterbean (RGC-936 and RGM-112) were conducted in Umaidnagar village. Due to improved practices, the seed yield increased by 34 to 92% in various kharif crops.

Kitchen garden: Three demonstrations on cucurbit vegetables, lady finger, bottle gourd, and clusterbean cultivation were conducted on farmer fields at Umaidnagar village.

Assessment of Women Empowerment Indicators

Women empowerment indicators such as gender activity and decision-making profile were measured. Responses indicated that majority of agricultural and livestock activities (70-75%) were carried out with the help of women. Most of the agricultural activities like field preparation, making bunds, clearing weeds, harvesting and transport of harvest were performed jointly. Women were always involved in weeding, threshing and winnowing operations (72.2, 52.8 and 77.8 respondents respectively) but involvement of male members in these activities was very less (16-33%).

In case of livestock production, women carried out all activities like fodder collection, drying, feeding, cleaning, milking, processing milk etc., but participated less in areas requiring more technical knowledge like heath care (13.9%) and marketing of produce (6.66%). In different household works, the contribution of women was very high (91.7-100%)

Participation of women in decision making was low. Male members dominated decision making related to agricultural and livestock, but females participated in decisions regarding household/domestic activities. Most of the decisions about breeding (66.7%), feeding (83.3%) as well as management of cattle were taken jointly (85.3%).

Women's Day in Agriculture Celebrated by KVK Jodhpur

Women's day in agriculture was celebrated by Krishi Vigyan Kendra, Jodhpur on 04th and 05th December 2011 at *Purkhawas* village of *Luni* Panchayat Samiti to sensitize the farm women about improved crop and livestock production technologies. Training on value addition of fruits and vegetables was organized on this occasion and 200 farmwomen from *Purkhawas* and nearby villages participated.

Activities undertaken by KVK

KVK Jodhpur conducted demonstrations on improved crop and livestock production technologies, training programmes and extension activities for farm women.

EDUCATION AND TRAINING

Various training courses organized by the Institute for disseminating information to different target beneficiaries are summarized below:

Topic	Date(s)	Number of participants	Sponsor/Organizers
Inter State Farmers' training on Cattle Feed Production at KVK, CAZRI, Jodhpur	March 8-11, 2011	20	Project Director ATMA, Jilla Panchayat, Sabarkantha (Gujarat)
	March 28-31, 2011	23	
Workshop cum Training Program hosted on Consortium on e-Resources in Agriculture (CeRA)	July 13, 2011	45	CAZRI, Jodhpur
Model Training Course on Integrated Farming Systems for Dry Lands	October 10-17, 2011	13	Directorate of Extension, Govt. of India, New Delhi
Mateera Field Day at RRS, Jaisalmer	October 11, 2011	100	CAZRI, RRS, Jaisalmer & PD (ATMA), Jaisalmer
Balanced feed preparation and its importance to increase animal productivity at Training Resource Centre, ACF, Marwar Mundwa, District: Nagaur	November 8, 2011	45	Ambuja Resource Center, Marwar Mundwa
Improved Agricultural Practices for Arid Horticulture	November 15-22, 2011	12	Directorate of Extension, Govt. Of India, New Delhi
Capacity Building Training Program on Watershed Management	January 18-20, 2012	21	Ministry of Rural Development Govt. of India, New Delhi
	January 23-25, 2012	19	
Training on Agriculture Practices for Tribal Areas	February 23-24, 2012.	200	CAZRI, Jodhpur KVK, Banswara KVK, Dungarpur
Nano Particles: Production, Characterization and Utilization In Agriculture	February 23-March 3, 2012	24	NAIP (World Bank)
Workshop for 'Targeting Agri-Based Technological Interventions in Arid Western Rajasthan'	February 29, 2012	72	Project Directorate, MPOWER, Jodhpur
Off-campus Training on Improved Cultivation Practices of Rabi Crops in Bhujawar Village	March 2, 2012	100	UNESCO under SUMAMAD Project
Field day on Improved Cumin Production Technologies in Bheenjwadia Village of Jodhpur Village	March 19, 2012	93	Division of TOT&PE, CAZRI, Jodhpur

TRAINING ON MUSHROOM CULTIVATION FOR PROSPECTIVE ENTREPRENEURS

Name of the Training	Date	Participants
Vocational Training on Mushroom Farming and Value Addition	November 16-18	30

TRAINING COURSES ORGANIZED FOR FARMERS

Subject	On-campus		Off-campus		Total	
	No. of courses	No. of trainees	No. of courses	No. of trainees	No. of courses	No. of trainees
Division of Transfer of Technology, Training and Production Economics, at Bheenjwadia village						
Improved Cultivation Practices of Groundnut Crop	–	–	1	12	1	12
Rodent Management in Kharif and Rabi Crops	–	–	2	27	2	27
Improved Cultivation Practices of Kharif Crops	–	–	2	39	2	39
Compost Preparation	–	–	3	44	3	44
Improved Cultivation Practices of Cumin	–	–	1	12	1	12
Use of Neem Cake	–	–	2	22	2	22
Plant Protection Measure in Cumin	–	–	1	16	1	16
Balance Feeding and Health Management of Livestock	–	–	1	20	1	20
Total	–	–	**13**	**192**	**13**	**192**
RRS, Bikaner						
Horticulture	6	197	–	–	6	197
Agronomy	1	20	–	–	1	20
Resource Management	1	40	–	–	1	40
Total	**8**	**257**	–	–	**8**	**257**
RRS, Jaisalmer						
Grassland Management	1	50	–	–	1	50
Agronomy	–	–	1	50	1	50
Agro-forestry	1	30			1	30
Total	**2**	**80**	**1**	**50**	**3**	**130**
KVK, Jodhpur						
Crop Production	7	188	14	430	21	618
Horticulture	5	193	13	337	18	530
Plant Protection	2	68	16	384	18	452
Livestock	4	120	7	138	11	258
Home Science	2	85	13	251	15	336
Agroforestry	4	115	10	187	14	302
Agril. Extension	9	254	21	558	30	812
Total	**33**	**1023**	**94**	**2285**	**127**	**3308**
KVK, Pali						
Agriculture Extension	7	175	11	310	18	485
Agronomy	12	285	18	356	30	641
Home Science	5	130	4	112	9	242
Horticulture	6	250	6	150	12	400

Various Trainings and Workshop.

Veterinary Science	5	83	13	280	18	363
Plant protection	3	95	6	200	9	295
Organic farming	4	125	5	175	9	300
Total	**42**	**1143**	**63**	**1583**	**105**	**2726**
KVK, Bhuj						
Feed and Fodder Management for Profitable Animal Husbandry	1	400	_	_	1	400
Training-cum-Seminar on Production Technology of Pomegranate	1	300	_	_	1	300
Total	**2**	**700**	_	_	**2**	**700**

RRS, BIKANER

Title of training	Duration	No. of participants	Sponsors
Sabji Utpadan Ki Naveentam Taknike	November 2-5, 2011	25 Women farmers	PD (ATMA), Jhunjhunu
Sushka Avum Ardhsushk Kshetro Me Phalotpadan			
Sabjityon Aum Phalo Ke Utpadan Ki Unnat Taknike	November 14-18, 2011	30 Farmers	PD (ATMA), Jaisalmer
	December 27-31, 2011	30 Farmers	
	January 30-31, 2012	57 Farmers	Secretary, DHDS & AD (Ag), Jaisalmer
	February 6-10, 2012	30 Women farmers	PD (ATMA), Jaisalmer
Krishi Utpadan Vridhi Hetu Sanshdhan Prabandhan	February 13-17, 2012	40 Krishi mitra	PD (ATMA), Bikaner
Fasalotpadan Ki Naveen Takanikain	February 21-25, 2012	20 Farmers	PD (ATMA), Jhunjhunu

TRAININGS AND DEMONSTRATION ON RODENT PEST MANAGEMENT

Village	Date	Farmers benefitted
Lunkaransar	10.03.2011	5
Mohangarh, Ramgarh, Nachana (Jaisalmer)	24-26.05.2011	15
Bijwadia (Jodhpur)	22.03/11.08.2011	19
Papasani (Nagaur)	03.08/ 28.08.2011	30
Telawadi, Maheawali, Dakawali (Sri Ganganagar)	18-19.10.2011	10
RRS, Bhuj (Gujarat)	05.11.2011	25
Bagadia (Jodhpur) (KVK)	26.11.2011	21
Budhi (Nagaur)	5.01.2012	2
Pabunada (Jodhpur) (KVK)	6.03.2012	18
Newra Road (Jodhpur) (KVK)	16.03.2012	15

SPECIALIZED TRAININGS ON RODENT PEST MANAGEMENT

Topic	Training for	Dates	No of participants
Rodent Pest Management in Zoos	Jodhpur Zoo Officials	20.09.2011	5
Rodent Pest Management in Hospitals	MG Hospital officials	22.02.2012	4
Rodent Pest Management Techniques	Dr. Abu Manzar, Astt. Prof. SKUAST, Srinagar	20-21.09.2011	1

TRAINING ON RODENT MANAGEMENT TO STATE OFFICIALS

Nature of training	Topics	Date
National Refresher Course on Rodent Management for the Officials of Kerala and Tamilnadu at KAU, Thrissur	(i)Assessment of economic losses of rodent menace in India and rodent damage to crops (ii) Recent trends in Integrated Management of Rodent pests in India (iii) Planning Process for Rodent Pest Management	September 13-14, 2011
Model Training Course on Horticulture at CAZRI, Jodhpur	Rodents Management in Horticultural Crops	November 18, 2011
Refresher Training on Rodent Pest Management for the officials of Bihar	(i) Recent trends in Integrated Management of Rodent pests in India (ii) Rodenticides and their application techniques (iii) Planning Process for Rodent Pest Management	January 11-14, 2012

RODENT CONTROL CAMPAIGNS

Village	Date	No of beneficiaries
Purkhawas	12.07.2011	26
Purkhawas	06.03.2012	50

KISAN MELA AND NATIONAL SYMPOSIUM

Topic	Date(s)	Number of Participants	Sponsor/Organizers
Kisan Mela	August 29, 2011	400	CAZRI and KVK
National Symposium on Resource Utilization through Integrated Farming System and Biodiversity Conservation in Drylands at Bhuj	December 20-22, 2011	130	AZRAI and CAZRI, Jodhpur

AWARDS AND VISITS

AWARDS

- Third prize during Hindi Saptah (September 14-20, 2011) to Dr. P.K. Malaviya, Dr. D. Mishra and Shri P. Sharma. *Hindi Shodh Patra Pradarshan* organized on September 17, 2011.
- Dr. J.S. Pruthi Award 2009 to Drs. R.N. Kumawat, Sunil S. Mahajan and R.S. Mertia on 8th December 2011 for Best Research Paper entitled "Response of cumin (*Cuminum cyminum* L.) to *panchgavya* and plant leaf extracts in arid western Rajasthan" in the Journal of Spices and Aromatic Crops 18(2): 92-99.
- First Prize for Poster entitled "Processing and Utilization Technology of Pearl Millet" to Dr. P.K. Malaviya, H.C. Bohra and P. Sharma during National Workshop on Stress Agriculture and Climate Change: Exploring Synergy with Natural Resources. December 21-22, 2011 Agricultural Research Station SKRAU, Mandor, Jodhpur.
- Bharat Jyoti Award 2011 to Dr. J.C. Tarafdar by the India International Friendship Society for outstanding contribution and remarkable role in science.
- Glory of India Gold Medal to Dr. J.C. Tarafdar by International Institute of Success Awareness on February 14, 2012 for meritorious services and outstanding role in agricultural sciences.
- Best Poster Presentation Award to Dr. V.S. Rathore, Birbal, N.S. Nathawat, S., Bhardwaj, Raj Singh and N.D. Yadava 2011. Improving crop water productivity: Needs and Options. In *National Symposium on Resource Utilization through Integrated Farming System and Biodiversity Conservation in Drylands* organized by AZRAI and CAZRI Jodhpur at CAZRI, RRS, Kukuma, Bhuj during 20–22 December, 2011.
- IEI Young Engineer Award to Dr. Deepesh Machiwal, Senior Scientist (Soil & Water Conservation Engineering) by the Institutions of Engineers (India) in 25th National Convention of Agricultural Engineers held at Kolkata, West Bengal.
- Fellow of the Range Management Society of India (RMSI) Jhansi 2011 to Dr. J.P. Singh for his contribution in grassland management and biodiversity conservation.
- Institute Foundation Day Awards, 2011, for the best research paper to Drs. P. Santra, R.S. Mertia and H.L. Kushawa (Scientists), as best workers to Smt. Savita Singhal (Technical category), Shri Mahender Joshi (Administrative) and Shri Sammandar Khan (Supporting) on 1st October, 2011.

VISITS ABROAD

- Dr. M.M. Roy visited Aleppo (Syria) to discuss about the Centre for Excellence for Dry Land Production System, during May 21-26, 2011.
- Dr. M.M. Roy visited Nairobi (Kenya) to attend Dryland Systems Regional Design Working Meeting of World Agroforestry Centre (DCRAF), during June 26-30, 2011.
- Dr. R.K. Bhatt visited Rome, Itlay from October 24-25, 2011 to attend the Geo-Carbon Conference: Carbon in a Changing World, at FAO Headquarter.
- Dr. Dheeraj Singh visited Nairobi, Kenya from November 13-18, 2011 to participate in 2nd GKRAS Annual Meeting and International Conference on "Innovation in Extension and Advisory Services".
- Dr. T.K. Bhati visited Burkina Faso from December 14-19, 2011 to participate in 9th International Workshop on "Sustainable Management of Marginal Drylands-Phase 2 (SUMAMAD)-2" at Babo Dioulasso.
- Dr. M.M. Azam visited USA from January 9 to May 8, 2012 to attend the USIEF Full Bright Nehru Environmental Leadership Programme 2011-12.
- Dr. M.M. Roy visited Bangladesh from January 22-26, 2012 to attend the Second Regional Committee of South Asia and China.

LINKAGES AND COLLABORATION

International

- UN Convention to Combat Desertification
- International Water Management Institute
- International Crops Research Institute for Semi-Arid Tropics
- International Committee on Irrigation and Drainage
- International Centre for Agricultural Research in the Dry Areas

National

- Department of Science and Technology, Govt. of India
- Ministry of Environment and Forests, Govt. of India
- Ministry of Rural Development, Govt. of India
- National Wasteland Development Board, Govt. of India
- National Bank of Agriculture and Rural Development
- National Oilseeds and Vegetable Oils Development Board
- Botanical Survey of India, Govt. of India
- National Remote Sensing Agency, Department of Space, Govt. of India
- Space Applications Centre, Department of Space, Govt. of India
- Department of Biotechnology, Govt. of India
- National Centre for Medium Range Weather Forecasting, Govt. of India
- National Commission on Farmers, New Delhi
- National Rainfed Area Authority
- National Horticulture Board
- National Bureau of Plant Genetic Resources
- Other ICAR Institutes
- District Rural Development Agencies, Govt. of Rajasthan
- State Departments of Agriculture, Livestock, Watershed and Groundwater, Govt. of Rajasthan
- Rajasthan State Mineral Development Corporation
- Swami Keshwanand Rajasthan Agricultural University, Bikaner
- Maharana Pratap University of Agriculture and Technology, Udaipur
- CCS Haryana Agricultural University, Hisar
- Sardarkrushinager Dantiwara Agricultural University, SK Nagar
- Jai Narayan Vyas University, Jodhpur
- Arid Forest Research Institute, Jodhpur

PUBLICATIONS

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RESEARCH PROGRAMMES

ICAR-FUNDED PROJECTS

Integrated Basic and Human Resources Appraisal, Monitoring and Desertification

- Integrated natural resources survey of the arid tehsils of Banaskantha and Sirohi districts
- Soil fertility assessment and mapping in arid region of Rajasthan
- Studies on evapotranspiration and yield relationships in sesame
- Quantitative erosion process measurement and spatio-temporal variability in sediment transport in arid ephemeral stream channels
- Impact of weather variation on agriculture production at Leh and around Leh in Ladakh

Biodiversity Conservation, Improvement of Annuals and Perennials

- Improvement of pasture grasses and legumes of arid zone: *Cenchrus ciliaris,* and *Cenchrus setigerus*
- Genetic improvement of arid zone trees: *Prosopis cineraria, Acacia senegal, Acacia tortilis, Acacia albida, Tecomella undulata, Salvadora oleoides* and date palm
- Screening and evaluation of date palm cultivars for commercial cultivation in Thar Desert
- Breeding and disease management for enhancing seed yield and quality of gum in guar and improvement of mung bean
- Development of hybrid parents and hybrids of pearl millet for arid areas
- Genetic enhancement of pearl millet for north west arid regions
- Collection, evaluation and genetic enhancement of sesame (*Sesamum indicum* L.) for improving productivity in arid area of Gujarat
- Development of techniques for quality seed production and post-harvest handling in cumin (*Cuminum cyminum*)
- Genotypic evaluation of sweet sorghum for fodder
- Genetic improvement of watermelon [*Citrullus lanatus* (Thunb.)] for seed yield suitable for rainfed situations of Jaisalmer
- Characterization of soil seed bank of *Lasiurus sindicus* and its effect on species dynamics in arid rangelands of India
- Genetic characterization and documentation of released varieties of cumin, coriander, fenugreek and fennel
- Evaluation of efficient rhizobial strains for better nodulation in *Acacia senegal* and *Prosopis cineraria*
- Collection evaluation and improvement of kair (*Capparis decidua*) for superior plants
- Improvement of arid zone trees for agroforestry system
- Genetic improvement of clusterbean, moth bean and mung bean

Integrated Arid Land Farming System Research

- Integrated farming system for sustainable agriculture in arid zone
- Development of *Ailanthus excelsa* (sendra) based silvi-agri-pastural system for hot arid tract
- Studies on agronomical management practice in arid legume under National Network Program
- Improvising the quality of sesame, mustard and unpalatable desert vegetation for incorporation in field and their effect on quality of soil organic matter
- Development of ber based oleri-horti models for higher economic return in arid region

- Development of agro-techniques for sustainable rainfed production of arid legume in extreme Thar Desert (NNP-AL)
- Effect of temperature and salinity on germination and planting density and cutting intensity on growth and productivity of Haloxylon recurvum, *Calligonium polygonoides* and *Acacia jacquemontii*
- Assessment and monitoring of carbon stock under different cropping systems in the Kachch region of Gujarat
- Evaluation and management of perennial forage legumes for establishment, growth and productivity in arid region of Gujarat
- Effect of pre-sowing seed treatments on performance of cumin crop
- Assessment of cropping systems under drip irrigation for improving resource use efficiency
- Studies on evaluating suitable combination of nutrient and water management approaches for sustainable vegetables production under potential irrigated condition of arid region
- Genetic study of salinity tolerance in Indian mustard (*Brassica juncea* L.)
- Role of sulphydryl compound for improving crop productivity of arid legume (moth bean & clusterbean)in water deficit environment
- Carbon sequestration, decomposition and nutrient dynamics of leaf litter and roots of predominant tree species and their effect on crop production in agri-silvi-horti systems of arid zone
- Identification of compatible crop and suitable row spacing for live mulching in rainfed crop grown with colocynth
- Physiological basis of effects of foliar spray of iron and zinc spray on temperature tolerance of principal crops of Indian arid zone
- Soil moisture conservation studies in *Pongamia* and *Henna* based agroforestry system in Pali region
- Introduction and evaluation of Cactus pear (*Opuntia ficus -indica* L.) for fruits and fodder
- Development of organic production system for high value crop of arid Zone
- Development of agri-horti. system in rejuvenated ber orchard in arid condition
- Evaluation of growth performance and adaptability of *Acacias* and *Prosopis* in Rajasthan
- Long term fertilizer trial on pearl millet
- Effects of organic input on system productivity and important soil attributes of an intensive *Prosopis cineraria* (L.) Druce, based arid zone agroforestry system
- Molecular characterization and documentation of arid zone fruit crops

Management of Land and Water Resources

- Study of intensive agroforestry models developed with organic input in arid zone
- Impact assessment of global warming on reference evapotranspiration for arid zone of Rajasthan
- Studies on fodder production potential round the year from different cropping systems under limited irrigation condition
- Production, potential and economics of alternate land use systems involving arid legumes in arid region of Gujarat
- Improving land use through crop intensification, newer tillage option and nutrient economy in Pali region
- Land use effect on soil properties in sandy arid plains of district Bikaner: Implication for soil condition appraisal
- Deficit irrigation management for increased water productivity of field crop under medium textured saline soils of semi-arid region
- Development of pedotransfer function for estimating soil hydraulic properties for Indian arid soils
- Impact of canal irrigation on soil salinity and water logging in IGNP-2 and Narmada command area in western Rajasthan
- Sensitivity analysis of climate variability and change on productivity of pearl millet and wheat in arid Rajasthan
- To study the effect of organic input on the physical, chemical and microbiological properties of soil of Pal series under different vegetation and management

- Evaluation and management of field crops for higher water productivity under limited water in arid Gujarat
- Soil biodiversity in grasslands of arid western plain
- Hydrological monitoring and interventions for development of Block-II of Beriganga Research Farm
- Status of soil sulphur and related biodiversity in transitional plain of Luni basin
- Production potential of established Agri-silvi-horti system under different management practices with micro irrigation system in arid zone of western Rajasthan
- Development of suitable deficit-irrigation schedule to improve crop-water productivity in Bikaner region
- Vegetable production through harvested rain water in Bikaner region
- Assessment of soil carbon stock in cultivated lands in Bikaner district
- Runoff and sediment yield in Kukma watershed

Improvement of Animal Production and Management

- Mineral profile of livestock *vis-a-vis* health status/deficiency diseases in arid zone
- Impact of drought on animal availability of feed and fodder, and fertility, health and productivity of animals
- Evaluation of different nutritional supplements for improving productivity of arid livestock
- Vitamin A status in lactating cattle under different feeding management conditions
- Assessment of climate stress on productivity of arid livestock and its amelioration through housing and feeding management

Plant Products and Value Addition

- Value addition in meat and dairy products of goats and sheep
- Studies on post-harvest processing of pearl millet
- Development of bio-diesel production unit and green building with hybrid system
- Molecular characterization, production and conservation of tropical mushrooms in arid regions
- Development of Aloe products for different applications
- Production of oleo-gum resin from *Commiphora wightii*

Integrated Pest Management

- Studies on bait shyness and poison aversion behaviour and its mitigation in desert rodents
- Testing *Prosopis cineraria* extracts and insect emissions as attractants for long horn beetles
- Dynamics of predatory insects in legume crop-tree-weed interface
- Isolation, characterization and multiplication of native microbial entomopathogens (*Bacillus* and *Metarhizium*) for the management of insect pests of the arid region
- Developing IPM schedule for mung bean and cumin crop under organic farming
- Developing bio-control enriched compost for suppression of soil borne plant diseases in Indian arid zone
- Impact of canal irrigation on changes in rodent faunal diversity in IGNP command areas

Non-Conventional Energy Systems, Farm Machinery & Power

- Design and development of medium and large size solar PV and integrated systems for multiple applications
- Improvement of passive cool chamber with alternative materials
- Design, development of PV-hybrid structures and improved devices for arid region
- Design, development and performance evaluation of solar desalination devices
- Assessment of existing wind farms and solar power plants in western Rajasthan
- Performance evaluation, refinement and field testing of mechanized traditional seed drill

Socio-economic Investigation and Evaluation

- Impact of depleting groundwater on agriculture and livelihood of farmers in Pali district of Rajasthan

- Impact of NREGA (National Rural Employment Guarantee Act) on livelihood security: A case study in the arid region of western Rajasthan
- Economics of sand dune cultivation under irrigated conditions
- Economics of camel production in southern Rajasthan and arid Gujarat

Technology Assessment, Refinement and Training

- Capacity building of farm women through selected agro-based technologies in Jodhpur district of Rajasthan
- Dissemination of improved farm technologies and constraint analysis in Osian tehsil
- Assessment of food security in some villages of Jodhpur district

Externally Funded Projects

- National seed project (crops) (i) Breeder seed production (ii) Seed technology research
- Integrated agro-meteorological advisory services (AAS) for farmers of Jodhpur region
- Identification and quantification of phosphatase hydrolysable organic P sources for plant nutrition and refinement of a non-destructive technique for phosphatase estimation
- ICAR Mega seed project on seed production in agricultural crops
- Nano-technology for enhanced utilization of native – phosphorus by plant and higher moisture retention in arid soils
- Network project on Guggal (*Commiphora wightii*)
- Value chain on value added products derived from *Prosopis juliflora*
- Development of model organic farm and organic farming production system for arid zone
- Farmers' participatory activities research program
- Harvest and post-harvest processing and value addition to natural resins and gums
- Vegetation carbon pool assessment project in India
- Application on seasonal forecasts for crop planning and livestock management in arid Rajasthan: A case study for Jodhpur district
- Improvement of infrastructural facilities in the botanical garden of the institute to develop the garden as lead garden
- Estimating marketing efficiency of horticultural commodities under different supply chain in India
- Developing a consortium of *Bacillus firmus* and *Trichoderma harzianum* for the control of soil borne plant pathogens of Indian arid region
- Forecasting agricultural output using space, agro-meteorology and land based observations (FASAL)
- Rehabilitation of the degraded rangeland and stabilization of production in arable arid land of Thar Desert, India
- Pilot Study on livestock intervention for livelihood improvement in Nagaur district of Rajasthan
- Geomorphological and lineament mapping in western Rajasthan
- Unravelling biochemical and molecular basis of bacterial and fungal endo-symbiosis for management of abiotic stress in plants
- Vulnerability assessment and adoption strategies for agriculture in respect of climate change in arid western India
- Evaluation of pearl millet genotypes under rainfed condition (AICRP on Pearl millet)
- Agronomic investigation in arid legumes (NNP-AL)
- Energy and mass exchange in arid grassland system
- DUS test centre for pomegranate
- Coping strategies for livestock smallholders in the face of climate change and soaring feed prices: case study of livestock mobility in the state of Rajasthan, India
- All India Network Project on Rodent Control
- National Network Project on Arid Legumes

INSTITUTE MEETINGS

Mid-Term: ICAR Regional Committee-VI

The midterm review of the Action Taken Report (ATR) on the Recommendations of XXI ICAR Regional Committee No. VI was held at CAZRI, Jodhpur on December 1, 2011. The meeting was chaired by Dr. A.K. Singh, Deputy Director General (NRM), ICAR, New Delhi. Dr. M.M. Roy, Director CAZRI, Jodhpur was the Member Secretary. The meeting was attended by officials from the Line Departments of state of Rajasthan and Union Territories of Daman & Diu and Dadra & Nagar Haveli, Heads of Regional Research Stations of CAZRI, PCs of AINP on Rodent Control and Arid Legumes, PC, KVK, Jodhpur, Head, NBPGR Research Station, Jodhpur, Heads of Divisions and members of PME Cell, CAZRI. Dr. Roy thanked the officials from states and union territories for sending the ATR on recommendations of the XXI ICAR Regional Committee Meeting, which was held at SKRAU, Bikaner (Oct. 21-22, 2010). Dr. A.K. Singh briefly outlined the importance of the meeting. He felt that such meetings provide good opportunities to get feedback from various state departments, and to strengthen the linkages between ICAR Institutes, the SAUs and the state agriculture departments. These meetings also highlight the important issues that need attention. He hoped that some of the issues raised could form the agenda for next ICAR Regional Committee Meeting. He then informed that ICAR had developed district level contingency plans, which can be downloaded from the ICAR/DARE websites, and hoped that the participants would go through the details and suggest fine-tuning of the region-specific plans.

Research Advisory Committee (RAC)

Chairman	:	Dr. H.P. Singh
Members	:	Prof. M.H. Qureshi, Dr. I.D. Tyagi, Dr. B.D. Kaushik, Dr. V.K. Singh, Dr. V. Nagadevara, Dr. M.M. Roy and Dr. R.K. Kaul
Date	:	April 11 and August 29-30, 2011
Discussion	:	The RAC Members interacted with the Heads of Divisions and Regional Research Stations on the Institute's Research Programmes and the research results for the previous year. Based on extensive discussion, suggestions for improvement were given by the RAC Members.

Quinquennial Review Team (QRT)

Chairman	:	Dr. S.M. Virmani, ICRISAT Principal Scientist (Retired)
Members	:	Dr. O.P. Pareek, Dr. P.S. Pathak, Dr. Mruthyunjaya, Dr. K.V.G.K. Rao, Dr. M.P. Yadav, Dr. Masood Ali and Dr. Amal Kar (Member Secretary)
Date	:	April 17-24, September 19-24, 2011
Discussion	:	Reviewed the functioning of CAZRI during 2005-09 including research, administration, funding and related matters, and to suggest improvements. The report of the QRT was prepared in September 2011, and submitted to the Director General, ICAR.

Mid Term Review: ICAR Regional Committee-VI.

Members of QRT (2005-09).

Release of book at RAC Meet.

IMC Meet.

Press Meet.

Hindi Week.

Dr. A.K. Singh, DDG (NRM), ICAR addressing the farmers at Kisan Mela.

Institute Management Committee (IMC)

The IMC meeting, held on July 11, 2011 discussed issues related to budget and expenditure of the Institute, audit report, purchase of equipment and other administrative matters.

Institute Research Council (IRC)

The IRC meeting was held on June 1-3, 2011, the annual progress reports of various ongoing and externally funded projects were discussed and two projects were extended/re-scheduled and 24 new projects were approved.

Institute Joint Staff Council (IJSC)

Meeting was held on September 4, 2011. A number of issues related to the Institute administration and staff members were discussed, and actions were taken/initiated for streamlining of the day-to-day working of the Institute.

Significant Days Celebrated by the Institute

World Environment Day (5th June): Environmental Information System (ENVIS) Centre organized an essay competition for school children on the theme "Forests: Nature at Your Service". Dr. Amal Kar delivered a lecture on theme. Dr. M.M. Roy, Director presided over the function. Dr. Raj Singh welcomed the guests and Shri Tirth Das, ENVIS coordinator briefed about ENVIS activities.

World Day to Combat Desertification (17th June): Dr. Ranjana Arya, AFRI, Jodhpur, delivered a lecture on the theme "Forests Keep Drylands Working". Dr. R.K. Bhatt, Director I/c, presided over the function. Dr. N.S. Panwar welcomed the Chief Guest and participants. Shri Tirth Das proposed vote of thanks.

Inter Zonal Sports Tournament (9-13 November): The ICAR West Zone Sports Tournament 2012 was organized during February 13-17. More than 450 sports persons and officials from 15 ICAR institutes from the West Zone (Rajasthan, Maharashtra, Gujarat and New Delhi) participated. Shri Narendra Kumar Gujjar, DIG, BSF, Rajasthan Frontier, Jodhpur, was the chief guest and inaugurated the sports meet. Dr. M.M. Roy, Director, CAZRI, welcomed the chief Guest and the sports contingents. Dr. Anurag Saxena, Secretary, Organizing Committee proposed a formal vote of thanks. Dr. Nisha Patel, Dr. R.K. Kaul and Dr. P.C. Pande conducted the function. Various events organized in the tournaments were athletics, such as races, shot put, javelin throw, discus throw, long jump and high jump for both men and women. The team events were badminton, basketball, table tennis, kabaddi, football, volleyball (smashing & shooting) and individual events, carrom and chess. A cultural programme was also organized on February 15. Ms. Smitha G.R., DMAPR and Mr. Bhuvanesh Verma, CAZRI, Jodhpur was adjudged as best women and men athlete, respectively. The overall championship was awarded to CAZRI team on the basis of the overall best performance in different events.

हिन्दी सप्ताह (14–19 सितम्बर): कार्यक्रम का उद्घाटन डॉ. बी.एस. राजपुरोहित, कुलपति जयनारायण व्यास विश्वविद्यालय, जोधपुर ने किया तथा अध्यक्षता डॉ. एम.एम. रॉय, काजरी निदेशक ने की। सप्ताह के अन्तर्गत हिन्दी निबन्ध, सामान्य हिन्दी, प्रार्थना पत्र लेखन, काव्यपाठ, शोध पत्र प्रदर्शन, क्विंज आदि आयोजित किये गये। समापन अवसर पर विजयी प्रतिभागियों को डॉ. वीरवानी, अध्यक्ष, क्यू.आर.टी. ने पुरस्कार प्रदान किये तथा अधिकाधिक कार्य हिन्दी में करने का आह्वान किया।

CAZRI Foundation Day (1st October): On this day all the retired CAZRIANs were also invited. Dr. Gurbachan Singh, Agril. Commissioner, Govt. of India, New Delhi was the Chief Guest. Appreciation certificates and mementoes were given to the best workers (one each from Technical, Administrative and Supporting Staff), and scientists for best poster. Best sportsmen were also awarded.

INFRASTRUCTURE DEVELOPMENT

- Construction of sale-cum-display counter
- Construction of Basket Ball Court
- Upgradation/renovation of street light fitting fixtures, cables, poles, etc. in colony area
- Electrical rewiring in type IV quarters
- White washing, distempering and painting in colony areas
- Termite treatment in Administrative Building of the Institute
- Construction of ladies toilet in Division VI.

REVOLVING FUND SCHEMES

- The Institute has seven schemes under Revolving Fund. Revenue of Rs. 2202246 was generated through such schemes.

REVENUE GENERATED

Particular	Amount (Rs.)
Sale of farm produce	1712587
Analytical testing fee	560000
Rent charges	579052
Interest on loans and advances	2278913
Miscellaneous receipts	4536712
Interest on TDR	3024736
Total	12692000



Events of the National Symposium at Bhuj

Various activities during sports meet.

PARTICIPATION IN CONFERENCE, WORKSHOP, SYMPOSIUM, SEMINAR AND MEETING

Date	Name of the seminar, organizers and venue	Name of participant(s)
January 28-30, 2011	1st India International Energy Summit, organized by the Vijnan Bharati, Society for Energy Engineers and Managers (SEEM), and Visvesvaraya National Institute of Technology, Nagpur	P.C. Pande N.M. Nahar
February 2-4, 2011	Workshop on Curriculum Development on Rodent Management in UG/PG Courses in Agriculture and Veterinary Sciences, Hyderabad	R.S. Tripathi
February 19-21, 2011	National Symposium on Integrated Farming Systems for Sustainable Agriculture – Challenges and Opportunities organized and held at Bundelkhand University, Jhansi	P. Ratha Krishnan
February 23-24, 2011	Directors Conference and Interface Meeting of VCs and PCs	R.S. Tripathi
February 26, 2011	Meeting of Working Group on Agriculture organized by Rajasthan State Planning Commission on Finalization of Draft on Agriculture Policy of Rajasthan and Issues Related to Oilseed and Pulse Production in the State, at Yojna Bhavan, Jaipur	T.K. Bhati
February 28, 2011	National Workshop on Developing Water Use Efficiency, organized by Central Ground Water Board, Western Region, Jaipur	Deepesh Machiwal
March 4-5, 2011	Energy Security for India – Opportunities & Challenges (ESIOC-2011), at the Institute of Engineers, Jodhpur	A.K. Singh P. Santra
March 4-5, 2011	Symposium on Banni Grassland organized by Gujarat Institute of Desert Ecology (GUIDE), Bhuj, Kachchh	Arvind Kumar Deepesh Machiwal Devi Dayal
March 8, 2011	Six Monthly Divisional Committee Meetings (NRM Division) for Monitoring and Reviewing of Foreign Aided Projects, at ICAR, New Delhi	T.K. Bhati
March 12-14, 2011	Pearl millet Workshop: Attended All India Coordinated Pearl Millet Improvement Project – Group Meeting held at HAU, Hisar	V.K. Manga
March15-16, 2011	NAIP Annual Review Workshop, at UAS, Dharwad	J.C. Tewari
March 20-21, 2011	Zonal Research and Extension Advisory Committee Meeting of Khariff 2011, organised by ARS, SKRAU, Mandore, Jodhpur	N.M. Nahar
March 22, 2011	Workshop on Inventorization and Documentation of Location Specific Problems Requiring S&T Intervention, organized by Department of Science and Technology, Govt. of Rajasthan, Jodhpur and KVK, CAZRI, Pali, at KVK, Pali	B.L. Jangid Khem Chand P.L. Regar S.M. Deb S.P.S. Tanwar S.S. Rao
March 23-24, 2011	National Workshop on *Prosopis juliflora*: Past, Present and Future organized and held at CAZRI, Jodhpur	Devi Dayal P.C. Pande P. Ratha Krishnan Suresh Kumar
April 19-20, 2011	National Symposium cum Brain Storming Workshop on Organic Agriculture, Organic Agriculture Society of India, CSK-HPKVV, Palampur (HP)	A.K. Sharma
April 22-23, 2011	National Seminar on Contemporary Approaches to Crop Improvement, UAS, GKVK, Bangalore	H.R. Mahla
April 26, 2011	Expert Group Meeting for Implementation of MGNAREGA on Watershed Platform, organized by National Rainfed Area Authority (NRAA), at NASC Complex, New Delhi	R.K. Goyal

May 2-4, 2011	XXVI Annual Group Meeting of AICRP, NSP (Crops), at CSKHPKV, Palampur	M.P. Rajora S.S. Mahajan
May 11, 2011	34th Regional Coordination Committee Meeting of Regional Station for Forage Production and Demonstration (Suratgarh)	M.P. Rajora
May 19-21, 2011	5th National Seminar on Multi Sectoral Innovations for Rural Prosperity organized jointly by MOBILIZATION, NDRI, BBNL, PPVFRA and held at NDRI, Karnal	A.K. Patel T.K. Bhati
May 20-21, 2011	Annual Arid Legumes Workshop, at SD Agricultural University, Sardarkrushinagar (Gujarat)	H.R. Mahla Raj Singh
May 21-23, 2011	National Workshop: All India Coordinated Research Project on Agroforestry, at College of Forestry, KAU PO Thrissur	J.C. Tewari
May 25, 2011	Workshop on Intellectual Property Rights, the Technology Information, Forecasting and Assessment Council (TIFAC), DST, GOI, New Delhi in Collaboration with AFRI Jodhpur	Akath Singh M.P. Rajora R.K. Bhatt S.S. Mahajan
May 30, 2011	Planning Commission Subgroup Meeting on Management of Natural Resources, at CRIDA, Hyderabad	Khem Chand
May 30-31, 2011	Sensitization Workshop on Rodent Pest/Vector Problems and their Management, Hyderabad	R.S. Tripathi
June 1, 2011	National Seminar on Transfer of Technology of Strategic Pesticides Use to Enhance Agricultural Production and Food Security, New Delhi	R.S. Tripathi
June 7, 2011	Workshop on National Network Project on Guggal, at Directorate of Medicinal and Aromatic Plant Research, Anand	N.K. Sinha
June 9-10, 2011	Workshop cum Review Meeting of Project Energy and Mass Exchange in Vegetative Systems, at Forest Research Institute, Jabalpur	P. Raja P. Santra
June 11-18, 2011	Meeting-cum-Workshop on Towards More Effective Role of Heads of Divisions and Regional Stations in ICAR Institutes, at CIAE, Bhopal	J.P. Singh
June 14-15, 2011	Meeting-cum-Workshop of the Head of the Division and Regional Stations/Centers, at CIAE, Bhopal	P.C. Pande R.K. Bhatt
June 16, 2011	Workshop on Towards More Effective Role of Project Coordinators and Directors of ICAR Institutes, at CIAE, Bhopal	R.S. Tripathi
June 17, 2011	Workshop on SLEM: Role of Forests in Dry Land Areas, ICFRE, Dehradun	P. Ratha Krishnan
June 18, 2011	National Conference on Clean Technologies and Green Business for 21st Century, at AIT, Kaushalganj, Distt. Rampur, Uttarakhand	S.P.S. Tanwar
June 20-24, 2011	National Workshop on Advance Soft Computing Techniques in Hydrology and its Applications (ASCTHA-2011), Indian Association of Hydrologists Roorkee and National Institute of Hydrology, Roorkee	Deepesh Machiwal R.K. Goyal
June 22-24, 2011	International Conference on Organic Agriculture, Government of Bihar in Collaboration with ICAR, at Patna	Uday Burman
June 24-25, 2011	13th World Congress on Environment Management, organized by World Environment Foundation, at New Delhi	Suresh Kumar
June 27, 2011	Second Meeting of Subgroup-IV Enhancing Preparedness for Climate Change of Working Group on Agriculture Extension in Agriculture & Allied Sector for the 12th Year Plan, at Yojna Bhawan, New Delhi	R.K. Bhatt
June 29, 2011	Workshop on Stakeholder Consultations to Identify Thrust Areas in Research & Development in the area of Food Processing, Ministry of Food Processing Industry, New Delhi	P.K. Malaviya
July 14-15, 2011	Pearl Millet Project Conference, at Desert Medicine Research Center (Indian Council of Medical Research), Jodhpur	P.K. Malaviya

July 19, 2011	Workshop on Forest in an Expanding Economy, at AFRI, Jodhpur	Khem Chand
July 20, 2011	Meeting of Subgroup on Enhancing Preparedness for Climate Change, at New Delhi,	R.K. Bhatt
July 22-24, 2011	International Seminar on Global Environment and Disaster Management: Law & Society, MoEF and Mo Law & Justice, GOI, Delhi	Uday Burman
July 25, 2011	2nd Meeting of Working Group on Natural Resource Management and Rainfed Farming System for 12th Five Year Plan, at Yojana Bhavan, New Delhi	Suresh Kumar
July 27, 2011	Brainstorming Workshop on Desertification Mapping and Impact Indicators, at MoEF, New Delhi	P.C. Moharana
August 1, 2011	Consultation Meeting on Road Map for Seed Research in India, at IARI New Delhi	R.K. Bhatt
August 1, 2011	Six-monthly Divisional Committee Meetings (NRM Division) for Monitoring and Reviewing of Foreign Aided Projects, at ICAR, New Delhi	T.K. Bhati
August 2, 2011	Consultation Meeting on Road Map for Seed Research in India, at IARI New Delhi	R.K. Bhatt
August 4-5, 2011	Workshop for Development of a Co-ordinated Project on Arid and Semi-arid Region (ASAR), Department of Science and Technology, at Arid Forest Research Institute, Jodhpur.	Satya Vir
August 5-6, 2011	Brain Storming Session on Prioritization of Plant Physiology and Biochemistry Research for 12th Five year Plan Period, Plant Physiology & Biochemistry Department, at IARI, New Delhi	N.S. Nathawat R.K. Bhatt
August 8, 2011	Workshop-cum-review Meeting on Collective Natural Resource Conservation (LPPS), at Gita Ashram, Jaisalmer, Rajasthan	N.K. Sinha
August 8-10, 2011	Programme on Clean Development Mechanism (CDM), Carbon Trading and REDD + Benefits in Forestry Sector organized by Engineering Staff College of India, at Hyderabad, AP	J.C. Tewari Suresh Kumar
August 25-26, 2011	National Meeting on Agricultural Entomology for 21st Century: The Way Forward, at National Bureau of Agriculturally Important Insects, Bangalore	M.P. Singh Nisha Patel R.S.Tripathi Satya Vir Sharmila Roy
September 10-11, 2011	National Symposium on Forage Resource and Livestock for Livelihood, Environment and Nutritional Security, RMSI and ICAR, IGFRI, Jhansi	M. Patidar R.K. Bhatt S.P.S. Tanwar S.S. Rao
September 10-11, 2011	Stakeholder Consultation on Climate Change Platform, Central Research Institute on Dryland Agriculture, Hyderabad	A.K. Misra
September 15-16, 2011	National Workshop on Conservation and Sustainable Utilization of *Commiphora wightii* (Guggal), Gujarat Forest Department with the Support of National Medicinal Plants Board, Dept. of AYUSH, Government of India, at Gandhinagar	Suresh Kumar
September 17-18, 2011	National Seminar on Environmental Challenges and Role of Social Responsibilities in Mining Sector, Jodhpur	Suresh Kumar
September 19-20, 2011	Review Meeting of ICAR Seed Project Seed Production in Agricultural Crops, at BP Pal Auditorium, IARI, New Delhi	S.S. Mahajan
September 19-20, 2011	National Stakeholders Consultation on Climate Change Platform, CRIDA, Hyderabad	Shalander Kumar
September 20, 2011	State Pest and Surveillance and Advisory Unit Meeting, Commissionerate of Agri., GOR, Pant Krishi Bhawan, Jaipur	M.P. Singh
September 21-24, 2011	19th Group Meeting of AICRP on Medicinal & Aromatic Plants and Betelvine, at Dr. Y.S. Parmar University of Horticulture and Forestry, Solan	J.P. Singh

September 22-23, 2011	Production of Disease Free Plantation Materials of Citrus, at Jaipur	Hari Dayal
September 24, 2011	Brainstorming Workshop on Academic Road Map of Central University of Rajasthan, at Kishangarh (Distt. Ajmer)	T.K. Bhati
September 24-25, 2011	1st IAVNAW Conference on the Significance of Veterinary Nutrition for Health and Production of Animals of Agro-Ecological Importance, at College of Veterinary Science and Animal Husbandry (IGKV), Durg	B.K. Mathur
September 26-27, 2011	Interactive Meeting of VCs, Directors and Project Coordinators, New Delhi	R.S. Tripathi
September 27-29, 2011	National Seminar on Innovative Extension Approaches for Enhancing Rural Household Income, at JNKVV, Jabalpur	M.L. Meena
September 29, 2011	1st Meeting of Working Group on Agriculture and Horticulture for Preparation of 12th Five Year Plan, at Pant Krishi Bhavan, Jaipur	T.K. Bhati
October 08-10, 2011	International Conference on Issues for Climate Change, Land Use Diversification and Biotechnological Tools for Livelihood Security, at Sardar Vallabhbh Patel University of Agriculture and Technology, Meerut, UP	Manoj Kumar
October 11-12, 2011	Working Group Meeting, at National Institute of Hydrology, Roorkee	R.K. Goyal
October 15-17, 2011	XXXI INCA International Congress, Department of Geography, Panjab University, Chandigarh	P.C. Moharana
October 16, 2011	Workshop on Right to Food for All, GRAVIS, at Nirali Dhani, Jodhpur	Khem Chand
October 17, 2011	Planning Commission Subgroup II Meeting on Agriculture Education, Research Prioritization with Special Focus on Rainfed Farming, at MPUAT, Udaipur	Khem Chand
October 19-21, 2011	National Symposium on Recent Advances in Applied Geochemistry: Current Status and Future Trends, Indian Society of Applied Geochemist (ISAG) at AMD, Hyderabad	P. Raja
October 24-26, 2011	International Geo-Carban Conference: Carbon in a Changing Word, at FAO Rome, Italy	R.K. Bhatt
November 2-3, 2011	National Workshop on Natural Resources Census: Results of First Cycle of Landuse/Land Cover Mapping, NRSC, Hyderabad.	P.C. Moharana
November 2-4, 2011	International Congress on Renewable Energy-2011 organised by the Solar Energy Society of India at Tezpur University, Tezpur	N.M. Nahar P.C. Pande
November 8, 2011	International Workshop on Earth Observations for Terrestrial Ecosystem, at Madhya Pradesh Council of Science and Technology, Bhopal, India	P. Santra
November 09-12, 2011	International Conference on Innovative Approaches for Agricultural Knowledge Management- Global Experiences organized by International Society of Extension Education, Nagpur and ICAR, New Delhi, at Vigyan Bhawan and NASC Complex, New Delhi	B.L. Jangid Dheeraj Singh M.L. Meena P.K. Tomar
November 9, 2011	International Conference on Water-use Efficiency in Industrial Sector of Rajasthan, organized by India Water Foundation (IWF), New Delhi and Rajasthan State Industrial Development & Investment Corporation (RIICO), Jaipur	R.K. Goyal
November 13-18, 2011	International Conference on Innovations in Extension and Advisory Services: Linking Knowledge to Policy and Action for Food and Livelihood, at Nairobi, Kenya	Dheeraj Singh
November 16-17, 2011	National Seminar on Augmenting Productivity of Mountain Farming through Agricultural Engineering Interventions, at CSK HPKV, Palampur, HP	P.K. Malaviya
November 22-25, 2011	1st Indian Forest Congress 2011, at NASC Complex, New Delhi	J.C. Tewari

November 23-25, 2011	International Symposium on Recent Trends in Processing & Safety of Specialty and Operational Foods, DFRL, DRDO, Mysore	P.K. Malaviya
November 24-26, 2011	National Seminar on Sustainable Crop Productivity through Physiological Intervention, organizer: Department of Life Science, Ramnarain Ruia College, Matunga, Mumbai & ISSP, New Dehli, at Ramnarain Ruia College, Matunga, Mumbai	N.S. Nathawat Uday Burman
November 25-26, 2011	International Workshop on Cactus Crop to Improve Rural Livelihood and to Adapt to Climate Change in the Arid and Semi-arid Regions of India, FAO-ICARDA Cactusnet, at NBPGR, New Delhi	A.K. Misra P.R. Meghwal Suresh Kumar
December 3-5, 2011	6th National Conference on Krishi Vigyan Kendra, Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur	Shalander Kumar
December 7-9, 2011	National Seminar on Prospects and Retrospect of Small Ruminant and Rabbit Production, Contribution to Socio-Economic Security, at Jaipur	M.L. Meena S. Kachhawaha
December 17-18, 2011	UGC Sponsored Conference on Current Status and Opportunities in Medicinal Plants of Thar Desert, at Mahila P.G. Mahavidyalaya, Jodhpur	Arun-Kumar
December 17-19, 2011	6th National Extension Education Congress organized by Society of Extension Education, Agra, at ICAR Research Complex, Ela, Old Goa	Bhagwan Singh M.L. Meena P.K. Tomar
December 20-22, 2011	National Symposium on Resource Utilization through Integrated Farming System and Biodiversity Conservation in Drylands, at Bhuj, Gujarat, India	
	Arvind Kumar / Dheeraj Singh / N.S. Nathawat / Raj Singh A.K. Patel / H.A. Khan / P. Santra / S. Kachhawaha A.S. Sirohi / H.R. Mahla / P.C. Moharana / Seema Bhardwaj A.S. Tomar / Hari Dyal / P.C. Pande / Sharmila Roy Akath Singh / J.P. Singh / Praveen-Kumar / Surjeet Singh Amal Kar / Khem Chand / P.R. Meghwal / S. Kumar Birbal / Mahesh Kumar / P. Ratha Krishnan / S.M. Deb Bhagwan Singh / M. Patidar / P.S. Bhati / S.P.S. Tanwar B.L. Jangid / M.K. Chaudhary / R.C. Meena / Savita Singhal Dayanand / M.P. Rajora / R.K. Goyal / V.S.Rathore Deepesh Machiwal / N.D. Yadava / R.K. Kaul D. Mishra / N.K. Sinha / R.R. Meghwal Devi Dayal / N.R. Panwar / R.S. Tripathi	
December 21-22, 2011	National Workshop on Stress Agriculture and Climate Change: Exploring Synergy with Natural Resource Management in Agriculture (NaRMA-III), organized by PROM Society, Udaipur and SK RAU, Bikaner, at Agricultural Research Station, Mandor-Jodhpur (Raj.)	Arun-Kumar A.K. Misra B.L. Gajja H.C. Bohra P. Sharma Pradeep Kumar R.K. Bhatt
December 24, 2011	Fifth Meeting of NICRA Expert Committee, at NASC Complex, New Delhi	R.K. Bhatt
January 6, 2012	Meeting of HMD 4, Non-Conventional Energy Sources Committee, Bureau of Indian Standards, Manak Bhavan, New Delhi	P.C. Pande
January 7, 2012	National Conference on Review of Renewable Energy- Present Study & Future Prospects with Special Reference to Rajasthan, Kautilya Institute of Technology, Jaipur	P.C. Pande N.M. Nahar
February 2, 2012	Sensitization-cum-Training Workshop on The use of Half Yearly Progress Monitoring (HYPM) Software for Online Submission of Targets and Achievements Progress by the Scientist, at CIFE Mumbai	Sharmila Roy

February 6-7, 2012	National Conference on Material Science and Technology: Current trends and Future Prospects, at Department of Physics and Chemistry, Lachoo Memorial Collage of Science and Technology, Jodhpur	J.C. Tarafdar Praveen-Kumar P.C. Pande R.K. Kaul
February 7-9, 2012	International Conference on Climate Change, Sustainable Agriculture and Public Leadership, Delhi	M.M. Roy Praveen-Kumar R.K. Bhatt
February 18-19, 2012	Brain Storming Workshop: Fodder for Sustainable Livestock Production and Environmental Security, at ARS, SKRAU, Keshwana, Jalor	A.K. Misra Hari Dayal J.P. Singh Khem Chand
February 21-24, 2012	International Open Science Congress Global Environmental Change-Challenges and Innovations, at Department of Geology, University of Madras, Chennai	P. Raja
February 23- 24, 2012	Seminar on Assistance to State for Control of Animal Diseases, organized by State Animal Husbandry Department, Government of Rajasthan, Jodhpur	B.K. Mathur
February 25-26, 2012	National Symposium on Role of Indigenous Animal Genetic Resources in Rural Food Security *vis-a-vis* Climate Change, organized by BAIF Development Research Foundation, Pune and Society for Conservation of Domestic Animal Biodiversity (SCODAB), Karnal, at BAIF, Pune	A.K. Patel
February 27-29, 2012	International Grain Storage Symposium and 46th ISAE Convention, at GBPUAT, Pantnagar	Dilip Jain
February 28, 2012	Brain Storming Workshop on Accelerated Fodder Development: Possibilities and Challenges, organized by Centre for Forage Management, ARS,SKRAU, Bikaner, at ARS, SKRAU, Bikaner	N.D. Yadava V.S. Rathore
February 29, 2012	Workshop on Targeting Agribased Technological Interventions in Arid Western Rajasthan, sponsored by Project Directorate of MPOWER Project, Jodhpur and organized by Central Arid Zone Research Institute, Jodhpur	
March 1-3, 2012	National Symposium on Chronobiology and Seminar on Diversity and Physiology of Desert Fauna, Jodhpur	R.S. Tripathi
March 1-3, 2012	National Conference on Advances in Nanomaterials and Nano-technology for Renewable Energy Conversion and Storage Device, organized by Jaipur Engineering College, Kukas, Jaipur	P.C. Pande
March 5, 2012	National Consultation on The Dying Luni River-A Struggle for Survival organized by Jal Bhagirathi Foundation, at Water Resource Centre, Bijolai, Jodhpur	R.K. Goyal
March 12-13, 2012	NAIP All India Workshop on Utilization of *Prosopis juliflora*: Challenges and Opportunities, at CAZRI, Jodhpur	A.S. Sirohi B.K. Mathur J.P. Singh Sharmila Roy
March 13-15, 2012	Global Conference on Women in Agriculture organized by ICAR-APAARI, at New Delhi	A.K. Misra Dheeraj Singh M.L. Meena Savita Singhal Soma Srivastava
March 16-18, 2012	Interaction Meet of Scientists (Farm Machinery and Power & Mechanical Engineering discipline), at CIAE, Bhopal	A.K. Singh D. Mishra

A.K. Misra	Khem Chand	Raj Singh	Shalander Kumar
A.K. Patel	M.P. Rajora	R.K. Bhatt	S.S. Mahajan
A.S. Sirohi	M.P. Singh	R.K. Goyal	Soma Srivastava
B.K. Mathur	P. Tewari	R.S.Tripathi	
Bhagwan Singh	P.C. Pande	Sharmila Roy	

March 19-20, 2012	National Consultation on Application Technologies for Harvested Rainwater in Ponds, organized by Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad	R.K. Goyal
March 25-28, 2012	International Workshop-cum-Field Programme on Desert Dune Systems: Past Dynamics and Chronology, PRL (ISRO) GSI (GOI), Ministry of GSI (GOI), Ministry of Earth Sciences	P. Raja
March 27-28, 2012	Policy Workshop on Assessing Training Transfer in National Agriculture Research System, NAARM, Hyderabad	B.K. Mathur
March 29, 2012	ICAR-ISPC Meet organized by ICAR, at New Delhi	A.K. Misra

HUMAN RESOURCE DEVELOPMENT

Staff members from Headquarter and Regional Research Stations who attended various training programmes during 2011-12:

Scientists

Date	Training course, organisers and venue	Name of participant(s)
January 10-15, 2011	Training Programme on SAAS Software under NAIP on Strengthening of Statistical Computing for NARS, at MPUAT, Udaipur, Rajasthan	Arvind Kumar S.P.S. Tanwar
March 29, 2011	Training on Water Management organized by Central Ground Water Board, Western Region, Jaipur, at CAZRI, Jodhpur	Deepesh Machiwal
April 5-18, 2011	National Training on Climate Change, Carbon Sequestration and Carbon Credits, at ISSS, Bhopal	Mahesh Kumar Seema Bhardwaj
May 6-19, 2011	NAIP Training Course on Rapid and Non-destructive Evaluation Quality and Safety Factors Using Spectroscopy and Biosensing Methods, Central Institute of Post-Harvest Engg. & Technology, Ludhiana	P.K. Malaviya
June 20-July 1, 2011	Technology and Innovation for Rural Development, organized by Centre for Disaster Management, LBSNAA, Mussoorie	A.K. Patel Soma Srivastava
July 16-29, 2011	Trends in Bioinformatics and Computational Systems: Exploring Interconnections for Molecular Biological Applications, at NBAIM, Maunath Bhajan (UP)	N.R. Panwar
July 29-30, 2011	Workshop on Leadership Effectiveness and Performance Enhancement in NARS, at NAARM Hyderabad	M.M. Roy
August 29- September 7, 2011	Short Course on Bioinformatics in Agriculture, organized by Indian Agricultural Statistics Research Institute (IASRI), ICAR, New Delhi	Arvind Kumar
September 6-29, 2011	Scheduled Castes, Scheduled Tribes and OBC's (RIS), at ISTM, New Delhi	Raj Singh
September 12-17, 2011	Training Programme on SAS Software under NAIP on Strengthening of Statistical Computing for NARS, at MPAUT, Udaipur	Akath Singh N.R. Panwar P. Rathakrishnan
September 29-30, 2011	Training on Conserving Natural Resources for Sustainable Development in Dry Areas, at Arid Forest Research Institute, Jodhpur	Akath Singh S.P.S. Tanwar
November 1-21, 2011	Training of Management Development Programme on Leadership Development, at NAARM, Hyderabad	S.M. Deb

November 3-23, 2011	Refresher Course on Agricultural Research Management for Newly Recruited Senior/Principal Scientists, at NAARM, Hyderabad	Dayanand
November 15-28, 2011	Training Programme on Recent Trends of Geo-informatics in Land Resource Database Management (LRDM) for Sustainable Agriculture, at NBSS&LUP, Nagpur	P. Raja
November 21-25, 2011	CEP Course on Energy Management, at IIT, Bombay	Priyabrata Santra
November 28-30, 2011	Impact assessment of International Trainings in Frontier Areas of Agricultural Sciences, Organizer: NAIP, ICAR, Venue: NASC Complex New Delhi	M.L. Soni
December 9-29, 2011	Winter School on Recent Advances in Functional Fermented Dairy Foods and their Quality Assurance, at NDRI, Karnal	Soma Srivastava
December 12-15, 2011	International Training Programme on Ecosystem Approach to Disaster Risk Reduction (Eco-DRR), at National Institute of Disaster Management (NIDM), New Delhi, India	N.K. Sinha V.S. Rathore
December 12-17, 2011	Training Programme on SAS Software under NAIP on Strengthening of Statistical Computing for NARS, at MPAUT, Udaipur	A.S. Sirohi Dayanand P. Raja
December 12-21, 2011	Short Term Course on Seed Business Management, at JNKVV, Jabalpur	Sunil Mahajan
December 13-20, 2011	Short Course on Crop Weather Modelling, at Central Research Institute for Dryland Agriculture, Hyderabad	H.M. Meena
January 16-21, 2012	Training Programme on SAS Software under NAIP on Strengthening of Statistical Computing for NARS, at MPAUT, Udaipur	N.S. Nathawat Seema Bharadwaj
January 30-February 03, 2012	Training Programme on Climate Change and Carbon Mitigation, at ICFRE, Dehradun	Sharmila Roy

Technical Personnel

Date	Training course, organizers and venue	Name of participant(s)
May 10-12, 2011	Employers Perspective on Labour Related Laws, at NAARM, Hyderabad	Gitam Singh
June 2, 2011	Use of Automatic Weather Station and its Maintenance, at CRIDA, Hyderabad	V.K. Badgujar
June 27-July 02, 2011	Application of PRA Tools in Agricultural Extension (ATMA), at EEI, Anand	Prahlad Singh R.K. Mathur R.S. Chouhan
July 11-16, 2011	Workshop on Integrated Pest Management (IPM) in Agriculture, at EEI, Anand	Hanuman Ram
July 14-20, 2011	Training on Mushroom Cultivation, at Directorate of Mushroom Research Chambagaht, Solan	Ajay Kumar Maru
July 15-16, 2011	GARUDA-NKN Partner's Meet, at CDAC, Bangalore	Mukesh Gehlot Vimal Purohit
July 21-27, 2011	Training on Mushroom Production Technology, DMR, Solan (HP)	Ajay Kumar Maru
August 01-05, 2011	Microsoft Office Suite for Officers and Staff Conducted by ISTM, New Delhi.	R.C. Bohra
August 5-6, 2011	Capacity Building for Animal Science Scientists Working in KVK, SKRAU, Bikaner	Subhash Kachhawaha
August 8, 2011	Main Streaming Agriculture for Climate Change Mitigation, at EEI, Anand (Guj.)	Manoj Kumar

August 8-11.2011	Workshop on Mainstreaming Agriculture for Climate Change Mitigation, at EEI, Anand	Fateh Singh Solanki M.R. Bhati Pushkar Singh Rawat
September 27-29. 2011	National Seminar on Innovative Extension Approaches for Enhancing Rural House Hold Income, at JNKVV, Jabalpur	Motilal Meena
October 17-20, 2011	Specialized Short Term Training for Improving Efficiency of Technical Personnel, conducted by NAARM, Hyderabad, at CAZRI, Jodhpur	25 Technical Officers
January 3-6, 2012	Workshop on Value Addition for Agriculture and Horticulture Crops, EEI, Anand	Ajay Kumar Maru
January 16-21, 2012	Knowledge Management System and Web Designing for Agricultural Extension, at EEI, Anand	Manoj Kumar

Administrative and Accounts Personnel

Date	Training course, organizers and venue	Name of participant(s)
July 18-22, 2011	Training Programme on Finance for Non-Finance Executives, at NIFM, Faridabad	Pawan Kumar Tewari
August 1-5, 2011	Microsoft Office Suite for Officers and Staff Conducted by ISTM, New Delhi	H.C. Sharma Nar Singh Ram Natwarlal Purohit V.P. Sathyadevan
September 21-25, 2011	International Financial Reporting Standards (IFRS) & Converged Indian Accounting Standards by the Institute of Cost Works Accounts of India, at Bangalore	Dharmendra Sankhla Pradeep Mathur
September 26-30, 2011	MDP on Financial Decision Making Using Excel, at National Institute of Financial Management, Faridabad	Sujit Kumar
November 2-06, 2011	International Financial Reporting Standards (IFRS) and Converged Indian Accounting Standards by the Institute of cost works Accounts of India, at Kolkata	Om Prakash Jayal Sunil Choudhary

VISITORS

DISTINGUISHED VISITORS

Date	Name of the distinguished visitor(s)
January 23	Dr. Tony Mc Donald, Ministry of Agriculture, Kabul, Afghanistan
February 7	Severin Kodderitzsch, Sericulture and Rural Training, Country Sector, Coordinator, World Bank
February 21	Prof. M.J. Modyail, Member, ASRB, New Delhi
March 5	Shri V. Venkatachalam, Additional Secretary, Ministry of Agriculture, Govt. of India, New Delhi
March 23	Brig. Manjeet Mehta, SM, VSM
April 4	Dr. H.P. Singh, Chairman RAC and Prof. M.H. Qureshi Dr. I.D. Tyagi, Dr. B.D. Kaushik, Members RAC; Dr. J.C. Dagar, ADG, ICAR, New Delhi
April 18-23	Dr. S.M. Virmani, Chairman, QRT and Dr. M.P. Yadav, Dr. Masood Ali, Dr. O.P. Pareek, Dr. P.S. Pathak, Dr. Mruthyunjaya, Dr. K.V.G.K. Rao, Members, QRT
May 10-11	Dr. Y.S. Ramakrishna, Ex-Director, CRIDA, Hyderabad, Dr. Nawab Ali, Ex-DDG (Engg.) ICAR, New Delhi, Dr. Y.V. Singh, Zonal Project Director Zone-VI
May 31	Dr. S.S. Kundu, Head of Division, NDRI, Karnal Mr. S. Jai Kumar, Executive Director, CLAFMO
June 21	Dr. V.K. Bahuguna, Director General, ICFRE, Dehradun Dr. T.S. Rathore, Director, AFRI, Jodhpur
June 23	Dipti Thapa, Washington DC (World Bank) Marianne Tinlot, France (FAO Consultant) Louis Bockel FAO Rome, Italia
July 12	Dr. J.C. Dagar, ADG, NRM, ICAR, New Delhi
August 12	Visited CAZRI Stall on State level 62nd Van Mahotsav at Beri Ganga, Jodhpur: Hon'ble Shri Ashok Gehlot, Chief Minister, Rajasthan Hon'ble Shri Badri Ram Jakhar, MP, Pali Hon'ble Shri Ram Lal Jat, Minister for Forests, Environment and Mining Department, Govt. of Rajasthan Shri U.M. Sahaya, Chief Forest Officer, Jaipur Shri Rameshwar Dadhich, Mayor, Nagar Nigam, Jodhpur
August 27	Dr. Bangali Baboo, National Director, NAIP, ICAR, New Delhi Dr. Sudhir Kochar, National Coordinator (NC-4), NAIP, ICAR, New Delhi Dr. K.V.B.R. Tilak, CIC, Chairman
August 29-30	Dr. A.K. Singh, DDG (NRM), ICAR, New Delhi Dr. H.P. Singh, Chairman, RAC, Dr. I.D. Tyagi, Dr. B.D. Kaushik, Members, RAC
September 9	Shri Gopal Gupta, IG (RPF) Railway Board, Rail Bhawan, New Delhi
September 14	Prof. B.S. Rajpurohit, Vice-Chancellor, JNVU, Jodhpur Dr. S.K. Meena, Ex-Head (Hindi Deptt.) JNVU, Jodhpur
September 19-24	Dr. S.M. Virmani, Chiarman QRT, Dr. O.P. Pareek, Dr. P.S. Pathak, Dr. Mruthyunjaya, Dr. K.V.G.K. Rao, Dr. M.P. Yadav, Dr. Masood Ali, Members, QRT
September 28	Dr. Ali Nefzaom, Livestock and Rangeland Scientist, ICARDA – General Coordinator of FAO-ICARDA

Dr. A.K. Singh, DDG (NRM), ICAR, and RAC Chairman and Members interacting with the scientists at exhibition of CAZRI technology.

Dr. K.D. Kokate, DDG (Agri. Extension) and ZDP Directors at Horticulture Stall.

Dr. Bangali Baboo, National Director, NAIP interacting with the scientists at CAZRI Farm.

Dr. Gurbachan Singh, Agril. Commissioner, GOI, New Delhi in CAZRI Dryland Gallery.

Dr. S. Ayyappan, Secretary, DARE and DG, ICAR

Dignitaries

at CAZRI Exhibition Stall at Global Conference on Women in Agriculture, at New Delhi.

October 1	Dr. Gurbachan Singh, Agril. Commissioner, Govt. of India, New Delhi Dr. R.P. Dhir, Ex-I/c Director, CAZRI, Jodhpur Dr. Y.V. Singh, Zonal Project Director, Zone-VI, Jodhpur
October 18	Dr. Purnima Chouhan, IAS, Induction Group 109th Course, LBSNAA, Mussoorie
October 20	Dr. P. Manikandan, NAARM, Hyderabad
November 3	Dr. Arun Gaur, Dy. Director, ISTM, GOI New Delhi with 16 Officers
November 3	Visited CAZRI Stall on Bharat Nirman Jan Soochna Abhiyan Mela at Balotra: Smt. Madan Kaur, Zeela Pramukha Shri O.P. Vishnoi, SDM, Balotra Shri Madan Prajapat, MLA, Pachapadra Shri Mahesh Chouhan, Chairman, Municipal Council, Balotra
November 5	Smt. Veena Pradhan, Collector, Barmer
December 1	Dr. A.K. Singh, DDG (NRM), ICAR, New Delhi
December 1	Shri Vahid Jafarian with 10 Iran Scientists – High Level Committee (Institutional Strengthening & Conference for Sustainable Natural Resource Management)
January 5, 2012	CAZRI Stall at Jodhpur in Paschimi Rajasthan Hastsilp Utsav-2012: Shri Pawan Kumar Bansal, Union Water Resource Minister, Govt. of India, New Delhi Shri Siddartha Mahajan, IAS, Collector, Jodhpur Shri Rameshwar Dadhich, Mayor, Nagar Nigam, Jodhpur Smt. Durga Devi Blai, Zeela Pramukh, Jodhpur Shri Umeash Leela, Chiarman, Marudhara Industries Association, Jodhpur Shri Sunil Parihar, Coordinator, PRHS Utsav Shri S.L. Paliwal, General Manager, DIC, Jodhpur
January 11, 2012	Dr. K.S. Yadav, Vice-President, 20 Sutri Karyakarm, Govt. of Rajasthan, Jaipur Shri Badri Ram Jakhar, Member of Parliament, Govt. of India Shri B.S. Detha, Agril. Commissioner, Govt. of Rajasthan, Jaipur Shri B.K. Singh, Director, Agril. (ATMA) Project Shri K.K. Goyal, I/c Director, Central Wool Development Board
January 15, 2012	Hon'ble Shri Ashok Gehlot, Chief Minister, Govt. of Rajasthan Smt. Surya Kanta Vyas, MLA, Govt. of Rajasthan Shri Kailash Bhansali, MLA, Govt. of Rajasthan Smt. Durga Devi Blai, Zeela Pramukh, Jodhpur Shri Rajendra Solanki, Chairman, JDA, Jodhpur Shri R.K. Jain, Commissioner, Jodhpur
January 16, 2012	Shri Rajiv Mehrishi, Additional Secretary, DARE and Secretary, ICAR, New Delhi Dr. K.D. Kokate, DDG (Agri. Extension) ICAR, New Delhi Dr. B.S. Hansra, ADG, ICAR, New Delhi Dr. A.M. Narula, Zonal Project Director (ZPD), Zone-I, Ludhiana Dr. A.K. Gogai, ZPD, Zone-III, Barapani Dr. A.K. Singh, ZPD, Zone-IV, Kanpur Dr. N. Sudhakar, ZPD, Zone-V, Hyderabad Dr. Y.V. Singh, ZPD, Zone-VI, Jodhpur Dr. U.S. Gautam, ZPD, Zone-VII, Jabalpur Dr. S. Prabhukumar, ZPD, Zone-VIII, Bangalore
February 6, 2012	Dr. G.S. Gujral, Head, Science British Council (India), New Delhi Dr. Kanupriya Harish, Project Director, Jal Bhagirathi Foundation, Jodhpur
March 1, 2012	Dr. Noordin, Agriculture Officer, MPOWER, Jodhpur
March 12, 2012	Dr. J.C. Dagar, ADG (NRM), ICAR, New Delhi
March 13-15, 2012	CAZRI Stall in Delhi on the Occasion of Global Conference on Women in Agriculture: Hon'ble Her Highness Smt. Pratibha Devisingh Patil, President of India Hon'ble Shri Sharad Pawar, Union Agriculture Minister, Govt. of India
March 14, 2012	Peter Crawford, ICRISAT, Hyderabad

March 17, 2012	Shri C.K. Dorjee, Director, PIB, Gangtok
March 25, 2012	Shri Ken Glennie, Aberddenshire, U.K.

VISITORS AT REGIONAL RESEARCH STATION, JAISALMER

Date	Visitor(s)	Farmers/Farm-women	Dignitaries/ Officials	Total
April, 25	Dr. B. Bhattacharya, SRAC, Ahmedabad	-	1	1
May 20	Shri P. Mansion, Joint Director (Ag), Jaipur Sh. G. L. Kumawat, Deputy Director (Ag.) Jaisalmer		2	2
August 15	Dr. H.P. Singh, DDG (Hort.) ICAR Dr. S.K. Sharma, Director	-	2	2
September 23	Dr. P.S. Pathak and Dr. K.V.G.K. Rao Members, QRT	-	2	2
September 7	Trainees Farmers under NFSM, Jaisalmer	63	3	66
September 14	Shri N.K. Sharma, Director, Desert Cultural Centre, Jaisalmer	-	1	1
September 16	Trainees Farmers under NFSM, Jaisalmer	42	2	44
September 22	Trainees Farmers under NFSM, Jaisalmer	36	1	37
September 28	Trainees Farmers under NFSM, Jaisalmer	54	3	57
October, 16	State District Level Officers under Dryland Training Prog, CAZRI, Jodhpur	-	8	8
November 24	Trainees of ATMA, Nagaur	30	2	32
January 16	Dr. P.N. Kalla, Director (Ext.) and team SKRAU, Bikaner	-	3	3
January 17	Prof. A.K. Dahma, VC, SKRAU, Bikaner Dr. K.D. Kokate, DDG (Agri. Extension) ICAR Dr. Y.V. Singh, PD and Team of ZPDs and other Officers	-	10	10
March 4	Dr. Gopal Lal, I/C Director and Team, NRC Seed Spices, Tabji, Ajmer		4	4
March 14	Trainees of Watershed, Lunkaranar, Bikaner	63	2	65

Hon'ble Shri Ashok Gehlot, Chief Minister, Govt. of Rajasthan interacting with the scientist at CAZRI Exhibition Stall.

Demonstration of CAZRI gum induction technology.

Celebration of Women's Day in agriculture.

Demonstration of multi-nutrients feed block making to international trainees.

Dr. M.M. Roy, Director, CAZRI distributing prizes on 15th August.

Women visitors at CAZRI exhibition stall.

GROUP VISITS

Groups of farmers, farm women, students, trainees, forest and army officers, NGOs from different parts of the country visited the Dry Land Gallery Museum, research farm/solar yard, technology park, dairy, horticulture block, botanical garden, medicinal plants block and laboratories, etc.

State	Farmers	Farm women	Students/Trainees Boys and Girls	Central/State/ other officers
Rajasthan	1686	281	2274	326
Haryana	-	-	70	72
Uttrakhand	-	-	25	27
Madhya Pradesh	10	-	40	56
Uttar Pradesh	50	-	-	4
Bihar	-	-	39	20
Karnataka	-	-	24	2
Delhi	-	-	25	18
Total	1746	281	2497	525

EXHIBITIONS

To popularize the technologies of CAZRI and to create awareness among the masses about the activities and achievements of CAZRI, Institute organized exhibitions:

Date	Place	Name of program
January 2-11	Rawan Ka Chabutra, Jodhpur	Rajasthan Paschimi Hastsilp Udyog Utsav-2011
February 10-12	NGFGR, Lucknow	Xth Agriculture Science Congress, AGROVISION-2011
March 5	Avikanagar, Tonk	Sheep Mela, Exhibition & Kissan Sangosthi Samaroha
March 15	Village Purkhawas, Jodhpur	Field Day
March 23-24	CAZRI, Jodhpur	National Workshop on *Prosopis juliflora* : Past, Present and Future
May 11-12	KVK Abusar, Jhunjhunu	Kissan Mela
June 4	CAZRI, Jodhpur	World Environment Day
July 15-16	NBPGR, New Delhi	ICAR Foundation Day & Director's Conference
August 12	Beri Ganga, Jodhpur	State level Van Mahotsav
August 29	CAZRI Jodhpur	Kissan Mela
September 8	Village Luni Panchayat Samiti Pabu Nada, Jodhpur	Field Day On Kharif Crops
September 14-20	CAZRI, Jodhpur	Hindi Saptaha
September 17	Village Harsolav, Nagaur	Kissan Mela

September 20	Village Jhanwar Rohilakala, Jodhpur	Demonstration on Solar Animal Feed Cooker
September 27	Village Purkhawas, Luni Panchayat Samiti, Jodhpur	Agriculture Technology Day
November 3-5	Balotra, Barmer	Bharat Nirman Jan Soochana Abhiyan Mela
November 16-18	CAZRI, Jodhpur	Mushroom Production
December 5	Village Purkhawas, Luni Panchayat Samiti, Jodhpur	International Woman Day
December 20-22	Bhuj, Gujarat	National Symposium on Resource Utilization through Integrated Farming System and Biodiversity Conservation in Drylands
January 5-15	Rawan Ka Chabutra, Jodhpur	Paschimi Rajasthan Hastsilp Utsav-2012
February 7	Jodhpur Chopasani Nursery)	Kissan Mela (ATMA Project)
March 2	Village Bujawar, Jodhpur	Field Day and Kissan Gosthi
March 3, 2012 (by RRS, Jaisalmer)	Pokran, Jaisalmer	Kisan Mela organized by Agriculture Department, Jaisalmer
March 13-16	IARI Mela Maidan, New Delhi	Global Conference on Women in Agriculture
March 19	Village Binjwaria, Jodhpur	Field Day on Cumin Crop

PERSONNEL

DIRECTORATE

1. Dr. M.M. Roy, Director
2. Shri A. Angel, Private Secretary (Retired on 31.8.2011)
3. Mrs. Sreedevi Mohanan, Private Secretary

RESEARCH COORDINATION AND MANAGEMENT

1. Dr. R.K. Kaul, Principal Scientist (Nematology)
2. Shri Vidyadhar, T-9
3. Shri B.K. Mathur, T-9 (Retired on 31.1.2012)
4. Dr. Y.N. Mathur, T-(7-8) (IPO) (Retired on 31.7.2011)
5. Shri Vimal Kishore Purohit, T-6
6. Shri Vijendra Kumar Jayalwal, T-5
7. Shri Suraj Prakash, T-5
8. Shri Shree Ballabha Sharma, T-5
9. Shri Mukesh Gehlot, T-5
10. Shri Bahadur Singh Sankhla, T-5
11. Shri Harish Purohit, T-5
12. Shri Kundan Mal Gawaria, T-5
13. Shri Ramesh Chandra, T-5
14. Shri Deva Ram, T-5 (from 01.01.2011)

DIVISION OF NATURAL RESOURCES AND ENVIRONMENT

1. Dr. Chandra Bhushan Pandey, Head (from 06.02.2012)
2. Dr. Amal Kar, Principal Scientist and Head (upto 5.2.2012)
3. Mrs. Pramila Raina, Principal Scientist (Soil Chemistry/Fertility) (Retired on 29.2.2012)
4. Dr. H.A. Khan, Principal Scientist (Organic Chemistry)
5. Dr. A.S. Rao, Principal Scientist (Agril. Meteorology) (upto 22.7.2011)
6. Dr. Praveen Kumar, Principal Scientist (Soil Chemistry/Fertility)
7. Dr. D.V. Singh, Sr. Scientist (Agronomy)
8. Dr. R.K. Goyal, Sr. Scientist (Soil & Water Cons. Engg.)
9. Dr. P.C. Moharana, Sr. Scientist (Geography)
10. Dr. Md. Mohibb-e-Azam, Sr. Scientist (Organic Chemistry)
11. Dr. Sharmila Roy, Sr. Scientist (Agril. Entomology)
12. Dr. Nav Raten Panwar, Sr. Scientist (Soil Science-Fert./Chem./Microbilogoy)
13. Dr. Mahesh Kumar, Scientist (Sr. Scale) (Pedology)
14. Shri Hari Mohan Meena, Scientist (Agril. Meteorology)
15. Shri J.S. Chouhan, T-(7-8)
16. Shri A.K. Kalla, T-(7-8)
17. Shri P.C. Bohra, T-(7-8)
18. Shri Mukesh Sharma, T-(7-8)
19. Shri R.S. Purohit, T-(7-8)
20. Shri Mohar Singh, T-(7-8)
21. Shri P.K. Joshi, T-6
22. Shri A.K. Gehlot, T-6
23. Shri Laxmi Narain, T-5
24. Shri R.S. Mertia, T-5
25. Smt. Meena Manglia, T-5
26. Shri Surendra Poonia, T-5
27. Shri Rajendra Singh Rajpurohit, T-5
28. Shri Ganpat Singh Deora, T-5
29. Dr. Manish Mathur, T-5
30. Shri Mota Ram Arya, T-5
31. Shri Sumer Singh, T-5
32. Shri Abhay Singh, T-5 (from 01.01.2011)
33. Shri Narsing Ram, Private Secretary

DIVISION OF INTEGRATED LAND USE MANAGEMENT AND FARMING SYSTEMS

1. Dr. Suresh Kumar, Head
2. Dr. D.K. Painuli, Principal Scientist (Soil Physics)
3. Dr. T.K. Bhati, Principal Scientist (Agronomy)
4. Dr. Uday Burman, Principal Scientist (Plant Physiology)
5. Dr. J.C. Tewari, Principal Scientist (Forestry)
6. Dr. Anurag Saxena, Principal Scientist (Agronomy)
7. Dr. P.R. Meghwal, Principal Scientist (Horticulture)
8. Dr. Rajwant Kaur Kalia, Principal Scientist (Agro. Forestry) (from 31.03.2012)

9. Shri A.K. Sharma, Scientist (Sel. Grade) (Agronomy)
10. Dr. Akath Singh, Sr. Scientist (Horticulture)
11. Dr. P. Ratha Krishnan, Sr. Scientist (Forestry)
12. Shri Pradeep Kumar, Scientist (Horticulture)
13. Shri S.P. Seth, T-(7-8)
14. Shri J.K. Lohiya, T-6
15. Shri Raj Kumar Mathur, T-6
16. Shri Shanti Lal Sharma, T-5
17. Shri Prahlad Singh, T-5
18. Shri Narain Ram, T-5
19. Shri Chandra Pal Singh, T-5
20. Shri Sohan Ram Bhaker, T-5
21. Shri Sohan Ram Choudhary, T-5
22. Shri Surendra Kumar Sankhla, T-5 (from 01.01.2011)
23. Shri V.P. Satyadevan, Private Secretary

DIVISION OF PLANT SCIENCES AND BIOTECHNOLOGY

1. Dr. R.K. Bhatt, Head
2. Dr. Satya Vir, Principal Scientist (Agril. Entomology)
3. Dr. M.P.S. Rathore, Principal Scientist (Agril. Entomology)
4. Dr. V.K. Manga, Principal Scientist (Plant Breeding)
5. Dr. S.K. Jindal, Principal Scientist (Plant Breeding)
6. Dr. R.R. Bhansali, Principal Scientist (Plant Pathology)
7. Dr. S.K. Lodha, Principal Scientist (Plant Pathology)
8. Dr. Arun Kumar, Principal Scientist (Plant Pathology)
9. Dr. R.K. Kaul, Principal Scientist (Nematology)
10. Dr. S.K. Singh, Principal Scientist (Plant Pathology)
11. Dr. Ramavtar Sharma, Principal Scientist (Genetics/Cyto Genetics) (from 31.03.2012)
12. Dr. Anjaly Pancholy, Sr. Scientist (Genetics/Cytogenetics)
13. Dr. Nisha Patel, Sr. Scientist (Agril. Entomology)
14. Dr. M.P. Rajora, Sr. Scientist (Plant Breeding)
15. Dr. Sunil S. Mahajan. Sr. Scientist (Seed Technology)
16. Shri Manohar Singh Solanki, T-5
17. Shri Puskar Singh Rawat, T-5
18. Shri Ramu Ram, T-5
19. Shri Rakesh Pathak, T-5
20. Shri Mohan Lal Sharma, T-5
21. Shri Rajan Lal, T-5 (Retired on 30.6.2011)
22. Shri Manga Ram Bhati, T-5 (from 01.01.2011)

DIVISION OF ANIMAL SCIENCES AND FORAGE PRODUCTION

1. Dr. A.K. Mishra, Head
2. Dr. H.C. Bohra, Principal Scientist (Animal Nutrition) (Retired on 31.12.2011)
3. Dr. B.K. Mathur, Principal Scientist (Animal Nutrition)
4. Dr. A.K. Patel, Principal Scientist (Livestock Prod. & Management)
5. Dr. Mavji Patidar, Principal Scientist (Agronomy)
6. Dr. Ajayvir Singh Sirohi, Sr. Scientist (LPM) (from 25.6.2011)
7. Shri Dinesh Mathur, T-6
8. Shri R.C. Bohra, T-6
9. Shri R.S. Chouhan, T-5
10. Shri Hanuman Ram, T-5 (Retired on 31.3.2012)
11. Shri Bhudha Ram, T-5

DIVISION OF AGRICULTURAL ENGINEERING AND ENERGY

1. Dr. P.C. Pande, Principal Scientist (Physics) and Head (21.5.2011)
2. Dr. N.M. Nahar, Principal Scientist (Physics)
3. Dr. P.B.L. Chaurasia, Principal Scientist (Physics) (Retired on 31.10.2011)
4. Shri Dinesh Mishra, Principal Scientist (Farm Machinery & Power)
5. Dr. P.K. Malaviya, Principal Scientist (ASPE)
6. Dr. Dilip Jain, Senior Scientist (AS&PE) (from 16.01.2012)
7. Dr. A.K. Singh, Sr. Scientist (Farm Machinery & Power)

8. Shri Priyabrata Santra, Sr. Scientist (Soil Physics)
9. Shri Purshottam Sharma, T-9
10. Shri Safiullah Ansari, T-9
11. Shri Hans Raj, T-9
12. Shri S.K. Vyas, T-(7-8)
13. Shri M.M. Purohit, T-(7-8)
14. Shri R.C. Bissa, T-6
15. Shri Khem Singh, T-6 (from 01-01-2011)
16. Shri Girdhari Ram, T-5
17. Shri Bhanwar Singh Solanki, T-5
18. Shri Ganga Singh Khichi, T-5
19. Shri Amar Jeet Singh, T-5
20. Shri Ramesh Panwar, T-5
21. Shri S.K. Thakur, T-5
22. Shri Sodi Singh, T-5
23. Shri Bal Kishan Dave, T-5
24. Shri Madan Lal, T-5
25. Shri Bhanwar Lal Verma, T-5 (Retired on 31.1.2012)
26. Shri Kale Shailendra Rambau, T-5
27. Shri Vijay Kumar, T-5
28. Shri C.S. Jodha, T-5 (Retired on 30.9.2011)
29. Shri Amit Kumar Singh, T-5
30. Shri Bhanwar Lal Boss, T-5

DIVISION OF AGRICULTURAL ECONOMICS, EXTENSION AND TRAINING

1. Dr. D.K. Saha, Principal Scientist (Agril. Extension) and I/c Head (upto 25.8.2011) (Retired on 31.8.2011)
2. Dr. Shalander Kumar, Head (from 26.8.2011)
3. Dr. R.N. Singh, Principal Scientist (Agril. Extension) (Retired on 31.7.2011)
4. Dr. B.L. Gajja, Principal Scientist (Agril. Economics) (Retired on 31.1.2012)
5. Dr. Pratibha Tiwari, Principal Scientist (Home Science)
6. Dr. Bhagwan Singh, Sr. Scientist (Agril. Extension)
7. Dr. Khem Chand, Sr. Scientist (Agril. Economics), Officer-in-Charge (from 13.4.2011)
8. Dr. Soma Srivastava, Scientist (Food & Nutrition)
9. Shri Virendra Kumar Soni, T-(7-8)
10. Shri Roop Chand, T-(7-8)
11. Shri Khinv Singh Jodha, T-5
12. Shri Nanu Ram Bhamoo, T-5
13. Shri Mohan Ram Karela, T-5
14. Shri Mohan Singh Mertia, T-5
15. Shri Rajendra Prasad Parihar, T-5
16. Shri Rupinder Singh, T-5
17. Shri Gaje Singh Jodha, T-5

ALL INDIA COORDINATED RESEARCH PROJECT ON RODENT CONTROL

1. Dr. R.S. Tripathi, Principal Scientist (Agril. Entomology) and Project Coordinator I/c
2. Shri B.K. Soni, Principal Scientist (Agril. Entomology)
3. Shri Ramesh Chandra Meena, T-5
4. Shri Ashok Sankhla, T-5
5. Shri Promod Singh Yadav, T-5 (Retired on 19.7.2011)
6. Shri Surjeet Singh, T-5

NATIONAL NEW WORK PROJECT ON ARID LEGUME

1. Shri Arvind Henry, Principal Scientist (Plant Breeding) & I/c PC
2. Dr. P.K. Roy, Sr. Scientist (Plant Breeding)

K.V.K. SCHEME, JODHPUR

1. Shri M.C. Bhandari, Principal Scientist (Agril. Extension) and Officer-in-Charge (Retired 31.5.2011)
2. Shri A.C. Mathur, T-9
3. Shri R.R. Meghwal, T-9
4. Shri A.S. Tomar, T-(7-8)
5. Shri Hari Dayal, T-(7-8)
6. Shri Vinod Kumar Badgujar, T-6
7. Mrs. Savita Singhal, T-6
8. Shri Ram Pal Singh, T-6
9. Dr. Manoj Kumar Gujar, T-6
10. Shri P.S. Bhati, T-5
11. Shri Jagdish Rohlan, T-5

12. Ms. Kalawati, Asstt. Adm. Officer (Retired on 31.7.2011)

NATIONAL FELLOW

1. Dr. J.C. Tarafdar, National Fellow (Soil Chemistry/Fertility)
2. Shri Badri Narain Sharma, T-5

LIBRARY

1. Shri Tirth Dass, T-5
2. Shri Kailash Detha, T-5
3. Shri Kamlesh Kumar Sharma, T-5

C.R. FARM

1. Shri Gitam Singh, T-9
2. Shri Roop Singh Rathore, T-5
3. Shri Fateh Singh, T-5 (from 01.01.2011)

SECURITY SECTION

1. Shri Pramod Kumar, Security Officer
2. Shri Shyam Singh, T-5

ADMINISTRATIVE WING

1. Shri Sanjay Bakolia, Chief Administrative Officer
2. Smt. Marriamma Mathews, Private Secretary
3. Shri Sujit Kumar Singh, Administrative Officer
4. Shri S. Sugathan, Asstt. Adm. Officer (Rectt.)
5. Shri D.M. Sancheti, Asstt. Adm. Officer (Adm. I) (from 8.8.2011)
6. Shri Joy Varghese, Asstt. Adm. Officer (Adm. II)
7. Shri H.L. Pargi, Asstt. Adm. Officer and DDO (Adm. III)
8. Shri Dhan Raj, Asstt. Adm. Officer (Adm. IV) (Retired on 31.3.2012)
9. Shri Ratan Lal Sunkariya, Asstt. Adm. Officer (Adm. V)
10. Shri Durlabh Chand, Asstt. Adm. Officer (from 8.8.2011) (Retired on 30.11.2011)
11. Mrs. Madhu Bala Charan, Asstt. Director (OL)

ACCOUNTING WING

1. Shri Ashok Gangwani, FAO
2. Shri Pawan Kumar Tiwari, AFAO
3. Shri Sunil Choudhary, AFAO
4. Shri Pradeep Mathur, AFAO (from 19.3.2011)

REGIONAL RESEARCH STATION, PALI MARWAR

1. Dr. S.M. Deb, Head
2. Dr. Khem Chand, Sr. Scientist (Agril. Economics) (upto 12.4.2011)
3. Dr. S.S. Rao, Sr. Scientist (Agronomy) (upto 9.12.2011)
4. Dr. B.L. Jangid, Sr. Scientist (Agril. Extension)
5. Dr. S.P.S. Tanwar, Sr. Scientist (Agronomy)
6. Dr. Vikas Khandelwal, Sr. Scientist (Plant Breeding) (from 19.03.2012)
7. Shri Pannalal Regar, Scientist (Sel. Grade) (Soil & Water Cons. Engg.)
8. Ms. Monika Shukla, Scientist (Agronomy) (from 23.12.2011)
9. Shri B.S. Jodha, T-5
10. Shri Sanjay Kumar Dashora, T-5
11. Shri Virendra Singh Nathawat, T-5
12. Shri Pratap Singh Solanki, T-5
13. Shri Ramesh Kumar Panwar, Asstt. Adm. Officer

K.V.K. SCHEME, PALI

1. Dr. Dheeraj Singh, Training Organizer
2. Dr. M.K. Choudhary, T-(7-8)
3. Shri Hari Dayal, T-(7-8) (upto 10.4.2011)
4. Dr. Moti Lal Meena, T-6 (SMS)
5. Ms. Aishwarya Dudi, T-6 (SMS)
6. Dr. Subhash Chandra Kachhawaha, T-6 (SMS)
7. Shri Mohan Singh Choudhary, T-5
8. Shri Tara Ram, T-5

REGIONAL RESEARCH STATION, BIKANER

1. Dr. N.D. Yadava, Principal Scientist (Agronomy) and Head (6.7.2011)
2. Dr. Jai Prakash Singh, Principal Scientist (Economic Botany) (upto 11.4.2011)
3. Dr. Motilal Soni, Sr. Scientist (Soil Chemistry/Fertility)
4. Dr. Vijay Singh Rathore, Sr. Scientist (Agronomy)
5. Dr. Narain Singh Nathawat, Sr. Scientist (Plant Physiology)
6. Dr. Birbal, Sr. Scientist (Horticulture)
7. Ms. Seema Bhardwaj, Scientist (Pedology)
8. Shri N.P. Singh, T-9

9. Shri J.C. Joshi, T-9
10. Shri Rahu Ram Meghwal, T-5
11. Shri Pratul Gupta, T-5
12. Shri Jogeshwar Ram, T-5
13. Shri Rajeev Kumar, T-5
14. Shri Bhagirath Mal Yadav, T-5

REGIONAL RESEARCH STATION, JAISALMER

1. Dr. Jai Prakash Singh, Principal Scientist (Economic Botany) (from 12.4.2011) and Head (6.7.2011)
2. Dr. R.N. Kumawat, Sr. Scientist (Agronomy) (upto 1.4.2011)
3. Dr. Hansraj Mahla, Sr. Scientist (Plant Breeding)
4. Dr. Nawlesh Kumar Sinha, Sr. Scientist (Seed Technology)
5. Dr. P. Raja, Sr. Scientist (Pedology)
6. Dr. Dayanand, Sr. Scientist (Agronomy) (from 19.4.2011)
7. Mr. Venkatesan K., Scientist (from 23.12.2011)
8. Shri Kana Ram Choudhary, T-(7-8)
9. Shri Daleep Singh, T-5

REGIONAL RESEARCH STATION, KUKMA-BHUJ

1. Dr. Devidayal, Head
2. Dr. Deepesh Machiwal, Sr. Scientist (Soil & Water Conservation Engg.)
3. Dr. Arvind Kumar, Scientist (Genetics)
4. Shri M. Shamsudeen, Scientist (Pedology)
5. Shri Sushil Kumar, Scientist (Agronomy) (from 22.12.2011)
6. Shri M.L. Swami, T-9
7. Sh. Suresh Chandra Vyas , T-5 (from 29.05.2011)
8. Sh. Hanwant Singh, T-5 (from 30.05.2011) (Retired on 31.5.2011)

CAZRI IN THE NEWS

बबूल का प्रयोग अब खरगोश

विलायती बबूल से बनेगी कॉफी

अभी चूहों पर चल रहा परीक्षण

sunday स्टोरी

जोधपुर (कासं). यदि प्रयोग सफल रहा तो देश भर में विलायती बबूल की फलियां ढूंढने पर भी नहीं मिलेंगी क्योंकि इनकी फलियों के पाउडर से कॉफी बनाने के लिए भारतीय पोषाहार संस्थान चूहे पर प्रयोग के बाद अब खरगोश पर भी परीक्षण कर जल्दी ही इसकी रिपोर्ट देगा। संस्थान ने हरी झण्डी दे दी तो आप विलायती बबूल की फलियों के पाउडर की कॉफी पीकर एक नई ताजगी का अहसास पाएंगे।

जोधपुर स्थित केन्द्रीय शुष्क क्षेत्र अनुसंधान संस्थान (काजरी) के प्रयोग की भारतीय पोषाहार संस्थान आखिरी परख कर रहा है। देखा जा रहा है कि इस पाउडर में कोई विषैले तत्व तो नहीं है और चूहे के लीवर आदि अंगों को तो कोई नुकसान तो नहीं पहुंच रहा। ऐसा ही दूसरा प्रयोग खरगोश पर भी होगा। इसके सफल होने पर संस्थान इस बात का प्रमाण पत्र देगा कि इस कॉफी के सेवन से मानव स्वास्थ्य को कोई खतरा नहीं ...

नतीजे पर पहुंचे ... पाउडर का उपयोग ... की कीमत तो लगभ... आय में भी इजाफा हो... लोगों को इसका फायद... बढ़ी तो इसकी आपूर्ति ... से ही संभव है। काजरी ... संस्थान से करार किया है, ... प्रति किलो के हिसाब से ... बबूल जंगल में ढेरों है और ... भी मिल सकता है। इसके ... भारतीय पोषाहार संस्थान ... वैज्ञानिकों का मानना है कि ... प्रतिशत कच्ची कॉफी मिला...

इनका क...

...तो भारतीय पोषाहार ... का इंतजार कर रहे हैं। ... चल रहा है। उसके बाद ...

काजरी के वैज्ञानिकों से मांगी राय

घास के उन्नत बीजों की उपलब्धता बढ़ानी होगी : राय

राष्ट्रीय स्तर पर चारे में बढ़ोतरी के लिए समिति की पहली बैठक संपन्न

• नवज्योति टीम

जोधपुर, 31 मई। भारत सरकार के योजना आयोग द्वारा ...

ईरान के वैज्ञानिकों ने देखी मरू विकास की तकनीक

जोधपुर, 1 दिसंबर। केन्द्रीय शुष्क क्षेत्र अनुसंधान संस्थान, जोधपुर में इन्स्टीट्यूशनल स्ट्रेन्थनिंग एण्ड कोहिरेन्स फॉर सस्टेनेबल नेचुरल रिसोर्स मैनेजमेन्ट के वैज्ञानिकों, महानिदेशक, प्रशासकीय अधिकारी, वरिष्ठ विशेषज्ञों के 11 उच्च स्तरीय अधिकारियों ने काजरी द्वारा ईजाद की गई तकनीकों की जानकारी लेने के लिए ...ोध क्षेत्रों का भ्रमण किया। दल के समन्वयक ...आईएनआरएम के मुख्य तकनीकी सलाहकार ... सिन्हा ने बताया कि प्राकृतिक संसाधनों का ...गोचर भूमि का प्रबन्धन, कृषि वानिकी पद्धतियों, ... टिब्बा स्थिरीकरण नहरी क्षेत्र के आस-पास ..., सेल्टर बेल्ट प्लान्टेशन, वन एवं वानिकी ... मूल्य संवर्द्धन तकनीक के कार्यों की जानकारी ...न में बहुत बड़ा भू-भाग शुष्क क्षेत्र है जिसका ...तत विकास करना चाहते है। ... के अधिकारी एवं काजरी वै... बैठक को संबोधित करते हु... परिषद् के उप-महानिदेशक ने कहा कि ईरान तथा भारत सरकार के बीच एक एमओयू तय हो चुका है जिसके अंतर्गत ज्ञान का आदान-प्रदान, तकनीकी हस्तांतरण होगा तथा संयुक्त परियोजना पर कार्य करने से दोनों ही देशों को लाभ मिलेगा। काजरी निदेशक डा. एम.एम. रॉय ने कहा कि शुष्क क्षेत्रों को हरा-भरा करने, कम पानी में फसल एवं फल का अधिक उत्पादन के लिए अनेक तकनीके विकसित की है। प्रधान वैज्ञानिक डा. जे.सी. तिवारी ने वानिकी नर्सरी में मरूस्थल के पेड़-पौधों, विलायती बबूल से कॉफी, बिस्कुट बनाने एवं कुमुट से अधिक गोंद प्राप्त करने तथा टिब्बा स्थिरीकरण की तकनीकों के बारे मे जानकारी दी। वरिष्ठ वैज्ञानिक डा. एम.पी. राजोरा ने चारागाह प्रबन्ध के उन्नत घासों की प्रजातियों, उनके बीज उत्पादन के बारे में, प्रधान वैज्ञानिक डा. एच.सी. बोहरा ने सूखे चारे को पौष्टिक ...

काजरी के शोध कार्यों का लाभ किसानों को मिला : मुख्यमंत्री

जोधपुर। केंद्रीय शुष्क क्षेत्र अनुसंधान संस्थान, क़ाजरी की ओर से कृषि प्रौद्योगिकी प्रबंधन अभिकरण आत्मा परियोजना के तहत चौपासनी नर्सरी में जिला स्तरीय किसान मेले का आयोजन रविवार को किया गया। जिसमें कृषकों को सम्बोधित करते हुए मुख्यमंत्री अशोक गहलोत ने कहा कि काजरी के शोध कार्यों, उपलब्धियों का लाभ क्षेत्र को एवं किसानों को मिला है। पूरी तकनीकी किसानों को मिले ताकि वे आगे बढ़ें, किसान को उसकी मेहनत का पूरा लाभ हो, वर्तमान हाइटेक युग में नवीन तकनीकी का प्रयोग जरूरी है। इस अवसर पर काजरी की ओर से प्रदर्शनी लगाई गई। मेले में डॉ.राजसिंह ने कृषि की विभिन्न नवीन तकनीकों, उन्नत किस्मों की जानकारी दी। सूचना एवं प्रचार अधिकारी बहादुरसिंह सांखला एवं एमएस मेड़तिया, पीसी बावनकर ने सौर ऊर्जा के विभिन्न उपयोग, कुमट से गोंद उत्पादन एवं मल्य संवर्द्धन के बारे

काजरी में 'शुष्क भूमि से सतत् कृषि उत्पादन' प्रशिक्षण के उद्घाटन सत्र में मंचासीन अतिथि।

शुष्क क्षेत्रों में कृषि उत्पादन बढ़ाना होगा

आठ दिवसीय प्रशिक्षण कार्यक्रम शुरू

...रेश कुमार ने किया। कार्यक्रम में वक्ताओं ने कहा कि देश में ... क्रान्ति के लिए शुष्क क्षेत्रों में कृषि का ... होगा। शुष्क क्षेत्रों में प्राकृतिक संसाधन ... इसलिए उनका समुचित एवं कुशलता... प्रयोग करना होगा। खेती में फसल, भूमि, ... एवं प्रकृति पर जलवायु परिवर्तन का प्रभाव ... है। देश में अनाज, दलहनी फसलों, ... सब्जियों से सतत उत्पादन लेने के लिए कृषि ... तकनीकों, उन्नत किस्मों के प्रयोग को ... पहुंचाने के प्रयासों में तीव्रता लानी होगी। ... लिए पोषक खाद्य व पशुओं के लिए पोषक ... अधिक उत्पादन लेने के लिए भूमि को ... को बढ़ाना होगा। प्रशिक्षणार्थियों को ...

खेतों में हो शोध का जीवंत ...

काजरी के शोध कार्यों का लिया ज...

एक्सप्रेस टीम

जोधपुर। भारतीय कृषि अनुसंधान परिषद, कृषि वैज्ञानिक चयन मंडल नई दिल्ली के सदस्य प्रोफेसर एम.जे. मोडाइल काजरी जोधपुर के शोध कार्यों का जायजा लेते हुए कहा कि शुष्क क्षेत्र को हरा-भरा बनाने, समृद्धि फैलाने तथा गांवों में रोजगार के साधन विकसित करने के लिए ज्ञान एवं तकनीक का इस्तेमाल किया जाना चाहिए। उन्होंने कहा कि शोध उपलब्धियों का प्रायोगिक एवं जीवन्त प्रदर्शन खेतों में होना चाहिए ताकि किसान उस तकनीक को देख समझ कर उसे स्वीकार करें। प्रोफेसर मोडाइल ने कहा कि मरूस्थल में सौर ऊर्जा के उपयोग की काफी संभावनाएं है तथा जो संयंत्र विकसित हुए हैं उनका गांवों में उपयोग बढ़ाया जाए। काजरी के निदेशक डॉ. एम.एम.रॉय ने कहा कि शुष्क क्षेत्र को हरा-भरा बनाने, समृद्धि फैलाने, गांवों में रोजगार के साधन विकसित करने, पशुओं से अधिक दुग्ध उत्पादन लेने के लिए संस्थान ने शोध कार्य कर अनेक तकनीकियां

विकसित की है। इनके उपयोग ... है। बाजरा, मूंग, मोठ, ग्वार की ... है जो बहुत ही कम समय में पक ... पशुओं के चारागाह विकास के लिए सेवण, धामण ... विकसित की गई है। प्रधान वैज्ञानिक डॉ. जे.सी. ... ने रेगिस्तानी रेत के टिलों की रोकथाम के लि... स्थिरीकरण तकनीक, कुमट से अधिक गोंद उत... की ... विलायती ब... मूल्य संवर्द्धन ... में बताया। ... वैज्ञानिक ... ने गेहूं एवं ... पादप कार्यि... के बारे में ... दी। शोध स... एवं प्रबंधन ... के प्रभारी ... आर.के.कॉल ... शस्य विज्ञा... क्षेत्र में ... बूंद-बूंद सिं... टमाटर एवं ... फूलों की ख... काफी आय अर्जित की जा सकती है। सौर ऊ... अभियांत्रि विभाग में विभागाध्यक्ष डॉ.पी.सी. पाण्डे... प्रकाश वोल्टीय गतिशील ईकाई, सौर कूकर, सौ... डस्टर, सोलर थ्री-इन वन संयंत्र, डेजर्ट कूल चे... खेती में काम आने वाले विभिन्न संयंत्रों के ... जानकारी दी।

ग्वारगम उद्योग की समस्याओं पर चर्चा

• नवज्योति टीम

जोधपुर, 10 मार्च। भारतीय प्राकृतिक राल एवं गोंद संस्थान नामकुम रांची और केन्द्रीय शुष्क क्षेत्र अनुसंधान संस्थान जोधपुर के सहयोग से भारतीय ग्वारगम उद्योग से जुड़ी जानकारी के लिए एक संगोष्ठी आयोजित की गई। इसमें जोधपुर के अग्रिम ग्वारगम की इकाईयों से जुड़े उद्यमियों ने हिस्सा लिया।

संगोष्ठी में चर्चा के दौरान ग्वार के बीज से कम क्षेत्र में अधिक उत्पादन, अधिक गुणवत्ता वाला बीज, ग्वारगम के बाजार मूल्य स्थिर रखने, ग्वार गम के मूल्य संवर्धित उत्पाद एवं उनके पोषक वृक्षों में उपयोग आने वाले रसायनों के आयातों की सुविधाओं पर व्यापक चर्चा की गई। इस दौरान भारतीय राल एवं गोंद संस्थान रांची के डॉ.आर.रमानी ने कहा कि सभी उद्यमियों की समस्याओं के समाधान के लिए उनकी संस्था एवं काजरी जोधपुर के वैज्ञानिक हमेशा तैयार रहेंगे। लेकिन इसके समुचित निदान के लिए सभी उद्यमियों का भी सहयोग जरूरी है।

काजरी के कार्यवाहक निदेशक डॉ.आर.के.भट्ट ने भी सभी को सहयोग देने का आश्वासन दिया।

इस संगोष्ठी में काजरी के वरिष्ठ वैज्ञानिकों, विभागाध्यक्षों एवं पूर्व प्रधान वैज्ञानिकों डॉ.एल.एन.हर्ष, डॉ.डी.कुमार ने भी भाग लिया। संगोष्ठी में जोधपुर के अग्रिम ग्वार गम इकाइयों हिन्दुस्तान ग्वारगम, श्रीराम ग्वारगम, लिवसीड कुलवाइड लिमिटेड, हाइड्रो कुलवाइड लिमिटेड, नवीन गम इंडस्ट्रीज, आरती गम इंडस्ट्रीज, विमल गम इंडस्ट्रीज से जुड़े उद्यमियों ने भाग लिया। कार्यक्रम के अंत में काजरी के प्रधान वैज्ञानिक डॉ.मुरारी प्रसाद ने धन्यवाद दिया।

काजरी के शोध क्षेत्रों का अवलोकन

जोधपुर. भारतीय कृषि अनुसंधान परिषद नई दिल्ली के उपमहानिदेशक डॉ. के.डी. कोकाटे सहित देश के विभिन्न क्षेत्रों के कृषि वैज्ञानिकों ने ...

...व किए गए कार्यों का डेटाबेस तैयार करने का सुझाव ... निदेशक डॉ. एम.एम. रॉय ने संस्थान में चल रही शोध...

डॉ. तरफदार को भारत ज्योति पुरस्कार

जोधपुर. केन्द्रीय शुष्क क्षेत्र अनुसंधान संस्थान के प्रधान वैज्ञानिक तथा भारतीय कृषि अनुसंधान परिषद के राष्ट्रीय अध्येता डॉ. जे.सी. तरफदार को इंडिया-इंटरनेशनल सोसायटी, नई दिल्ली की ओर से भारत-ज्योति...

उपलब्ध तकनीक का लाभ उठाएं: डॉ. रॉय

जोधपुर, 16 मार्च। काजरी कृषि विज्ञान केंद्र जोधपुर की ओर से लूणी पंचायत समिति के गांव पुरखावास में मंगलवार को किसान दिवस मनाया गया। मुख्य अतिथि काजरी निदेशक डॉ.एमएम रॉय थे। उन्होंने कहा कि आईसीएआर काजरी, केवीके जोधपुर ने इस गांव को गोद लिया है। उन्होंने कहा कि ग्रामीणों की समस्या के समाधान के लिए संस्थान पूर्णरूप से प्रयासरत है। उन्होंने कहा कि तकनीकियां उपलब्ध हैं उसका फायदा उठाएं। केंद्र प्रभारी डॉ. एमसी भंडारी जल संरक्षण और सौर उर्जा के उपयोग पर बल दिया। तकनीकी अधिकारी डॉ. आलोक माथुर ने कहा कि जलवायु परिवर्तन के अनुरूप कृषि तकनीकियों का गांव में प्रदर्शन किया जाएगा। ...ने कहा कि संस्थान ने गांव को गोद लिया है तथा वे भी अपनी पूर्ण भागीदारी निभाएंगे। ...री, ओमाराम गोदारा, नाथूसिंह, खरताराम, बाबूलाल, मेघाराम बिश्नोई, गोरधनराम...

किसानों से नई तकनीक अपनाने का आह्वान

जोधपुर 16 मार्च (कासं)। काजरी, कृषि विज्ञान केन्द्र, जोधपुर द्वारा लूणी पंचायत समिति के गांव पुरखावास में किसान दिवस मनाया गया। कार्यक्रम के मुख्य अतिथि काजरी निदेशक डॉ.एम.एम.रॉय ... जानते हैं उस पर हमें विजय पाना है। नवीन ज्ञान से खेती अच्छी हो, जीवन स्तर में सुधार हो तथा रोजगार मिले। उन्होंने कहा कि उनकी समस्या के समाधान के लिए संस्थान पूर्णरूप से प्रयासरत ... हेतु राष्ट्रीय पहल परियोजना के तहत इस क्षेत्र को हरा-भरा बनाने, पशुओं से अधिक दुग्ध उत्पादन लेने एवं स्थानीय स्तर पर उपलब्ध संसाधनों से अधिक लाभ ... सूक्ष्मी के बारे में जानकारी ... तकनीकी अधिकारी डॉ. आलोक माथुर ने कहा कि जलवायु परिवर्तन के ...

काजरी में चार दिवसीय प्रशिक्षण शुरू

जोधपुर। गोंद उत्पादन पर इथेफोन ... प्रभाव पर काजरी में मंगलवार ... की चार दिवसीय प्रशिक्षण कार्यक्रम शुरू हुआ। प्रशिक्षण काजरी निदेशक डॉ. एम.एम रॉय के निर्देशन में हो रहा है। यह प्रशिक्षण वन विभाग से आए ... नीसीएफ डॉ. अनुराग चौधरी सहित 30 सदस्यों के प्रतिनिधिमण्डल को दिया जा रहा है। प्रशिक्षण की शुरुआत में काजरी खण्ड द्वितीय अध्यक्ष डॉ. सुरेश कुमार ने चिन्हित गोंद उत्पादक पेड़ों के बारे में ...

काजरी निपटेगा चारे की समस्या से

रिपोर्ट आईडेंट

'पशु चारा एवं दाणा की उपलब्धता' विषयक संगोष्ठी आयोजित

जोधपुर,31 मई (कासं)। ... विभागाध्यक्ष डॉ. अमरेश ... डॉ. ... आधुनिक तकनीक व चारागाहों ... काजरी परिसर में ऊर्जा 'पशु चारा एवं दाणा की उपलब्धता' विषयक संगोष्ठी आयोजित की गई। संगोष्ठी में काजरी के निदेशक डॉ एम एम रॉय ने कहा कि ... की मांग की पूर्ति के लिए ... पौधों तथा घासों की उन्नत ... की बीज की उपलब्धता को ... होगा। गोचर भूमि के उपयुक्त ... एवं प्रबंधन तथा सामुदायिक चारागाहों के विकास पर ... होगा। राष्ट्रीय डेरी अनुसंधान संस्थान, करनाल के विभागाध्यक्ष ... एस कुंडू ने कहा कि चारे के ... उपयुक्त पेड़ पौधों के उन्नत ...

रोजगारोन्मुखी कार्यक्रम व ज्ञान के प्रसार पर बल

काजरी में आईसीएआर की उच्च स्तरीय समिति की बैठक

सिटी रिपोर्टर, जोधपुर

भारतीय कृषि अनुसंधान परिषद, नई दिल्ली की उच्च स्तरीय समिति की बैठक सोमवार को काजरी में हुई। इसमें विशेषज्ञों ने कृषि विज्ञान केंद्रों के मार्गदर्शन के लिए चर्चा कर प्रशिक्षण, रोजगारोन्मुखी कार्यक्रम एवं ज्ञान के प्रसार पर बल दिया। बैठक की अध्यक्षता करते हुए परिषद सचिव राजीव महर्षि ने कृषि विज्ञान केंद्रों के बारे में विस्तृत जानकारी दी। भारतीय कृषि अनुसंधान परिषद, नई दिल्ली के वित्त सलाहकार चमनकुमार ने वित्त प्रबंधन पर सुझाव दिए। बैठक के ...

काजरी के शोध कार्यों का अवलोकन करते वैज्ञानिक ... योजनाओं के बारे में जानकारी दी। बैठक में देशभर से आ... ने अपने विचार व्यक्त किए।

समृद्धि के लिए सामंजस्य जरूरी: डॉ रॉय

काजरी में तकनीकों के लक्ष्यीकरण पर कार्यशाला आयोजित

पर संबोधित कर रहे थे। उन्होंने बताया कि वैज्ञानिकों ने शोध कार्य कर शुष्क क्षेत्रों में हरियाली फैलाने, ग्रामीण इलाकों के लोगों की आमदनी बढ़ाने व जीविकोपार्जन के साधन बढ़ाने के लिए कई तकनीक विकसित की हैं। ... लेने की बात कही। कार्यशाला आयोजन के सचिव डॉ. शैलेन्द्रकुमार ने गांवों में नमी बढ़ाने के लिए खेती से आय बढ़ाने और किसानों की रुचि को ध्यान में रखकर कार्य करने की बात कही। तकनीकी सत्र में डॉ. पीयूषचन्द्र पांडे ने सौर ऊर्जा के ...

जोधपुर, 29 फरवरी।

अब गर्मियों में खराब नहीं होंगी सब्जियां

वैज्ञानिक का कहना है

किसानों के लिए फायदेमंद

उत्कृष्ट परिणाम मिल रहे

काजरी के शोध क्षेत्रों का अवलोकन

अब मिलेगी जूलीफ्लोरा कॉफी

विलायती बबूल से मिलता है 70 प्रतिशत ईंधन : डागर

काजरी में विलायती बबूल पर दो दिवसीय राष्ट्रीय कार्यशाला शुरू

औषधीय गुणों से भरपूर

काजरी ने बनाया उत्कृष्ट पशु आहार सौर चूल्हा

काजरी के कृषि अभियांत्रिकी और ऊर्जा विभाग में कार्यरत वैज्ञानिक लगे हैं पर्यावरण संरक्षण और सौर ऊर्जा का सर्वाधिक उपयोग करने में

प्रतिदिन 10 किलो आहार

चूल्हे की कोई भी बना सकता है

इनका कहना

ओलिया में हो रहा है उपयोग

प्रति वर्ष 1800 किलो लकड़ी की बचत

किसानों व पशुपालकों को मिलेगा पर्याप्त कृषि ज्ञान

जोधपुर कृषि विज्ञान केन्द्रों के लिए मार्गदर्शन का उच्च स्तरीय समिति की बैठक सोमवार को काजरी में आयोजित हुई। बैठक की अध्यक्षता कर रहे परिषद के सचिव राजीव महर्षि ने बताया कि भारत के बड़े जिलों में अतिरिक्त कृषि विज्ञान केन्द्र खोले जा रहे हैं ताकि जिले के किसानों, पशुपालकों को कृषि ज्ञान हो तथा उनकी समस्याओं का निदान कृषि वैज्ञानिकों द्वारा हो सके। उन्होंने बताया कि बैठक में कृषि विज्ञान केन्द्र की कार्यप्रणाली पर चर्चा की गई जिससे ज्यादा से ज्यादा किसान लाभान्वित हो सके। इसके साथ ही ग्रामीण महिलाओं के ... भारतीय कृषि अनुसंधान परिषद के ... कुमार ने वित्त प्रबंधन पर सुझाव दिए। बैठक के संयोजक ... वाई.वी. सिंह ने बताया कि वैज्ञानिक, किसानों, ... विभागों और स्वयंसेवी संस्थाओं में समन्वय व भागीदारी ... जाएगी। आईसीएआर के उपमहानिदेशक के.डी. कोकाटे ने ... आगामी 12वीं पंचवर्षीय योजना के संभावित प्रारूप से ... योजनाओं की जानकारी दी। बैठक में डॉ. ए.जी. सांवत, ... बी.एस. ढिल्लन, डॉ. ए.एम नरूला, डॉ. ए.के. गोगोई, डॉ. ए., ... सिंह, डॉ. एस. सुधाकर, डॉ. वाई.वी. सिंह, डॉ. यू.एस. गौतम ...

किसान मेला | कृषि वैज्ञानिकों ने किसानों को दी उन्नत तकनीक की जानकारी

'समय के साथ चलें किसान'

मिली उन्नत तकनीक की जानकारी

लगाई प्रदर्शनी

40 किसानों का सम्मान

बिना कांटे वाले बबूल की प्रजाति तैयार की काज

विलायती बबूल पर राष्ट्रीय संगोष्ठी शुरू, हुई शोध कार्यों पर चर्चा, बबूल फली का उत्पाद तैयार

ये अनुसंधान किस की जिंदगी बदल दे

जलवायु परिवर्तन की समस्या पर 'काजरी' में होगा शोध

कच्छनी सूकी खेतीमां प्राण फूंकीने खेडूतोने समृद्ध बनावाशे

काजरीनी रजतजयंति निमित्ते सेमिनारनो प्रारंभ कराशे

आईसीएआर की क्षेत्रीय समिति की बैठक आयोजित

• नवज्योति टीम

जोधपुर, 1 दिसंबर। भारतीय कृषि अनुसंधान परिषद की क्षेत्रीय समिति-छह मिड-टर्म की बैठक काजरी में परिषद के उप-महानिदेशक डा. ए.के. सिंह की अध्यक्षता में आयोजित हुई। इस बैठक का उद्देश्य अनुसंधान संस्थानों, कृषि विश्वविद्यालयों तथा राज्य के संबंधित विभागों में समन्वयन को बढ़ाना था। बैठक में राजस्थान राज्य तथा दादर नगर हवेली के कृषि, पशुपालन, मत्स्य विभाग के अधिकारियों, काजरी, कृषि विश्वविद्यालयों तथा समन्वित अनुसंधान परियोजनाओं के वैज्ञानिकों ने इस क्षेत्र की कृषि संबंधित शोध एवं विकास के मुद्दों पर विस्तार से चर्चा की। इस बैठक के प्रारम्भ में काजरी निदेशक डा. एम.एम. रॉय ने मुख्य अतिथि एवं सभी सदस्यों का स्वागत किया।

राजस्थान एवं गुजरात राज्य में ऊंटों की घटती संख्या पर चिन्ता व्यक्त करते हुए डा. एके सिंह ने उनके संरक्षण की आवश्यकता पर जोर दिया। बैठक में प्रजनक बीजों की उपलब्धता को सुनिश्चित करने के निगमों द्वारा अनुसंधा पर प्रजनक बीज व आग्रह किया गया।

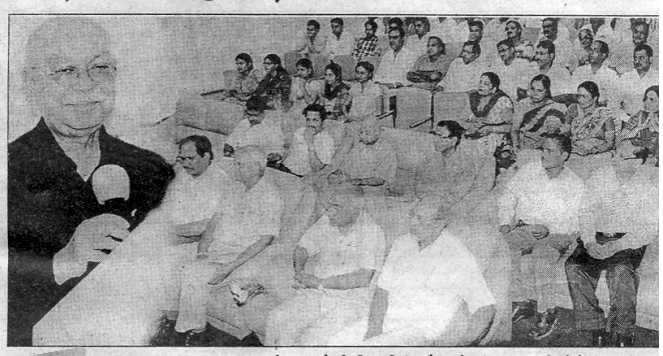
मात्रा में सौर ऊर्जा की उपलब्धता को देखते हुए सौर चलित कृषि उपयोगी यंत्रों के विकास एवं लोकप्रिय बनाने की आवश्यकता पर बल दिया। डा. गोम सिंह चौधरी, संयुक्त निदेशक मत्स्य पालन ने पश्चिमी राजस्थान में मत्स्यपालन की असीम संभावनाओं को रेखांकि करते हुए बताया कि यहां पर सजावट मछलियों एवं पर्लकल्चर पर अनुसंधा एवं विकास की आवश्यकता है। बैठ के अन्त में प्रधान वैज्ञानिक डा. आर.ने कौल ने धन्यवाद ज्ञापित किया।

हिन्दी का प्रयोग हर क्षेत्र में करें : वीरमानी

• नवज्योति टीम

जोधपुर, 20 सितम्बर। हिन्दी आपस में जोड़ने और एक दूसरे को समझने का सशक्त माध्यम है। राष्ट्र के विकास के लिए हिन्दी का प्रयोग हर क्षेत्र में होना चाहिए। यह विचार काजरी में मनाए जा रहे हिन्दी सप्ताह के समापन अवसर पर शोध समिति के अध्यक्ष डॉ. एसएम वीरमानी ने व्यक्त किए।

काजरी निदेशक डॉ. एमएम रॉय ने बताया कि आम आदमी तक अपनी बात पहुंचाने, उसे समझाने का सबसे सरल और उत्तम उपाय हिन्दी भाषा है। कार्यालयी



मुख्यमंत्री ने चखा इलायची बेर का स्वाद

जोधपुर ■ पश्चिमी राजस्थान हस्तशिल्प उत्सव 2012 के रविवार समापन कार्यक्रम के मुख्य अतिथि मुख्यमंत्री अशोक गहलोत ने

हस्तशिल्प मेले में काजरी के स्टॉल पर बेर देखते मुख्यमंत्री।

जल सुरक्षा- संग्रहण में मारवाड़ का ज्ञान वृहद : डॉ. कुमार

चाहिए तभी आम आदमी विभाग

प्रेमाराम चौधरी, हिम्मतसिहं राठौड़, रमेशचंद्र, सामान्य हिन्दी में सजीतकुमारसिंह, अमितकमार, मंज माथर, टंकण में करणसिंह गहलोत.

नैनो टेक्नोलॉजी से बढ़ेगा 40 प्रतिशत तक फसल उत्पादन

काजरी में नैनो टेक्नोलॉजी की दो दिवसीय कार्यशाला संपन्न, वैज्ञानिकों ने विकसित किए नैनो पार्टिकल्स

विश्व बैंक में भारत की साख बढ़ी : डॉ. बाबू

बीजोत्पादन कर स्वावलम्बी बने काश्तकार

काजरी द्वारा किसान मेले का आयोजन

जोधपुर। काजरी के निदेशक डॉ. एमएम. रॉय ने बीज मांग एवं आपूर्ति की समस्या पर चिन्ता जताते हुए कहा कि किसान बीजोत्पादन कर फसलों की तुलना में अधिक आमदनी अर्जित कर सकता है। साथ ही कृषि विविधता पर भी जोर दिया। वे कृषि विज्ञान केन्द्र जोधपुर द्वारा ग्राम पाबुनाड़ा में आयोजित किसान मेले को संबोधित कर रहे थे।

उन्होंने कहा कि बेहतर पैदावार के लिए अच्छा व स्वस्थ बीज का उपयोग करने के साथ बीजोत्पादन अपनाएं। बीजोत्पादन कर किसान अपने साथ अन्य किसानों की जरूरत को भी पूरा करेगा। उन्होंने किसानों से डेयरी, फलोत्पादन से जुड़ने की बात भी कहीं।

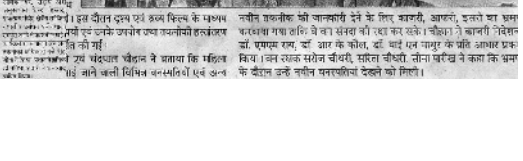
क्षेत्रीय परियोजना निदेशक एवं कार्यक्रम के मुख्य अतिथि डॉ. युद्धवीर सिंह ने कहा कि निकट भविष्य में कृषि विज्ञान केन्द्रों के माध्यम से ग्रामीण क्षेत्रों में रोजगार सृजन के कार्यक्रम शुरू किया जाएगा। किसा केवीके प्रभारी डॉ. ए.के. मिश्रा ने टिकाऊ खेत पशु नस्ल सुधार सहित कृषि क्षेत्र की जानकारियां किसानों को दी।

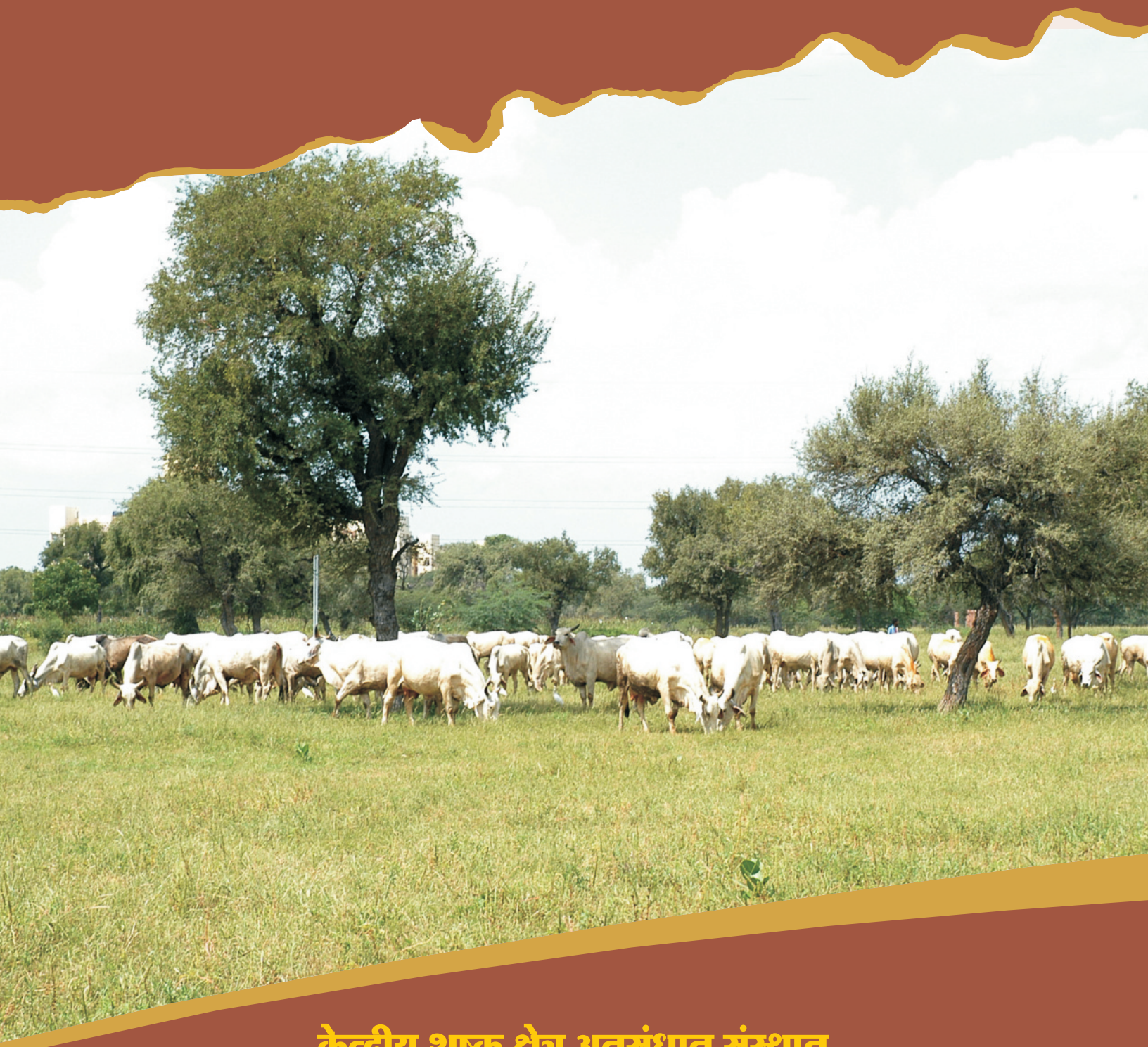
अग्रिम पंक्ति प्रदर्शन का अवलोकन

किसान मेले के बाद अतिथियों ने पाबुनाड़ा सागर, जनादेसर आदि स्थानों पर बाजरा, मूंग अग्रिम पंक्ति प्रदर्शन का अवलोकन किया रेवतराम मेघवाल व डॉ. हरिदयाल ने कहा कि परिणाम देखने को मिले हैं। कार्यक्रम के सिंघल, डॉ. आलोक माथुर ने भी सम्बोधित

किसान मेला वैज्ञानिकों व किसानों का संगम: डॉ. सिंह

वन रक्षक दल काजरी शोध से रूबरू





केन्द्रीय शुष्क क्षेत्र अनुसंधान संस्थान

(भारतीय कृषि अनुसंधान परिषद्)

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